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VOLUME II

ELECTROMAGNETIC PULSE/TRANSIENT THREAT TESTING OF PROTECTION DEVICES FOR AMATEUR/MILITARY AFFILIATE RADIO SYSTEM EQUIPMENT

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This technical report discusses the vulnerability of equipment used by amateur/MARS radio operators in the United States to disruption or damage by transient electromagnetic effects such as lightning, voltage surges, and electromagnetic pulse (EMP) waves. It also reports the results of two test programs; one to evaluate existing transient suppression devices and components, and one to evaluate the response of amateur radio equipment to an EMP transient environment.

Based on the test results, the report recommends procedures and a low-cost installation scheme which will significantly increase the operational survivability of amateur type communications equipment in a lightning or EMP environment.

This report consists of three volumes. Volume I (200 pages) contains the test results and recommendations for transient protection of amateur radio equipment. Volume II

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Block 19 Continued - ABSTRACT
(136 pages) contains supporting documentation including: the test plans for the two EMP tests, descriptions/specifications of the tested transient suppression devices and the amateur radio equipment, and photographs of the test facilities and test set-ups. Volume III (1298 pages) contains the raw test data in the form of oscilloscope photographs attached to the test data sheets for both test programs, as well as, written test descriptions and bench check measurements from the equipment test program. For most purposes Volume I should provide sufficient information. Volume II would be required to obtain more detailed descriptions of the test programs and tested devices and equipment. Volume III would only be required if a separate analysis of the test data is being made.

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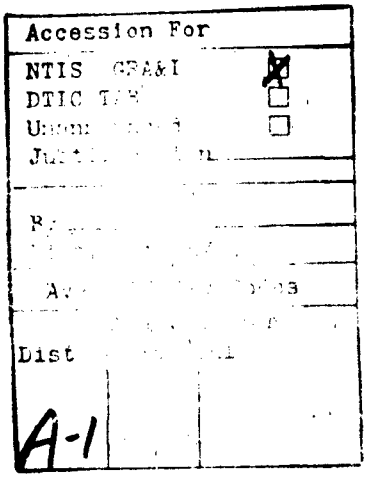

NCS TECHNICAL INFORMATION BULLETIN 85-10

ELECTROMAGNETIC PULSE/TRANSIENT THREAT TESTING OF PROTECTION DEVICES FOR AMATEUR/MILITARY AFFILIATE RADIO SYSTEM EQUIPMENT

OCTOBER 1985

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FOREWORD

The National Communications System (NCS) is an organization of the Federal government whose membership is comprised of 22 Government entities. Its mission is to assist the President, National Security Council, Office of Science and Technology Policy, and Office of Management and Budget in:

- The exercise of their wartime and non-wartime emergency functions, and their planning and oversight responsibilities.
- The coordination of the planning for and provision of National Security/Emergency Preparedness communications for the Federal government under all circumstances including crisis or emergency.

In support of this mission the NCS has executed a Memorandum of Understanding with the American Radio Relay League. Its purpose is to establish a broad framework for a cooperative and close working relationship with volunteer radio amateurs for support of national emergency communications functions. It is intended through joint coordination and exercise of the resources of both organizations, to enhance the nation-wide posture of telecommunications readiness for any conceivable national emergency. This particular Technical Information Bulletin is one of a series aimed at developing an awareness in the radio amateur community of practical, low cost EMP protective procedures, devices, and equipment which may if utilized significantly enhance the probability of amateur radio resources escaping serious damage during emergency situations involving EMP events.

Comments, on this TIB are welcome, and should be addressed to:

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VOLUME II

Contents

Section 1

TEST PLAN
FOR
TRANSIENT PROTECTIVE DEVICES
SUITABLE FOR FAST-RISING PULSES

May 28, 1985

Contents

OVERVIEW

There are now abundant supplies of devices, available to both the public and specialized electronic market, which are claimed by their manufacturers to provide transient protection for electrical equipment. However, there is no common test procedure for determining "success" in transient pulse protection that can be generally applied to all devices. In this program, a family of protective devices has been selected for application to transient protection of amateur radio stations. A test plan for qualification testing of such devices is described here which offers a rational approach to certifying the average performance of particular groups of devices against such fast-rising (nanoseconds) and powerful (kilovolts) transient pulses as might be generated by lightning or electromagnetic pulse (EMP). The laboratory facilities of IRT Corporation, San Diego, California have been selected for this test activity, with test results to be reported by Electrospace Systems, Inc. Those devices found to be qualified may then be used with confidence in transient protection applications such as the amateur radio configurations to be developed under this program.

CONCEPT

The protective device qualification program depends on the careful testing of a statistically significant sample of protective devices against an appropriate transient threat pulse, with results stated precisely in terms of pre-determined criteria for success.

The success criteria includes ability to reject a sufficient percentage of the applied transient threat, determined in accordance with the desired application, to allow use of the device as part of a transient protection scheme. This capability will be characterized by a rejection ratio, measured in decibels, defined as

$$RR_{db} = 20 \log_{10} \frac{\text{Peak Signal In}}{\text{Peak Signal Out}} .$$

The rejection ratio will be certified by comparison of an input and output waveform suitably scaled to allow direct overlay of the waveforms. Other success criteria will include the ability of the device to withstand at least a minimal number of threat stresses without failure (degradation of the rejection ratio below a specified error margin), a measure of variance between tested devices, and an absolute magnitude of voltage and current which cause actual failure of the device to support its intended use.

A detailed test concept on which this test plan is based is provided as Attachment 1.

TEST PROGRAM

Threat Definition

Qualification is desired against both EMP and lightning transients in this program. Other than the case of a direct lightning stroke, EMP is generally considered a more stringent threat to electrical systems than lightning. Consequently, the qualification test pulse will approximate the characteristics of EMP, rising to full strength in fewer than 20 nanoseconds and decaying exponentially in about one microsecond. A "typical" EMP waveform for free field was defined in "EMP Engineering and Design Principles" (Bell Telephone Laboratories, 1975) according to the exponential equation

$$E(t) = 5.25 \times 10^{4} \left[\exp(-4 \times 10^{6} t) - \exp(-4.76 \times 10^{8} t)\right]$$

where E is in volts per meter, and t in seconds. As that waveform is frequently used in unclassified work, it will also be utilized in this test program.

The transient threat to electrical hardware does not come directly from the free field, but rather from the interaction of the electric and magnetic fields with electrical conductors. For this program, it is considered likely that voltage and current transients in conductors will exhibit rise times slower than the free field, and may oscillate or decay at a much slower rate than the free field. However, approximation of the free field waveform in injected current or voltage test transients is a reasonable worst case transient pulse and will be used in this program.

For currents, peaks in excess of thousands of amperes have been predicted as response to EMP. Similarly, voltages may reach hundreds of kilovolts. However, in practice, the physical dimensions and characteristics of the conductors themselves will tend to limit currents and voltages, although not always without physical damage to the conductors. For example, it has been proposed that the highest transient voltage transmitted through a residential power distribution breaker box would be limited by air discharge breakdown. Conversely, antenna leads and signal cables in an amateur radio station may not possess such close tolerances, and the peak transients experienced, if limited at all, would be determined by the lengths and configurations of conductors exposed to the fields, and the dielectric strength of their electric insulation. Devices exposed to limited voltages will be first tested against a low level, but fast rising pulse before being exposed to maximum values of voltage and current. Therefore, the following peak values will be used in the protective device qualification tests for this program:

CONDUCTOR	PEAK VOLTAGE volts	PEAK CURRENT amps	TEST CLASS
Power connections	600	120	A
Box interconnections	600	20	B
Exterior Conductors	4500	1000	C

Threat Definition (continued)

The highest pulse level obtainable in the laboratory will also be utilized to test for insulation breakdown of the protective devices. Should a device fail under voltage stress, or be predicted to fail by its published operating characteristics, an attempt will be made on similar devices to determine the maximum safe voltage limits for the device class. Similarly, the current shunting capability of the protective devices will be examined, and limitations observed during testing will be reported.

Each protective device will be subjected to ten equal pulses, in order to ensure that protection is not circumvented by the first threat transient received. A cooling time of approximately one second will be allowed between pulses. Devices which are designed to provide protection for only one pulse will be listed as limited qualifiers for this program, as it is conceivable that singular replacement of inexpensive devices might provide a cost-effective means of obtaining protection.

Device Selection

For this test, selection of devices was governed by the applicability of their use in protection of the "typical" amateur radio configurations defined under this overall program. Appendix I contains a detailed listing of devices and the Test Class to which they have been assigned. In some cases, a particular device may have multiple applications in the protection scheme which require it to survive more than one class of threat peaks. Qualification results against each test class will be reported separately for those devices.

Required Measurements

Direct Testing:

A direct device test consists of driving its terminals with a differential mode signal from a pulse generator. The direct test is conducted once with source impedance appropriate to the tabulated voltages and currents listed previously, and once with the tabulated voltage and a source impedance of fifty ohms. Fifty ohms was chosen because it is most commonly encountered in house wiring and antenna connections. The input and output pulse magnitudes will be recorded by photograph on a suitable scale vs time to allow direct comparison and determination of rejection ratio for both test situations. Markers will be inserted into each photograph to fix the point of "zero" time, and to calibrate voltage magnitudes.

For each protective device, the number of identical devices listed in Appendix I will be tested. This number will vary from one to fifteen depending on the device and on test results. Values of the rejection ratio (and spike duration, if any) will be statistically compared in real test time to evaluate the mean and standard deviation of those data for each device. When as many as ten identical devices have been subjected to both forward

Required Measurements (continued)

and reverse tests and the statistical parameters are converging to a useful value, no further testing of the device against that particular threat will be required. Conversely, when results do not indicate a convergent mean and/or standard deviation, more devices will be tested (if available within the cost restraints of the program) in order to better define the characteristics of the device.

When a device under test fails to maintain a rejection ratio within five decibels of its original value against the second thru tenth pulses, an identical device will be repeat tested under a series of reduced stress levels (25%, 50%, and 75%) in an attempt to find any value under which satisfactory protection under repeated stress is probable. The test results for that device would then indicate a limitation on use of the device for this program.

Reverse Polarity Testing:

After completion of the direct testing described above, the entire test series will be repeated with opposite polarity of the pulser to the device terminals. The recorded data for the reverse polarity tests will be photographed separately from the direct test results.

Tests to Failure:

For those devices listed in Appendix I as requiring "Test to Failure," after completion of both series of tests described above, the voltage output of the pulser (with a low source impedance) will be increased (direct polarity followed immediately by reversed polarity) until device failure occurs, or the operating limitation of the pulser is reached. Manufacturer's operating data will be compared with measured operating parameters where necessary to define failure. The lowest voltage value for which failure occured under either polarity will characterize the failure voltage for this program. Response to Test-To-Failure pulses will be indicated in the test results as "T" level tests.

Data Organization

Device Identification:

Test data will be identified with the Device Identification Number as listed in Appendix I. Data obtained with reversed polarity pulses will show an "R" after the Device Identification Number. The first suffix , separated by a "-", will indicate the letter code of the Test Class followed immediately by an "L" for the low (tabulated current) impedance or an "H" for the 50 ohm impedance test. Data for repeated pulses of the same device will carry an additional suffix "-n" where "n" is the sequence number of the pulse (1-10). Data for repeat tests of an identical replacement device will also carry a suffix "-L" where "L" is the letter designator of the replacement. For example:

Test Data Set 24R-AH-3-B

indicates a reversed polarity test of device 24, with "A" class

Data Organization (continued)

pulses from a 50 ohm source, this set being the third repetition of the pulse against the second identical device tested.

Test Waveforms:

Test Data for each pulse will be recorded on a suitable time scale to adequately indicate the initial firing of the threat transient, the firing of the device under test, and the settling level of the device. Both the input (threat) and output (reduced threat) magnitudes will be normally be recorded on the same photograph, which may also be utilized for the nine repeat pulses to provide more efficient recording of data.

Failure Levels:

Test pulses which result in device failure instead of expected protection will be identified with the device nomenclature as described above plus the peak magnitude of the pulse which resulted in failure. Note the required use of the suffix "R" to indicate failure under reversed polarity.

REPORTING REQUIREMENTS

Device Results:

Data photographs for each protective device will be consolidated as raw data for the report of test results. Additional graphics will be prepared where they may depict meaningful device characteristics. All data will be reviewed and utilized in the development of a narrative characterization of each device which specifically addresses its suitability for the purpose of transient protection in this program. Any limitations on use resulting from the tests, as well as cost and availability, will be included in the characterization.

Test Methods:

The generic methods and procedures utilized during the protective device tests are summarized as Appendix II. A discussion of error sources and their effect on test results is included.

Final Report:

A final report of test activity will be prepared to contain a summary of methods and generalized results. In addition, specific recommendations, based on test results, will be provided to guide utilization of tested devices in the remaining activity of this program.

TEST PROGRAM COORDINATION

Laboratory Responsibility:

Lab scientists of IRT Corporation will have sole responsibility for operation of the transient pulse sources and data recorders in a manner which provides maximum safety for personnel and government property not under test, including previously recorded test data.

Test Program Coordination (continued)

Program Engineer(s):

Program engineers representing Electrospace Systems, Incorporated will assist the Lab Scientists in conducting the test program, including management of protective device inventory and preparation of devices for test connection. These personnel are responsible for selection of devices for test, and review of results to determine additional tests required, with appropriate guidance from IRT scientists. Program engineers shall arrange for custody and transportation of test materials owned by the government , ESI or its other contractors, and for obtaining and safeguarding unclassified test data from IRT scientists. No classified information will be utilized or generated by this program.

Attachment

A TEST CONCEPT
FOR
TRANSIENT PROTECTIVE DEVICES
SUITABLE FOR FAST-RISING PULSES

December 3, 1984

Contents

OVERVIEW

There are now abundant supplies of devices, available to both the public and specialized electronic market, which are claimed by their manufacturers to provide complete transient protection for electrical equipment. However, there is no common test procedure for determining "success" in transient pulse protection that can be generally applied to all devices. A concept for qualification testing of protective devices is described here which offers a rational approach to certifying the average performance of a particular group of devices against such fast-rising (nanoseconds) and powerful (kilovolts) transient pulses as might be generated by lightning or electromagnetic pulse (EMP). Those devices found to be "qualified" may then be used with confidence in transient protection applications such as the amateur radio configurations to be developed under this program.

BACKGROUND

As mechanical devices and vacuum tubes are phased out of common radio and communications equipment, a realization has developed that the solid state devices now in use are becoming more and more vulnerable to transient electrical signals. Hence, a new market for transient protection has arisen, causing manufacturers to increase development and production of such devices.

Some limited government research into transient protective devices against EMP has been accomplished during the past fifteen years, but the results are not generally available to the public, and generally not compiled into any useful data base.

If a standard test method and reporting system for transient protective devices were available, individual private radio amateurs could make rational decisions concerning the purchase of such devices. Without such information, devices are not likely to be installed, or, if installed, the sole criterion for the purchase decision might be initial cost.

CONCEPT

The following paragraphs describe features of a protective device qualification program which depends on the careful testing of a significant sample of protective devices against a recognized transient threat pulse, with results stated precisely in terms of pre-determined critera for success.

The success critera will include ability to reject a sufficient percentage of threat magnitude, determined in accordance with the desired application, to allow use of the device as part of a transient protection scheme. This capability will be characterized by a rejection ratio, measured in decibels, defined as:

$$\approx 20 \log_{10} \frac{\text{Peak Signal In}}{\text{Peak Signal Out}} .$$

The rejection ratio will be certified by comparison of an input and output waveform suitably scaled to allow direct overlay of the waveforms. Other critera will include the ability of the device to withstand at least a minimum number of threat stresses without failure (degradation of the rejection ratio below a specified error margin), a measure of variance between tested devices, and an absolute magnitude of voltage and current which cause actual failure of the device to support its intended use.

FEATURES

Selection of Devices

There exist three commonly used approaches to the general problem of transient protection. The undesired transient signal may be diverted to a more harmless path (diversion), reflected back toward its source (reflection), or absorbed in a lossy medium (absorbtion). Among the most popular gadgets purchased by the public for protection of computers and radio gear are such diversion devices as spark gaps, silicon transient voltage suppressors, and metal oxide varistors. The more serious radio operator may be familiar with such reflection devices as filters, or combination diversion-reflection devices commonly called hybrid transient suppressors. Conventional protection devices such as circuit breakers, fuses, or relays are generally considered too slow to interrupt fast lightning or EMP, and will not be tested here.

Screening of protective devices available over the counter should result in a test list of the most inexpensive units considered representative of each type. Where economically feasible, enough units of each type will be tested to define a significant statistical sample. Experience in prior test programs indicates that about 15 units of each device should provide such a sample. Appendix I lists examples of such devices in common use.

Features (continued)

Threat Definition

Other than the case of a direct lightning stroke, EMP is generally considered a more stringent threat to electrical systems than lightning. Consequently, the qualification test pulse must rise to full strength in fewer than 10 nanoseconds and decay exponentially in about one microsecond. For currents, peaks in excess of thousands of amperes have been predicted as response to EMP. Similiarly, voltages may reach hundreds of kilovolts. In some cases, the required operating parameter for a protective device is the slope of the voltage (or current) wavefront with respect to time.

The protective devices must also be tested more than once, in order to ensure that protection is not circumvented by the first threat transient received.

Facility Requirements

The selection of facilities and test equipment for the qualification testing is one of two key factors governing success or failure of this program. The test lab must be large enough to provide a stable environment for device tests, even if similar devices are tested weeks apart. The transient source must be calibrated and demonstrated to perform according to its calibration at frequent intervals during testing. Specialized equipment will be required to connect the source to the devices under test without introducing spurious signals or lengthening the rise times of the pulses, and to record the input and output waveforms across each device tested. An efficient system of controlling test data and documenting results must be provided by the test facility. Use of one of the appropriate government labs for this effort is possible, if potential problems of cost, availability, scheduling, and over-classification of data can be overcome.

Features (continued)

Personnel Requirements

The other key factor governing the success of this program is ensuring that testing is conducted under the direct control and guidance of personnel who have documented, specific experience in EMP pulse test programs. Failure to provide EMP-test qualified personnel is certain to generate test results that will not be considered adequate by the Defense scientific community, most likely with good reason, for few technicians in industry or government routinely deal with the myriad problems caused by testing almost to failure with high powered, fast rising transients. Sophisticated pulsers and test probes requiring calibration of both time and amplitude, with limited distortion-free ranges of operation, create many opportunities for inexperienced personnel to unknowingly record invalid data.

From a program standpoint, effective use of a hired laboratory (be it government or commercial) will require the continuous assistance of at least one knowledgeable member of the program team, who can interpret results and make any required changes in device selection as the test progresses.

Reporting of Results

A general plan for organizing data records must be included in the overall test plan for this program. As a minimum, it will be necessary to determine the average transient attenuation of the threat pulse for each group of like protective devices, and the amplitude evel where failure of the device occurs. Organizing the devices will allow any correlations between standard operating parameters and test results to be easily observed. A modern lab is expected to obtain directly digitized tabulations of the input and output waveform for comparison with limits of the protection design.

Program Coordination

From the partial listing of transient protection devices available (see Appendix I), the protection design engineer should indicate those of least cost that are expected to perform the protective function as desired. If they can be obtained, the less costly devices should be of prime importance for testing, because one of the goals of the program is minimal cost to the radio operator who installs the protection. As discussed under "Personnel Requirements", final day-to-day selection of devices for test is dependent upon results to date and the availability of substitutes for tested devices which did not "qualify". Depending on the availability of test time, it would be desirable to qualify as many devices as possible to expand the availability of parts for the "Protection Kits" which will be developed under this contract.

Appendix I

TYPE	MANUFACTUREF	TRADE NAME	MODELS
SG	C P CLARE AND CO	COMM GAP	21
SG	FISCHER CUSTOM COMM	GAS-CAP DIODE	
SG	JOSLYN ELECTRONICS SYS	MSP	16
SG	JOSLYN ELECTRONICS SYS	TRIGARD	7
SG	JOSLYN ELECTRONICS SYS	SURGITRON	26
SG	SIEMENS	BUTTON TYPE SVP	13
SG	SIEMENS	POWER TYPE SVP	5
SG	SIEMENS	COMMUNICATIONS TYPE SVP	11
SG	TII INDUSTRIES INC	SURGE ARRESTOR TUBES	13
MOV	GENERAL ELECTRIC CO	SURGE ARRESTOR	
MOV	INTERNATIONAL RECTIFIER	ZENAMIC MOV TRANS SUPPR	95
TVS	GENERAL ELECTRIC CO	HOME LIGHTNING PROTECTOR	
TVS	GENERAL SEMICNDCTOR IND	TRANSZORB	18
TVS	GENERAL SEMICNDCTOR IND	ZORB ELECTROSTAT DISCHARGE	9
TVS		TRANSI-TRAP	
TVS	TRW CAPACITORS	TRANSIENT VOLTAGE PROTECT	157
HTP	CONTROL CONCEPTS CORP	ISLATROL	35
HTP	CONTROL CONCEPTS CORP	ISLATROL BI-DIRECTIONAL	9
HTP	FISCHER CUSTOM COMM	SPIKEGUARD	12
HTP	JOSLYN ELECTRONIC SYS	PROTECTORS	8
HTP	KAPUSI LABORATORIES	INTERGUARD	3
HTP	KAPUSI LABORATORIES	LINE SURGE ABSORBER	4
HTP	KAPUSI LABURATORIES	POWER GUARD	2
HTP	KONIC INTERNATIONAL	TRANSTECTORS	40
HTP	MCG ELECTRONICS INC	EQPT & BRANCH PROTECTORS	13
HTP	MCG ELECTRONICS	SIGNAL LINE PROTECTOR	3
HTP	MCG ELECTRONICS. INC	WALL OUTLET PROTECTOR	4
HTP	TII INDUSTRIES INC	OVER-VOLTAGE SURGE PROT	9
HTP	TII INDUSTRIES INC	POWERLINE SURGE PROTECTOR	7
FIL	RFI CORPORATION	SUBMINATURE FILTERS	34
FIL	ERIE TECH PRODUCTS	EMI FILTERS	42
FIL	SPRAGUE ELECTRIC CO	RADIO INTERFERENCE FILTERS	225

SG = SPARK GAP, HTP = HYBRID, MOV = METAL OXIDE VARISTOR, TVS = TRANSIENT VOLTAGE SUPPRESSOR, FIL = FILTERS

Appendix II

Direct Injection Equipment

The following equipment is typical of that required to inject a standard EMP waveform into a selected test device. Choice of the equipment actually used depends on the levels of voltage or current desired, and the method of signal driving:

Coaxial charge line pulse generator
(nanosecond rise, 500 volts into 50 ohms)

High power pulse generator
(10 nanosecond rise, up to 100 microsecond length, 500 volts into 50 ohms)

Optically triggered pulse generator
(nanosecond rise, 3 amps into 50 ohms)

High power Marx generator
(400 kilovolt, 40 kiloamp into short circuit)

Capacitive discharge pulse generator
(40 kilovolt)

Damped sinusoid generator
(variable ring/frequency, 0.5 kw into 50 ohms)

Controllable capacitive discharge pulse generator
(20 kv-100 kv, 10 nanosecond risetime)

Response Measuring Devices

High impedance voltage probes
(calibrated, shielded against spurious signals)

Differential voltage probes
(calibrated, adjustable reference point)

Calibrated impedance matching transformers
(with adjustable attenuation)

Current probes of various AC ranges
(calibrated, with adjustable attenuation)

Shielded data links from probes to recorders
(calibrated amplifiers and attenuators)

Digitizing Oscilloscopes
(calibrated, with internal and external triggers, with reference time marks)

Section 2

LIST OF DEVICES

ITEM	MANUFACTURER	PART	DESCRIPTION
1	FISCHER	FCC-120F-P	SPIKEGUARD SUPPRESSOR - AC POWERLINE PROTECTOR
2	FISCHER	FCC-250-300-UHF	SPIKEGUARD SUPPRESSOR COAXIAL LINE
3	FISCHER	FCC-250-350-UHF	SPIKEGUARD SUPPRESSOR COAXIAL LINE
4	FISCHER	FCC-250-75-BNC	SPIKEGUARD SUPPRESSOR COAXIAL LINE
5	FISCHER	FCC-250-150-UHF	SPIKEGUARD SUPPRESSOR COAXIAL LINE
6	FISCHER	FCC-250-120-UHF	SPIKEGUARD SUPPRESSOR COAXIAL LINE
7	FISCHER	FCC-450-120-UHF	SPIKEGUARD SUPPRESSOR COAXIAL LINE
8	JOSLYN	2027-23-B	MINIATURE GAS-TUBE SURGE PROTECTOR (MSP)
9	JOSLYN	2027-35-B	MINIATURE GAS-TUBE SURGE PROTECTOR (MSP)
10	JOSLYN	1270-02	SURGITRON - PLUG-IN AC SURGE ARRESTOR
11	JOSLYN	1250-32	SURGITRON - SURGE ARRESTOR
12	JOSLYN	1664-08	TRANSIENT PROTECTOR FOR DATA INPUT CIRCUIT
13	JOSLYN	2027-09-B	MINIATURE GAS-TUBE SURGE PROTECTOR (MSP)
14	JOSLYN	2027-15-B	MINIATURE GAS-TUBE SURGE PROTECTOR (MSP)
15	JOSLYN	2022-44	TRIGUARD THREE-ELECTRODE GAS-TUBE SURGE PROTECTOR
16	JOSLYN	2031-23-B	MINIATURE GAS-TUBE SURGE PROTECTOR (MSP)
17	JOSLYN	2031-35-B	MINIATURE GAS-TUBE SURGE PROTECTOR (MSP)
18	GENERAL ELECTRIC	V39ZA6	METAL OXIDE VARISTOR (GE-MOV)
19	GENERAL ELECTRIC	V82ZA12	METAL OXIDE VARISTOR (GE-MOV)
20	GENERAL ELECTRIC	V180ZA10	METAL OXIDE VARISTOR (GE-MOV)
21	GENERAL ELECTRIC	V8ZA2	METAL OXIDE VARISTOR (GE-MOV)
22	GENERAL ELECTRIC	V36ZA80	METAL OXIDE VARISTOR (GE-MOV)
23	POLYPHASER CORP	IS-NEMP	COAXIAL LINE PROTECTOR
24	POLYPHASER CORP	IS-NEMP-1	COAXIAL LINE PROTECTOR
25	POLYPHASER CORP	IS-NEMP-2	COAXIAL LINE PROTECTOR
26	TII	T11428	PLUG-IN POWERLINE PROTECTOR
27	SIEMENS	S10K11	METAL OXIDE VARISTOR (SIOV)
28	SIEMENS	S20K25	METAL OXIDE VARISTOR (SIOV)
29	SIEMENS	S14K50	METAL OXIDE VARISTOR (SIOV)
30	SIEMENS	S10K60	METAL OXIDE VARISTOR (SIOV)
31	SIEMENS	S14K130	METAL OXIDE VARISTOR (SIOV)

LIST OF DEVICES (Contd)

ITEM	MANUFACTURER	PART	DESCRIPTION
32	SIEMENS	B1-C75	BUTTON TYPE SURGE VOLTAGE PROTECTOR
33	SIEMENS	B1-C90/20	BUTTON TYPE SURGE VOLTAGE PROTECTOR
34	SIEMENS	B1-C145	BUTTON TYPE SURGE VOLTAGE PROTECTOR (AC)
35	SIEMENS	B1-A230	BUTTON TYPE SURGE VOLTAGE PROTECTOR
36	SIEMENS	B1-A350	BUTTON TYPE SURGE VOLTAGE PROTECTOR
37	SIEMENS	S8-C150	POWER TYPE SURGE VOLTAGE PROTECTOR
38	SIEMENS	T61-C350	COMMUNICATIONS TYPE SURGE VOLTAGE PROTECTOR
39	ALPHA DELTA	TRANSI TRAP LT	COAXIAL LINE SURGE PROTECTOR
40	ALPHA DELTA	TRANSI TRAP R-T	COAXIAL LINE SURGE PROTECTOR
41	GENERAL SEMICONDUCTOR	587B051	120 VAC LINE PROTECTOR TRANSORB
42	GENERAL SEMICONDUCTOR	ICTE-5	TRANSZORB
43	GENERAL SEMICONDUCTOR	ICTE-15	TRANSZORB
44	GENERAL SEMICONDUCTOR	ICTE-8C	TRANSZORB
45	GENERAL SEMICONDUCTOR	LCE6.5A	TRANSZORB
46	GENERAL SEMICONDUCTOR	LCE15A	TRANSZORB
47	GENERAL SEMICONDUCTOR	LCE51	TRANSZORB
48	GENERAL SEMICONDUCTOR	LCE130A	TRANSZORB
49	GENERAL SEMICONDUCTOR	PHP 120	TRANSZORB BIDIRECTIONAL AC POWER PROTECTOR
50	GENERAL SEMICONDUCTOR	GHV-12	BIDIRECTIONAL SURGE PROTECTOR
51	GENERAL SEMICONDUCTOR	GSV101	BIDIRECTIONAL VARISTOR
52	GENERAL SEMICONDUCTOR	GSV201	BIDIRECTIONAL VARISTOR
53	ELECTRONIC PROTECTION DEVICES	LEMON	AC SURGE PROTECTOR
54	ELECTRONIC PROTECTION DEVICES	PEACH	AC SURGE PROTECTOR
55	S. L. WABER	LG-10	AC POWERLINE PROTECTOR
56	ARCHER	61-2785	3 OUTLET VOLTAGE SPIKE PROTECTOR

Section 3

MANUFACTURERS

1. Alpha Delta Communications
   P.O. Box 571
   Centerville, Ohio 45459
   (513) 435-4772

2. Electronic Protection Devices, Inc.
   P.O. Box 673
   Waltham, Massachusetts 02254
   (617) 890-2518
   1-800-343-1813

3. Fischer Custom Communications, Inc.
   P.O. Box 581
   Manhattan Beach, California 90266
   (213) 642-0049

4. General Electric
   MD38. Building 7, Electronics Park
   Syracuse, New York 13221
   (315) 253-7321
   (315) 456-3515

5. General Semiconductor Industries, Inc.
   2001 West Tenth Place
   Tempe, Arizona 85281
   (602) 968-3101

6. Joslyn Electronic Systems Division
   P.O. Box 817
   Santa Barbara Research Park
   6868 Cortona Drive
   Goleta, California 93116
   (805) 968-3551

7. Polyphaser Corporation
   1425 Industrial Way
   Gardnerville, Nevada 89410-1237
   (702) 782-2511

8. Siemens Corporation
   186 Wood Avenue South
   Iselin, New Jersey 08830
   (201) 321-3400

MANUFACTURERS

9. S. L. Waber Division
   S. L. Industries, Inc.
   300 Harvard Avenue
   Westville, New Jersey 08093
   (609) 456-5400
   (800) 257-8384

10. TII Industries, Inc.
    1375 Akron Street
    Copiague, New York 11726
    (516) 789-5020

SECTION 4

Description of Devices

SPIKEGUARD SUPPRESSORS

NANOSECOND TRANSIENT PROTECTION

MODELS AVAILABLE FOR

- COAXIAL LINES
- TELEPHONE CIRCUITS
- I/O SEMICONDUCTOR CIRCUITS

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SPIKEGUARD PROTECTOR CHARACTERISTICS

MODEL FCC-120F-P

The FCC-120F-P is designed to protect 120 VRMS 60-400 Hz single phase powerlines. The protector is designed with metal oxide type components.

It is capable of sustaining 4000 peak amperes for a transient having a duration of 20 microseconds, and 400 peak amperes for 400 microseconds. It is also capble of dissipating 25 watts of average power, and 30 joules of energy.

The unit will clamp line to ground transients to 400-600 peak volts depending upon the exact risetime gradient of the transients, the impedance of the circuits, and the length of leads from protector to ground. The maximum clamping voltage will be for those transients approximating a gradient of one megavolt per microsecond, with total clamping occurring in a few nanoseconds for very fast transients.

The above clamping characteristics will be maintained when tested to the requirements of the Surge Withstand Capability specified by ANSI C37.90a

Physically, the FCC-120F-P is 2.5" X 3.5" X 2.0" in shape. It has solid ground straps which can be used to mount the unit, and at the same time provides a low impedance path to the mounting cabinet or ground plane. A terminal is mounted on the surface opposite the grounding tabs in order to make the electrical connection to the 120 VRMS powerline. In order to provide optimum clamping of transients, the lead to this terminal should be trimmed as short as possible to minimize its inductance.

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SPIKEGUARD SPECIFICATIONS
LIGHTNING AND TRANSIENT PROTECTION

Characteristics:

Spikeguards provide protection from transients originating from switching, lightning, and EMP. Spikeguards have been designed to provide protection for sensitive electronic circuitry as well as for transmitters and receivers at their antenna transmission line terminals.

They exhibit fast response through the UHF region, and are constructed from proven transmission line, gaseous discharge components, silicon components, and can be subjected to many repeated transients.

Spikeguards have been organized into various types that will optimize those protective characteristics required.

The FCC-250 series (the part numbering system will be described later) are rated at 10,000 amperes for a duration of 10 microseconds. This series is available in a number of dc breakdown voltages varying from 75 volts to 2000 volts. For dc voltages up to 2000 volts this series has a pulse (overshoot) breakdown varying from 1000 to 3000 volts for a pulse rise time of 1 megavolt/microsecond. The impedance of this series is approximately equivalent to 2.5 picofarads in shunt with the transmission line load.

Typical VSWR characteristics of this series for type N, UHF, and C coaxial connectors are as follows:

100 MHz	1.2:1
200 MHz	1.4:1
300 MHz	1.6:1
400 MHz	1.8:1

The 1.8:1 VSWR will create less than 5 per cent of the incident power being reflected back to the transmitter.

In the event that the total tolerable VSWR is specified for the entire coax-to-antenna system, a determination can be made if the addition of a Spikeguard will exceed the limit. It is merely necessary to specify the VSWR and impedance of the system without the Spikeguard, and the above analysis can be carried out.

The FCC-350 series is rated at 3000 peak amperes for a 15 microsecond pulse halfwidth for breakdown voltage ratings from 550 to 4000 volts. This series is available in various breakdown voltages varying from 550 to 30,000 volts.

The 350 series is extremely fast in reacting to transient voltages. The overshoot to the dc specified trip voltages for transients having a pulse rate of rise of 1 megavolt/microsecond is minimal, since the trip voltage is achieved in 1 to 2 nanoseconds. The impedance of this series is approximately equivalent to 2 picofarads in shunt with the transmission line load.

Typical VSWR characteristics of the 350 series, for type N, UHF, C, and HN coaxial connectors are as follows:

Frequency (MHz)	VSWR			
	N	UHF	C	HN
50	1.1:1	1.1:1	1.05:1	1.1:1
100	1.2:1	1.3:1	1.1:1	1.12:1
200	1.3:1	1.5:1	1.4:1	1.2:1
300	1.6:1	1.7:1	1.7:1	1.45:1
400	2.4:1	2.3:1	2.2:1	2.0:1

An improved 250 and 350 series has been developed, now designated the 250A and 350A series. These units have improved VSWR characteristics with all electrical and mechanical characteristics remaining the same as previously stated for the 250 and 350 series.

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The 250A series for the type N and UHF connectors have nominal VSWR values as follows:

Frequency (MHz)	VSWR
50	1.1:1
200	1.2:1
300	1.35:1
400	1.5:1

The 350A series for type N, UHF, C, and HN connectors have nominal VSWR values as follows:

Frequency (MHz)	VSWR			
	N	UHF	C	HN
50	1.05:1	1.05:1	1.05:1	1.1:1
100	1.1:1	1.1:1	1.1:1	1.1:1
200	1.2:1	1.3:1	1.35:1	1.2:1
300	1.6:1	1.7:1	1.6:1	1.4:1
400	2.0:1	2.1:1	2.0:1	1.8:1

The insertion loss of all the previously mentioned types is approximately 0.5 db up to 450 MHz.

The FCC 450 series Spikeguards have been designed to provide transient protection for receivers and transmitters up to 100 watts of output power. They have also been designed to provide transient protection for sensitive semiconductor components and integrated circuits.

The 450 series are constructed from proven silicon components, that are in turn encased in epoxy.

They can be provided with clamping voltages varying from 6 to 200 volts. The 6 to 20 volt units are capable of sustaining 70 amperes of peak current for a triangular pulse having a 4 microsecond pulse width. From 20 volts and up the units have a decreasing current capability, with the 200 volt unit capable of sustaining 5 amperes of peak current for 15 microseconds.

The dc impedance in the nonconducting mode is equal to or greater than 5 megohms.

The clamping voltages are achieved in approximately 1 nanosecond for transients having a risetime gradient of 1 megavolt/microsecond. Of particular importance is the fact that these units exhibit a capacitance of approximately 2 picofarads.

Since these units operate extremely fast and have such low capacitance, they will provide transient protection for sensitive semiconductor components, particularly, integrated circuits, such as TTL, ECL, DTL, MOS, and MSI. Due to the fact that they have low capacitance these units can protect not only power supplies, but input and output data lines, without degrading the data transmission operating characteristics, by excessive capacitive loading.

Typical dimensions of these units are 0.75" long by 0.5" wide by 0.5" high.

The FCC 450 series are also packaged in coaxial connectors to protect receivers and transmitters from transients. They exhibit fast response through the UHF region by clamping in approximately 1 nanosecond when subjected to transients exhibiting risetime gradients of the order of 1 megavolt/microsecond. These units also have a distributed capacitance of approximately 2 picofarads.

For example, the FCC-450-10-(connector type) is used to protect receivers and clamps fast transients at 10 volts peak.

Typical VSWR characteristics for type N, C, and UHF coaxial connector versions of the FCC-450-( )-( ) are as follows:

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Frequency (MHz)	VSWR
50	1.1:1
100	1.3:1
200	1.4:1
300	1.5:1
400	2.0:1
500	2.5:1

The 450 series when clamping a transient will not permit the energy levels to exceed the microjoule level even for transients lasting 20 microseconds. The VSWR values permit normal receiver operation with little or no degradation in performance to frequencies of 500 MHz.

The 450 series that clamp up to 200 volts are capable of protecting transmitters up to 100 watts.

It must be cautioned that, since the 450 series can only sustain a limited transient pulse, they should be used in combination with a 250 series. The 450 series must be placed as close to the transmitter or receiver as possible, and the 250 series must be placed as close to the antenna as possible. The 250 series will intercept the transient first and will limit the overall energy to the low millijoule level thus not permitting the transient energy to exceed the safe level of the 450 series.

In order to obtain optimum transient protection the two units must be separated via the coaxial cable by at least 50 feet for a slow transient having a risetime gradient of 20 kilovolts/microsecond; and by 3 feet for a fast transient having a risetime gradient of 1 megavolt/microsecond.

The above hybrid combination provides optimum protection of both transmitters and receivers.

Even though the 250 series will have some overshoot, those units used for transmitters up to 100 watts will still clamp at 1800 volts or lower, for a transient having a risetime gradient of 1 megavolt/microsecond, and 1000 volts or lower for a transient having a risetime gradient of 20 kilovolts/microsecond.

In most instances these overshoot voltages will not cause failure of an antenna or transmission line since they will only last for 2 nanoseconds for the 1 megavolt/microsecond risetime gradient, and 50 nanoseconds for the 20 kilovolt/microsecond gradient.

The energy levels finally permitted to arrive at a transmitter or receiver during a transient will be well within the safe levels of 450 series normal operation.

As transmitter power output levels approach 10 kilowatts the 250 series performance nearly equals that of the 350 series. The Spikeguard clamp voltage for a 10 kilowatt transmitter would ideally be about 2000 volts in order to prevent inadvertent firing of the Spikeguard due to transmitter power and antenna VSWR. A 2000 volt rated 250 series will only overshoot to 3000 volts before clamping a 1 megavolt/microsecond gradient transient. This overshoot will only exist for a period of about 1 nanosecond. Even for a 100 watt transmittor the condition isn't much more severe. A 100 watt transmitter will be rated to clamp at 230 volts. A 1 megavolt/microsecond gradient transient will cause an overshoot voltage of about 1500 volts. This will only permit the overshoot to exist for a period of approximately 2 nanoseconds. The energy permitted to exist during either of the above two examples would not exceed 200 microjoules, which is insufficient to damage 100 to 500 watt transmitters.

Therefore, transmitter protection is recommended as follows. For transmitters up to 100 watts output, a hybrid combination of a 250 series placed at or near the antenna, and a 450 series at the transmitter is recommended. For transmitters of 100 watts to 10 kilowatts, a 250 series unit placed near the antenna is recommended. A 350 series is recommended for all transmitters exceeding 10 kilowatts.

In the event that the 250 series overshoot for 100 to 10 kilowatt transmitters cannot be tolerated, the 350 series will remove that condition.

The 250, 350 and 450 series protectors have also been configured for protection of telephone, and computer data lines. Protection is offered for 1 to 150 pairs of data lines. Installation is convenient and economical through the use of a Quick-Connect Terminal Block providing junction points to the protectors that shunt the lines to ground.

The Quick Connect Terminals, strip, connect, and trim wire in one operation. The terminals are designed to make a positive connection to unskinned 20-24 gauge conductors, or 18 and 19 gauge skinned wire, and accomplish this through a spring tensioned terminal clip, and Quick-Connect tool combination.

The procedure for installation of a data line is to just hook the unstripped conductor to the top of the clip. Then using the Quick-Connect tool, push the wire down into the clip. This action automatically strips the insulation, forms an electrical connection, and cuts off excess wire. All of the above in one fast operation.

The overall data line protector comes with a 250, 350, or 450 type Spikeguard installed between each terminal strip and the ground strip. The ground strip runs the entire length of the block, and has convenient bolt holes to permit mounting and attachment to any earth connection available. The position of the ground strip permits very short leads, minimizing inductance in the installation.

The entire terminal block can also be supplied in a metal housing, if no convenient terminal box is already available.

All Spikeguards used for transmitter protection have a "Warning" decal specifying the maximum wattage rating that the transmitter should be operated at. This is to remind a transmitter operator not to accidentally run up the transmitter power output above its normal operating level. This would cause the transmitter output to be short circuited and create a high VSWR. This is a safety precaution since each Spikeguard will have a voltage rating that will allow operation of the transmitter at its designed power output, and also provide the desired protection from an incoming transient.

Fischer Custom Communications power line transient protectors are especially designed to achieve optimum suppression of high energy nanosecond risetime transients.

Two types of protectors are available.

The FCC-120-P Model plugs into the free electrical outlet next to the one your equipment receives its power. The FCC-120-P is a 120 VAC (60-400 Hz) power line rated device, which is capable of sustaining a transient peak current of 1000 amperes for 5 microseconds, and 100 peak amperes for 100 microseconds.

Transients varying from 400-100,000 peak volts will be clamped at 400 to 600 peak volts. This type of suppressor is constructed from a metal oxide semiconductor, which clamps transients having risetime gradients of the order of a megavolt/microsecond.

The FCC-120A-P is capable of withstanding 2000 peak amperes for 5 microseconds, and 200 peak amperes for 100 microseconds. All other characteristics are as previously stated.

The other type of power line protector not only enables optimum performance of the metal oxide component, but increased overall circuit protection by the addition of common mode chokes placed in series with the power line between the metal oxide components and the equipment being protected. This circuit configuration permits the metal oxide component to have a high common mode inductive impedance in series with the load, thus increasing its ability to clamp. Clamping under these conditions will occur with the transient delivering minimum current to the load being protected. Transients varying from 400-100,000 peak volts will be clamped at 300 to 500 peak volts.

Other advantages of this design are as follows:

1. The common core inductor toroidal windings will not suffer core saturation, and voltage drop when passing the high power line currents.

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2. The inherent capacitance of the metal oxide components, and the common mode chokes create an LC filter that will constantly provide protection from lower level transients and interference caused by common mode currents.

This model is designated the FCC-120-PC. It is capable of continuously carrying 15 amperes of either 60 or 400 Hz single phase power line currents. It is capable of sustaining 2000 peak amperes for 5 microseconds, and 200 peak amperes for 100 microseconds.

Installation is convenient, just plug the male receptacle of the suppressor into a single phase, third wire grounded, wall outlet. Then plug the equipment to be protected into a grounded socket provided in the suppressor.

Special units such as three phase circuits, greater transient current capability, or greater continuous current capability will be quoted on request.

Installation information is extremely convenient. All that is required for the coaxial types is the insertion of the T connector assembly at any convenient coaxial cable connector near either the antenna terminals, or near the transmitter and or receiver terminals.

The data line 450 series must have its terminals soldered across the terminals to be protected.

The Quick-Connect data line Spikeguard assembly comes with the suppressors already assembled. The only tasks for installation are the mounting of the block, wire connections, and routing of the leads.

Ordering information is straight forward with the part numbering system as follows, for the 250, 350, and 450 series:

Example: FCC-250-90-N

FCC	–	250	–	90	–	N
		↑		↑		↑
		50 ohms		Nominal Breakdown Voltage		Connector

Example: FCC-350-550-UHF

FCC	–	350	–	550	–	UHF
		↑		↑		↑
		50 ohms		Nominal Breakdown Voltage		Connector

No designation of a coaxial connector for the 450 series will identify a series mounted directly to a circuit via soldered terminals, such as follows:

Example: FCC-450-10

FCC	–	450	–	10
				↑
				Nominal Breakdown Voltage

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The Quick-Connect block part numbering is as follows:

Example: FCC-250-75-25-S

FCC	–	250	–	75	–	25	–	S
		↑		↑		↑		↑
		Series		75 Volts		25 Pairs		Shielded

Example: FCC-450-10-6-(Blank)

FCC	–	450	–	10	–	6	–	(Blank)
		↑		↑		↑		↑
		Series		10 Volts		6 Pairs		Unshielded

Any type of coaxial connector can be specified to fit specific requirements. Since a coaxial Spikeguard is in shunt with the load, it is only necessary that the T connector carry the desired power of the transmitter; and the clamping circuit provide the breakdown voltage desired. The part numbering system is readily adaptable to specifying other connectors along with the desired impedance and clamping voltage, thus assuring the transmitter and/or receiver of protection during normal operation.

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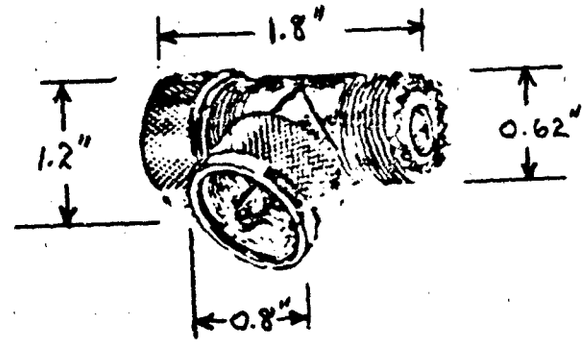
Spikeguard Shapes

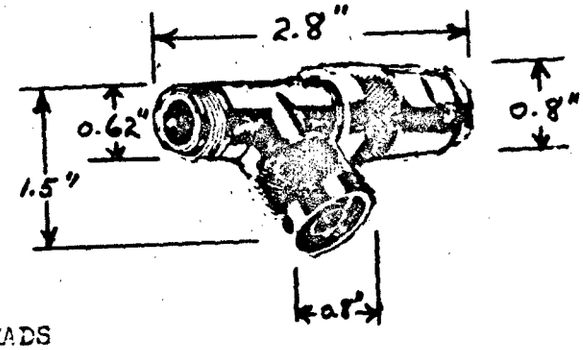
UHF COAXIAL CONNECTOR

SAME DIMENSIONS FOR THE FOLLOWING MODELS:
250, 250A, 350, 350A, 450

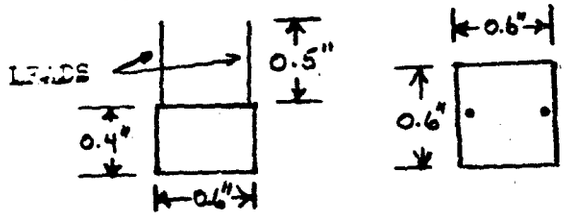


TYPE N COAXIAL CONNECTOR

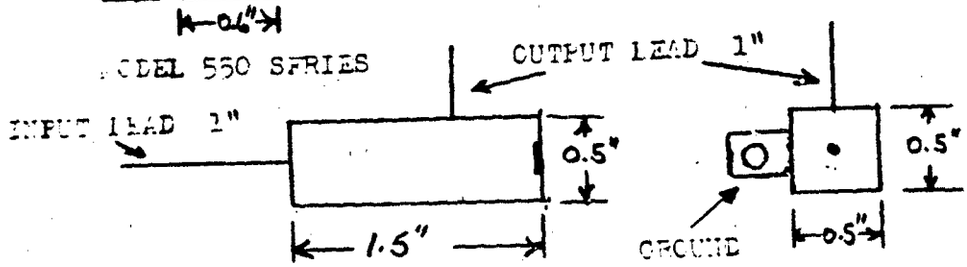
SAME DIMENSIONS FOR THE FOLLOWING MODELS:
250, 250A, 350, 350A, 450

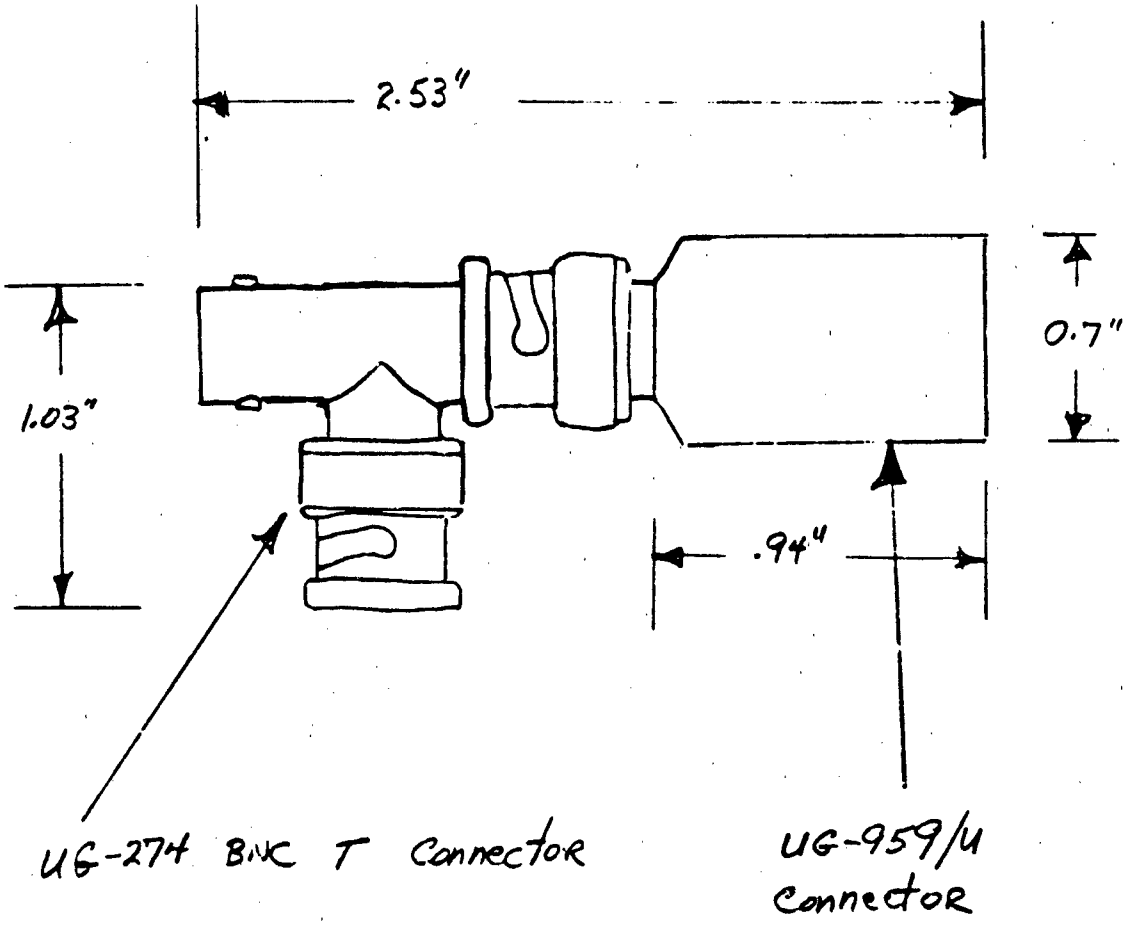


MODEL 450 SERIES WITH WIRE LEADS



MODEL 550 SERIES





FCC-250-( ) - BNC

FCC-450-( ) - BNC

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Post Box 581, Manhattan Beach, California 90266
213-545-4617

JOSLYN

TECHNICAL DATA

MSP®
Miniature Gas-tube Surge Protectors

2027 and 2029 Series

Joslyn MSP® gas-tube protectors are precision built surge and transient protection devices. Performance is repeatable over a long life period.

APPLICATION

The MSP® protects against overvoltages caused by switching surges, contact with foreign circuits, and lightning discharges, either induced or conducted. Fast response makes the MSP® particularly effective as protection against transients. It protects electronic circuits and associated components in telecommunication, computer, industrial control equipment, data logging, CRT displays, microwave, traffic control, and missile firing systems.

METHOD OF OPERATION

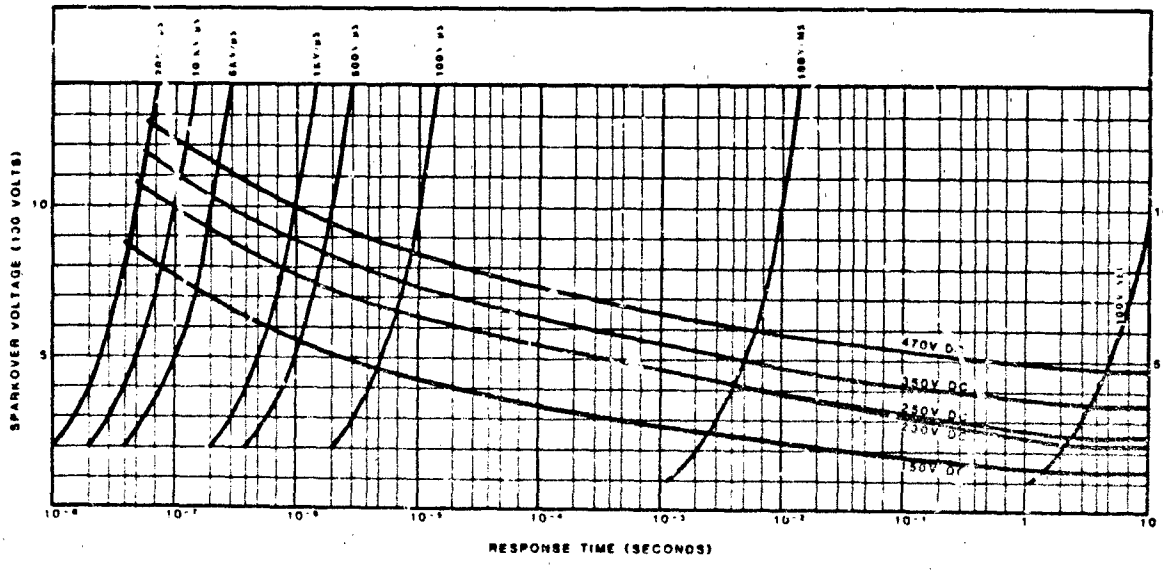
When a surge exceeds the breakdown voltage of the tube (surge sparkover voltage), the gap becomes intensively ionized, and conduction takes place within a fraction of a microsecond. The ionized protector becomes a short circuit and remains so until the voltage returns to normal. Ionization and deionization are extremely fast due to the type of gas fill and physical configuration used.

CONSTRUCTION

The gas tubes are assembled under clean room conditions. Inspection in accordance with stringent quality assurance procedures ensures total reliability.

The special alloy metal electrodes of the gas tube are hermetically sealed at high temperature to a high-alumina ceramic body. This provides leak-proof dependability. The high-alumnia ceramic is formulated for high insulation resistance and low dielectric loss. Symmetry of construction provides equal performance with either polarity of applied voltage.

JOSLYN MSP® SURGE SPARKOVER CHARACTERISTICS



JOSLYN MSP® TECHNICAL DATA

P/N	Leads	Dimensions (See Figure)	DC Sparkover Voltage Line-to-Ground (Volts)	Maximum Impulse Sparkover Voltage At 100V/μsec Rate of Rise (Volts)	Maximum Impulse Sparkover Voltage At 1kV/μsec Rate of Rise (Volts)	Insulation Resistance @ 50 Vdc (Ohms)	Insulation Resistance @ 100 Vdc (Ohms)	Surge Capability 8 x 20μsec Surge, 10 Operations (Amperes)	Surge Life 100 A 10 x 1000μsec Surge (Operations)	Surge Life 500 A 10 x 1000μsec Surge (Operations)	AC Discharge Current 50-60 Hz 10 Operations at 1 Second Duration at 3 Minute Intervals (Amperes rms)	Arc Voltage (Volts)	Glow Voltage (Volts)	Glow to Arc Transition Current (Amperes)	Capacitance (Picofarads)	Operating Temperature (Degrees C)
2027-09-A	No	A	90 ± 25%	≤400	≤800	10^9	—	10,000	>1000	>500	10	<20	<100	<0.5	<1.0	−55 to +250
2027-09-B	Yes	B	90 ± 25%	≤400	≤800	10^9	—	10,000	>1000	>500	10	<20	<100	<0.5	<2.0	−55 to +250
2027-15-A	No	A	150 ± 20%	≤400	≤650	10^9	—	10,000	>1000	>500	10	<20	<100	<0.5	<1.0	−55 to +250
2027-15-B	Yes	B	150 ± 20%	≤400	≤650	10^9	—	10,000	>1000	>500	10	<20	<100	<0.5	<2.0	−55 to +250
2027-23-A	No	A	230 ± 20%	≤600	≤850	—	10^9	5,000	>1000	>500	10	<20	<100	<0.5	<1.0	−55 to +250
2027-23-B	Yes	B	230 ± 20%	≤600	≤850	—	10^9	5,000	>1000	>500	10	<20	<100	<0.5	<2.0	−55 to +250
2027-25-A	No	A	250 ± 20%	≤600	≤850	—	10^9	5,000	>1000	>500	10	<20	<100	<0.5	<1.0	−55 to +250
2027-25-B	Yes	B	250 ± 20%	≤600	≤850	—	10^9	5,000	>1000	>500	10	<20	<100	<0.5	<2.0	−55 to +250
2027-35-A	No	A	350 ± 20%	≤750	≤900	—	10^9	5,000	>1000	>500	10	<20	<100	<0.5	<1.0	−55 to +250
2027-35-B	Yes	B	350 ± 20%	≤750	≤900	—	10^9	5,000	>1000	>500	10	<20	<100	<0.5	<2.0	−55 to +250
2029-23-A	No	A	230 ± 20%	≤700	≤900	—	10^9	20,000	>1000	>500	20	<20	<100	<1.0	<1.0	−55 to +250
2029-23-B	Yes	B	230 ± 20%	≤700	≤900	—	10^9	20,000	>1000	>500	20	<20	<100	<1.0	<2.0	−55 to +250
2029-25-A	No	A	250 ± 20%	≤700	≤900	—	10^9	20,000	>1000	>500	20	<20	<100	<1.0	<1.0	−55 to +250
2029-25-B	Yes	B	250 ± 20%	≤700	≤900	—	10^9	20,000	>1000	>500	20	<20	<100	<1.0	<2.0	−55 to +250
2029-35-A	No	A	350 ± 20%	≤700	≤900	—	10^9	20,000	>1000	>500	20	<20	<100	<1.0	<1.0	−55 to +250
2029-35-B	Yes	B	350 ± 20%	≤700	≤900	—	10^9	20,000	>1000	>500	20	<20	<100	<1.0	<2.0	−55 to +250
2029-47-A	No	A	470 ± 20%	≤900	≤1000	—	10^9	20,000	>1000	>500	20	<20	<100	<1.0	<1.0	−55 to +250
2029-47-B	Yes	B	470 ± 20%	≤900	≤1000	—	10^9	20,000	>1000	>500	20	<20	<100	<1.0	<2.0	−55 to +250

The 2027 Series Protectors are also available without radioactive prompting. Their characteristics differ only slightly from those with radioactive prompting. The nonradioactive devices are designated by a "Y" in the part number, example 2027-35-BY.

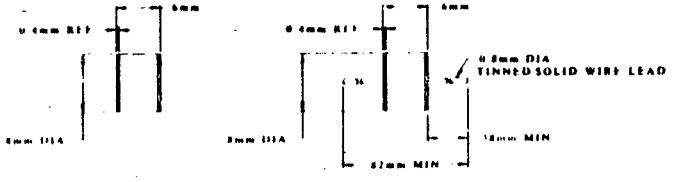


Figure A Figure B

Specifications Subject to Change Without Prior Notice.

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TWX 910-334-3464

JES 280-2M 10-83 H P

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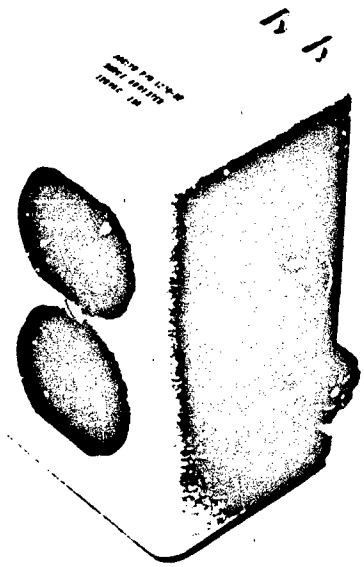
TECHNICAL DATA



MODEL 1270-02

SURGITRON*

PLUG-IN AC SURGE ARRESTER

110-135V RMS, 50-60 Hz

3 Wire Grounded Single Phase

Listed by Underwriters Laboratories Inc.

DISTINCTIVE FEATURES

1. Instantaneous and reliable response in any environment.
2. Absolutely no interruption of power nor drop in voltage during or after passage of a surge.
3. Extremely long life with dependable protection.
4. Low voltage clamping level even with high current surges.
5. Ability to protect against surge currents up to 12,000 amps peak (8 x 20 μsec wave).
6. Reliable and equal performance in either polarity.

APPLICATION

The surge arrester model 1270-02 is designed to protect against transients caused by lightning, induction, switching surges and EMP.

The instantaneous response makes it particularly effective in preventing damage to delicate solid state electronic equipment.

For this reason, this surge arrester has widespread use in computer installations and microwave stations as well as in the telephone, railroad, and petroleum industries.

METHOD OF OPERATION

When a surge voltage exceeds the normal system voltage the arrester instantaneously conducts the surge to ground. The arrester continues to conduct the surge to ground until the surge has passed and the system voltage has returned to normal. The arrester automatically restores itself to its normal operating condition. The 1270-02 incorporates a fuse which opens the circuit, thereby extinguishing the indicator light and removing the protector and its protected load from the circuit, when one or more of the following events takes place:

1. If the load exceeds 15 amperes.
2. If the surge current is substantially greater than 4000 amperes or longer in duration than 8 x 20 microseconds.
3. If the protector reaches its end-of-life.

Replacing the fuse restores the protector to service if the fuse opened because of events 1 or 2. Event 3 will cause the replacement fuse to open also.

*Covered by one or more of the following patents:

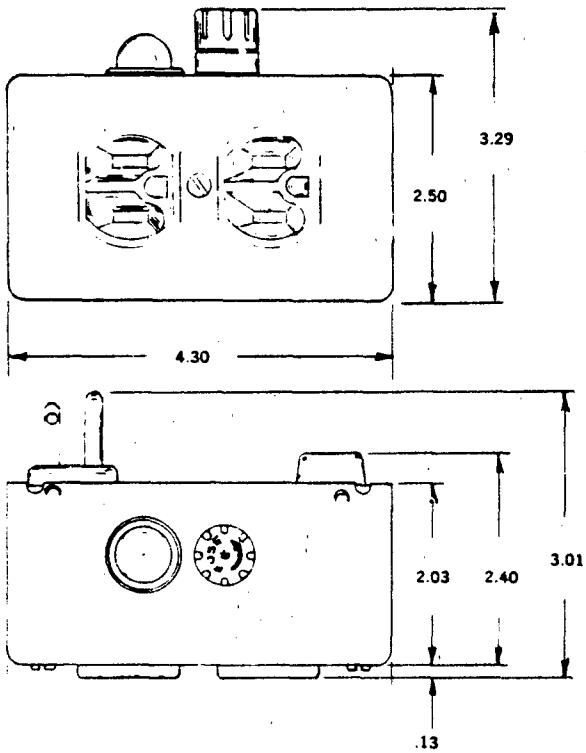
3,312,868	3,320,462	3,353,066	3,388,274	3,413,587	3,448,337	
3,535,582	3,543,207	3,564,473	3,588,576	3,811,064	3,813,577	3,828,290

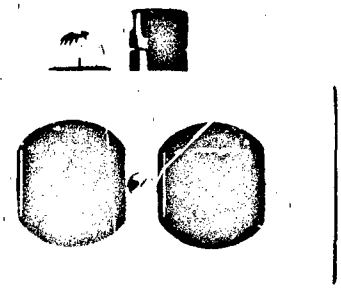
SPECIFICATIONS

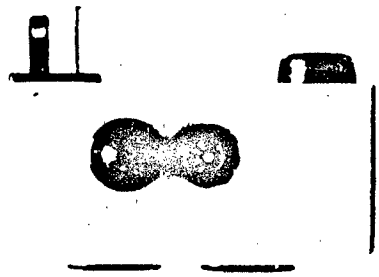
APPLICATION	120 Vrms, Single Phase 3-wire Grounded 50/60 Hz
Voltage Rating:	110-135 Vrms Phase to Neutral
Power Rating:	15 amperes
Clamping Voltage:	190 Vrms
Response Time:	Instantaneous (No Delay — Continuous Conduction)
Discharge Voltage: **At 1,500 amperes** **5,000 amperes**	 450 V Nom. 500 V Nom.
Minimum Life: 1.5 KA 8x20μsec wave **4.0 KA 8x20μsec wave**	5,000 Operations 1,000 Operations
Extreme Duty Discharge Capacity: **(8x20μSec wave)**	12,000 amperes peak*
wer Consumption: Excluding Light **cluding Light**	Less than 0.040 Watts Less than 0.300 Watts
sing:	15 ampere, 250 Vrms
ipping Weight:	Approx. 1 pound

*rge Currents greater than 4,000 amperes may require replacing fuse to restore arrester function.

mensions:







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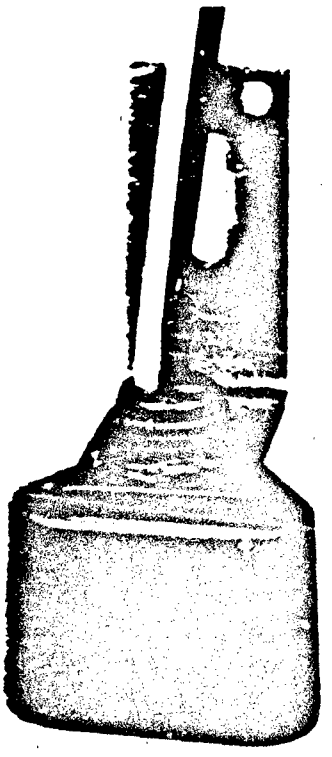
TELEPHONE (805) 968-3551
TELEGRAM: JOSLECTRON, GOLETA

JOSLYN

TECHNICAL DATA



MODEL 1250-32

SURGITRON®

SURGE ARRESTER

110-175V RMS, 50-60 Hz

2 Wire, Single Phase

Listed by Underwriters Laboratories Inc.

DISTINCTIVE FEATURES

1. Instantaneous and reliable response in any environment.
2. Absolutely no interruption of power nor drop in voltage during or after passage of a surge.
3. Extremely long life with dependable protection.
4. Low voltage clamping level even with high current surges.
5. Ability to withstand surge currents up to 20,000 amps peak (8 x 20 μsec wave) and survive.
6. Reliable and equal performance in either polarity.

APPLICATION

The power arrester model 1250-32 is designed to protect against transients caused by lightning, induction, switching surges and EMP.

The instantaneous response makes it particularly effective in preventing damage to delicate solid state electronic equipment.

For this reason, this power arrester has widespread use in computer installations and microwave stations as well as in the telephone, railroad, and petroleum industries.

With increased use of sensitive electronics such as computers, air conditioning controls and video recorders in homes, low voltage arresters are needed to prevent damage from electrical surges. These arresters are ideally suited for this and are designed for easy installation at fuse boxes and similar locations.

Long life and maintenance free operation, even in heavy surge conditions, make this unit the perfect arrester for remote and unattended stations, or stations with no back-up circuits available. The arrester is enclosed in a moisture proof housing to ensure reliable operation in any environmental condition.

METHOD OF OPERATION

When a surge voltage exceeds the normal system voltage the arrester instantaneously conducts the surge to ground. The arrester continues to conduct the surge to ground until the surge has passed and the system voltage has returned to normal. The arrester automatically restores itself to its normal operating condition without interruption of service and with no necessity to replace fuses or to reset circuit breakers.

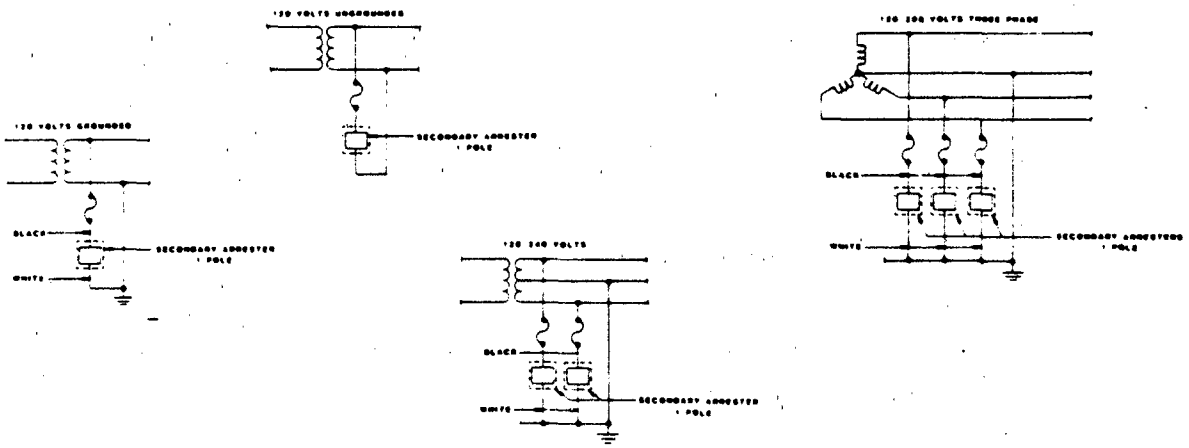
*Covered by one or more of the following patents:

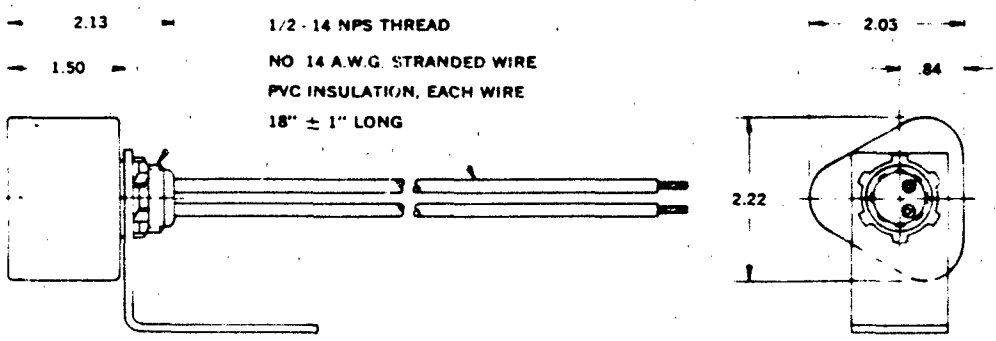
3,312,868	3,320,462	3,353,066	3,388,274	3,413,587	3,448,337	
3,535,582	3,543,207	3,564,473	3,588,576	3,811,064	3,813,577	3,828,290

SPECIFICATIONS

APPLICATION	120V RMS, Single Phase 2-wire 50/60 Hz
Voltage Rating:	110-175 Vrms Phase to Neutral
Power Rating	Unlimited
Response Time	Instantaneous (No Delay — Continuous Conduction)
Response with Rate-of-Rise of 10kV/μs	Less than 350V pk
Discharge Voltage 8x20μsec Wave with 5,000 Amps 10,000 Amps	650 V Nom. 750 V Nom.
Minimum Life 1.5 KA 8x20μsec wave	2500 Operations
Extreme Duty Discharge Capacity (8x20μsec wave)	20,000 Amps Peak
Power Consumption	Less than 30 Milliwatts
Operating Temperature Range	−40°F to +140°F
Maximum Operating Altitude	12,000 Feet
Shipping Weight:	Approx. .5 pound

CONNECTION DIAGRAMS





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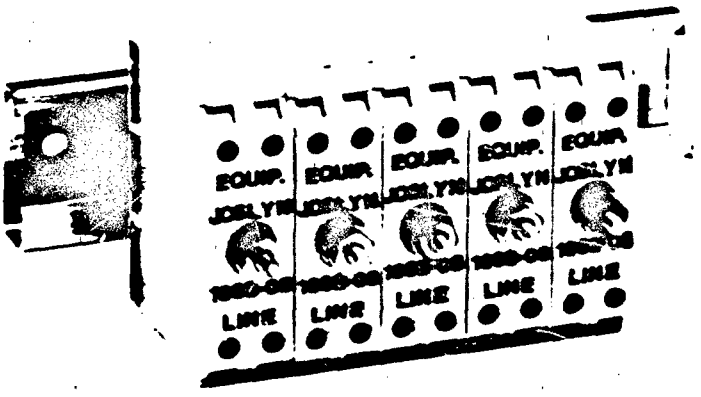
JES 254 2M 2/84 © H P.



JOSLYN

TECHNICAL DATA

MODEL 1663-08

TRANSIENT PROTECTOR

For Data Input Circuit, DC to 20kHz

Model 1663-08 is designed to fit and protect all typical 4-20 MA current loops from damaging transients induced by lightning or switching of heavy equipment and powerlines.

The 1663-08 will protect any low voltage/low current DC to 20kHz circuits.

P/N 36213 mounting rail allows easy installation on any equipment rack. Simulated lightning tests in our laboratory, using a variety of transmitters, showed all transmitters still performing to specification with no change to either protector or transmitters, even after repeated surges of 10,000A.

CONSTRUCTION

The 1663-08 surge and transient protector is a two-stage protection unit. A common chamber, three-element, gas tube assures ultra-fast and balanced clamping. The solid state portion clamps the voltage to a very low, safe level.

The circuit design ensures equal protection against surges of either polarity. Reliability, long-life, and easy mounting are the outstanding features of this unit.

GROUNDING

Top center 6-32 stud with nuts and washers is the ground terminal. Ground strap P/N 34860 will connect all protector ground terminals and only one earth ground connection is required. One ground strap for each protector is required.

Use a #6 or larger nickel-clad copper wire to connect the equipment housing to a suitable earth ground as shown in Figures 1 and 2.

Basically, these protectors divert the lightning induced surge current to ground before it can reach the instrument, thereby reducing the voltage potential between the housing and electronic components inside from several thousand volts to a low and safe level.

If for any reason direct grounding of transmitter is not permissible (cathodic protection or other), a Joslyn 2002-01 gas tube in series with the ground wire will isolate the transmitter from earth and still hold potential between housing and earth at a reasonable level during a discharge. See Figure 2.

*Covered by one or more of the following patents:

3,312,868	3,320,462	3,353,066	3,388,274	3,413,587	3,448,337	
3,535,582	3,543,207	3,564,473	3,588,576	3,811,064	3,813,577	3,828,290

ELECTRICAL CHARACTERISTICS

Typical Signal Level:	24V
DC Breakdown: line-to-line	66V
line-to-ground	33V
Discharge Voltage: with 10,000 amp 8 x 20μs surge	
line-to-line	<100V
line-to-ground	<50V
Surge Life: (No. of operations)	
with 500 amp 10 x 1000μs surge L-G	>400
with 10,000 amp 8 x 20μs surge L-G	10
Series DC Resistance: (per line)	22Ω
Leakage Current at 24V	<15μA
Maximum Load-Current	100ma

FIG. 1

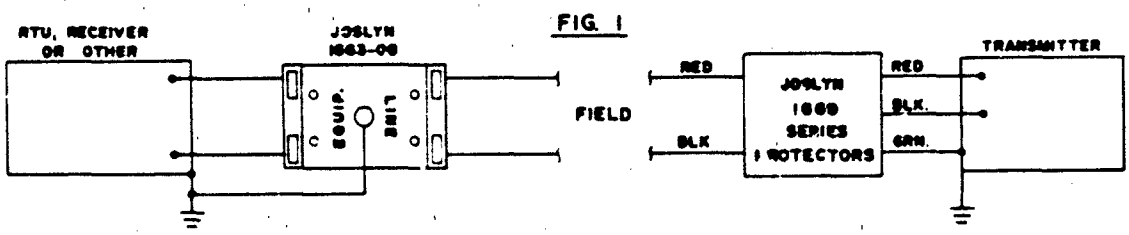
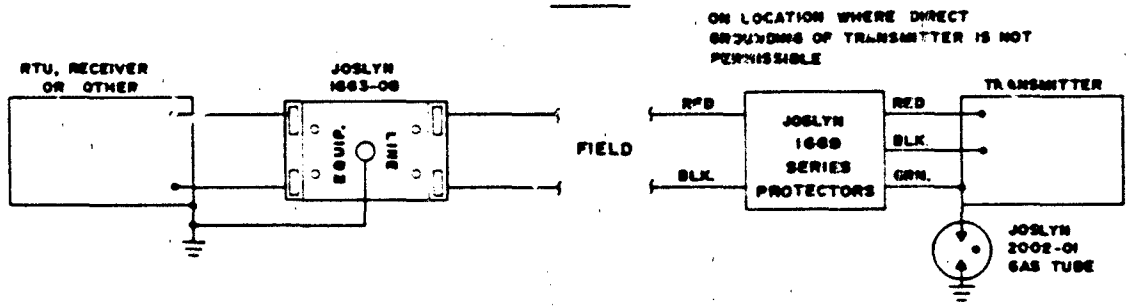
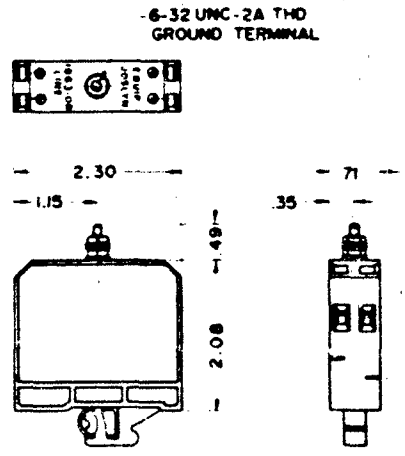


FIG. 2





Net weight approx. 3 oz. Standard accessories include P/N 36213 Mounting Rail and P/N 34860 Ground Strap.

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JES 269-2M 10/83 H P

JOSLYN

TECHNICAL DATA

TRIGARD®
Three-Electrode Gas-tube Surge Protectors

Joslyn TRIGARD® gas-tube protectors are precision built, heavy duty, surge and transient protection devices. Performance is repeatable over a long life period.

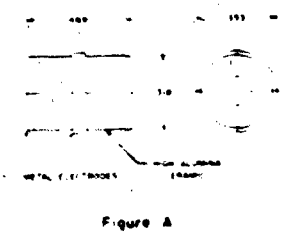


Figure A

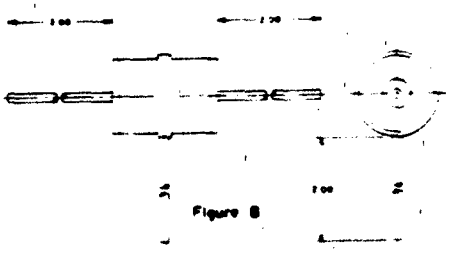


Figure B

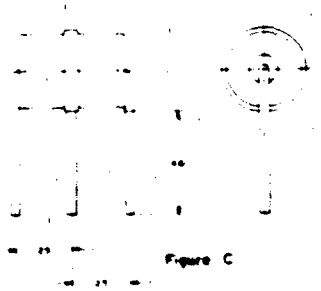


Figure C

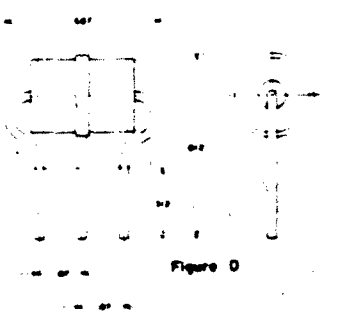


Figure D

DISTINCTIVE FEATURES

1. Extremely fast and repeatable response in light or dark environment (see Figure 1)
2. Equal performance on surges of either polarity
3. Balanced response from either line to ground
4. 100% inspected
5. Delivery from stock

APPLICATION

The TRIGARD® protects balanced pairs against overvoltages caused by switching surges, contact with foreign circuits, and lightning discharges, either induced or conducted. Fast response makes the TRIGARD® particularly effective as protection against transients. It protects electronic circuits and associated components in telecommunication, computer, industrial control equipment, data logging, CRT displays, microwave, traffic control, and missile firing systems.

METHOD OF OPERATION

When a surge exceeds the breakdown voltage across any portion of the tube (surge sparkover voltage), the entire gap becomes intensively ionized, and full conduction takes place within a fraction of a microsecond. The ionized protector becomes a short circuit from line-to-line and from each line-to-ground and remains so until the voltage returns to normal. Ionization and deionization are extremely fast due to the type of gas fill and physical configuration used.

CONSTRUCTION

The gas tubes are assembled under clean room conditions. Inspection in accordance with stringent quality assurance procedures ensures total reliability.

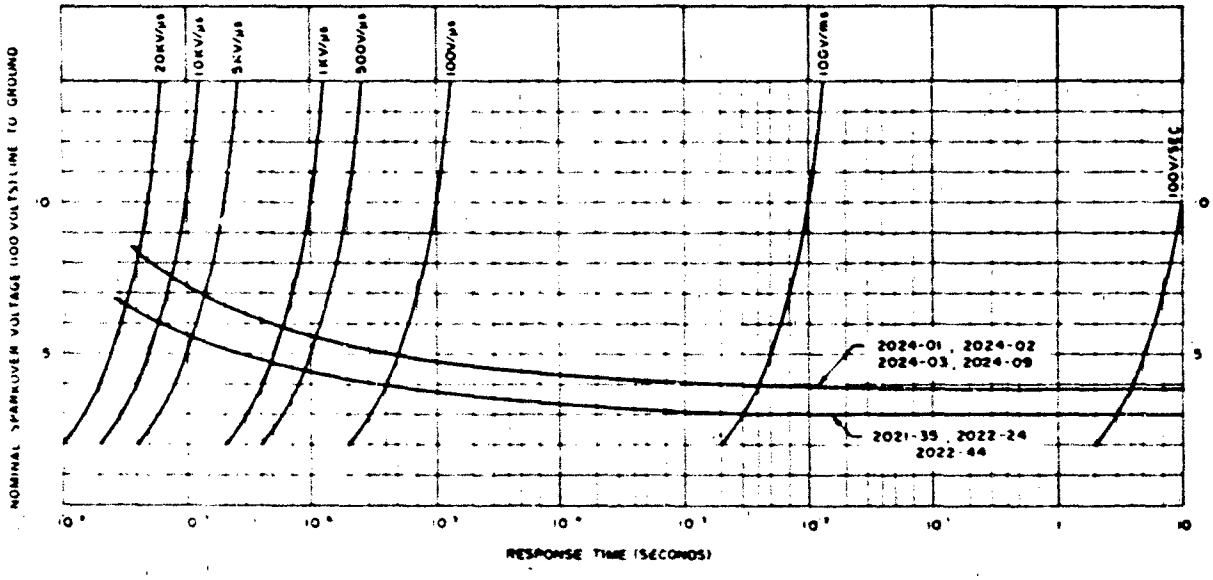
The special alloy metal electrodes of the gas tube are hermetically sealed at high temperature to a high-alumina ceramic body. This provides leak-proof dependability. The high alumina ceramic is formulated for high insulation resistance and low dielectric loss. Symmetry of construction provides equal performance with either polarity of applied voltage.

TABLE 1

P/N	Leads	Dimensions (See Figure)	DC Sparkover Voltage Line-to-Ground (Volts)	Nominal Impulse Sparkover Voltage At 10kV/μsec Rate of Rise (Volts)	Surge Life 1000 A* 10x1000μsec (Operations)	Surge Life 20,000 A* 8x20μsec (Operations)	Maximum Single Surge* 8x20μsec (Amperes)	60 Hz Current Carrying Ability* 1 Operation For 11 Cycles (Amperes)	60 Hz Current Carrying Ability* 10 Operations Of 1 Sec Duration (Amperes)	Holdover Voltage Per REA PE-56 @ 200 mA (Volts)
2021-35	None	A	250-350	600	>1000	>50	40,000	180	30	175
2022-24	# 20 AWG	B	250-350	600	>1000	>50	25,000	180	30	175
2022-44	# 20 AWG	C	250-350	600	>1000	>50	25,000	180	30	175
2024-01	# 18 AWG	D	250-500	750	>1000	>50	35,000	180	30	175
2024-02	# 18 AWG	B	250-500	750	>1000	>50	35,000	180	30	175
2024-03	# 18 AWG	C	250-500	750	>1000	>50	35,000	180	30	175
2024-09	None	A	250-500	750	>1000	>50	40,000	180	30	175

*Both Lines Simultaneously to Ground

FIGURE 1



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TELEGRAM: JOSLECTRON GOLETA

JES 281 2M 2 83 H P

The New Low Voltage GE-MOV II Varistor. (For protection of circuits 5V d c and below)

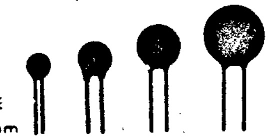
Sebald R. Korn

General Electric Company
Application Engineering
Semiconductor Products Department
Auburn, New York

GENERAL ELECTRIC

Z SERIES RATINGS AND CHARACTERISTICS TABLE

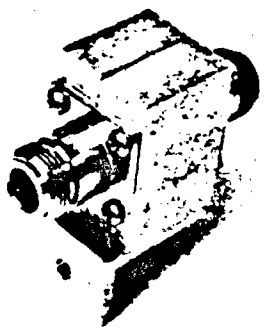
Z SERIES, RADIAL LEAD STYLE 7, 10, 14, 20mm



MODEL NUMBER	MODEL SIZE DIA (mm)	MAXIMUM RATINGS (25°C) CONTINUOUS: RMS VOLTAGE $V_{m(ac)}$ VOLTS	DC VOLTAGE $V_{m(dc)}$ VOLTS	TRANSIENT: ENERGY (10×1000µs) W_{tm} JOULES	PEAK CURRENT (8×20µs) I_{tm} AMPERES	CHARACTERISTICS: VARISTOR VOLTAGE @ 1mA DC TEST CURRENT MIN VOLTS	V_N VOLTS	MAX VOLTS	MAXIMUM CLAMPING VOLTAGE V_C @ TEST CURRENT (8×20µs) V_C VOLTS	I_P AMPS	TYPICAL CAPACITANCE f = 0.1-1MHz PICOFARADS
V8ZA1	7	4	5.5	.4	100	6	8.2	11	22	5	4500
V8ZA2	10	4	5.5	.8	250	6	8.2	11	20	5	12000
V12ZA1	7	6	8	.6	250	9	12	16	34	5	3000
V12ZA2	10	6	8	1.2	250	9	12	16	30	5	7500
V12ZA1	7	6	8	0.6	250	8.4	12	16.0	34	5	3000
V18ZA1	7	10	14	0.8	250	14.4	18	21.6	42	5	2500
V18ZA3	14			3.5	1000				39	10	12000
V18ZA40	20			50.0*	2000		18†		37	20	25000
V22ZA1	7	14	18	0.9	250	18.7	22	26.0	47	5	2000
V22ZA3	14			4.0	1000				43	10	10000
V24ZA50	20	14	18	100.0*	2000	19.2	24†	26.0	43	20	20000
V27ZA1	7	17	22	1.0	250	23.0	27	31.1	57	5	1700
V27ZA4	14			5.0	1000				53	10	8500
V27ZA60	20		22	120.0*	2000		27†		50	20	18000
V33ZA1	7	20	26	1.2	250	29.5	33	36.5	68	5	1400
V33ZA5	14			6.0	1000				64	10	7000
V33ZA70	20	21	27	150.0*	2000		33†		58	20	15000
V36ZA80	20	23	31	160.0*	2000	32.0	36†	40.0	63	20	12000
V39ZA1	7	25	31	1.5	250	35.0	39	43.0	79	5	1200
V39ZA6	14			7.2	1000				76	10	6000
V47ZA1	7	30	38	1.8	250	42.0	47	52.0	92	5	1000
V47ZA7	14			8.8	1000				89	10	5000
V56ZA2	7	35	45	2.3	250	50.0	56	62.0	107	5	800
V56ZA8	14			10.0	1000				103	10	4000
V68ZA2	7	40	56	3.0	250	61.0	68	75.0	127	5	700
V68ZA10	14			13.0	1000				123	10	3500
V82ZA2	7	50	66	4.0	250	74.0	82	91.0	152	5	600
V82ZA12	14			15.0	1000				147	10	3000
V100ZA3	7	60	81	5.0	250	90.0	100	110.0	180	5	500
V100ZA15	14			20.0	1000				175	10	2500
V120ZA1	7	75	102	6.0	1200	108.0	120	132.0	205	10	200
V120ZA6	14			22.0	4500				210	50	1200
V150ZA1	7	95	127	8.0	1200	135.0	150	165.0	250	10	170
V150ZA8	14			30.0	4500				255	50	1000
V180ZA1	7	115	153	10.0	1200	162.0	180	198.0	295	10	140
V180ZA10	14			35.0	4500				300	50	800

*[illegible] pulse duration [illegible] seconds minimum to one half of peak current value
[illegible]
[illegible] 24V [illegible]

NOTE Power dissipation of transients not to exceed 0.25, 0.4, 0.6, 1.0 watts for size 7, 10, 14 and 20mm respectively.



N-EMP PROTECTOR SERIES BULKHEAD MOUNTABLE WITH EMI/RFI GASKET

Dimensions (LxWxH)
Inches - 2.45 x 1 x 2.25
MM - 62.1 x 25.5 x 57
Weight (approx. before packaging)
Ounces 4.5 Grams 127.6

IS-NEMP available in UHF, N or BNC connectors

PolyPhaser model IS-NEMP Series is designed to protect from High Altitude Nuclear Blast(s) effects on communications equipment. The ultra-fast 1 nanosecond response time* can prevent the induced antenna ringing energy from damaging sensitive solid state equipment.

PolyPhaser's IS-NEMP Series is the only protector which uses our Patented equipment isolation technique to ensure proper operation no matter what your equipment input port looks like electrically (L, R or C; series or shunt to ground). Thus, we can specify what the maximum throughput energy to your equipment would be under the worst case conditions. As with all EMP gas tube type protectors, maximum transmit power is a function of frequency. This is to ensure proper turn-off after a pulse, even under transmit power.

Made from highly conductive 6101-T5 aluminum extrusion with 18-8 fasteners, these water tight models use Type N, UHF or BNC Female Teflon connectors (standard) but Rexolite is available on special request. Male connectors for both N, UHF or BNC available; indicate either surge side or protected side or both. 18-8 Stainless mounting hardware and EMI/RFI washer included

	IS-NEMP	IS-NEMP-1	IS-NEMP-2
Receive**	1-500 MHz.	30-700 MHz.	125-1 GHz.
Transmit (CW-single channel)	1-100 MHz. @ 100W. 100-250 MHz. @ 50W. 250-500 MHz. @ 25W.	30-250 MHz. @ 30W. 250-300 MHz. @ 25W.	125-250 MHz. @ 50W. 250-500 MHz. @ 25W. 500-1 GHz. @ 10W.
EMP Throughput energy max	13.3 M Joules	600 *u*.Joules	270 *u*.Joules

* Time measured after wavefront reaches DC threshold and until 30 VDC is achieved.
** Frequency response for 1.1 to 1 VSWR or less and less than 0.1dB loss.
** For Receive Only DC-30MHz., see our IS-50BB Protector on Page 17.

POWERLINE PROTECTORS

TII hybrid Powerline Surge Protectors use the synergistic action of Metal Oxide Varistors (MOVs) and the TII Maximum Duty gas tube arrester to guard against dangerous and destructive powerline surges caused by switching, lightning and other transient sources.

A major producer of overvoltage and surge protection products for the telecommunications industry for 15 years, TII Industries has designed a combination of components that provides superior protection characteristics on ac powerlines.

These components are a hybrid of very fast acting solid state devices and very high power dissipation gas tube devices. Together these components act in a way that is superior in performance to that which any arrangement of either component used alone can provide.

TII products with this combination of components can be used on both 120 and 220 240 volt service with up to 15 20 and 30 amp loads. They protect sensitive electronic equipment such as PABX, key telephone systems and data systems. Metal Oxide Varistors (MOVs) respond to fast rise time lower energy content pulses and limit the peak voltages seen by the protected equipment. On higher energy surges, the major portion of the surge current will be diverted from the MOV to the gas tube which can handle many times the peak current of an MOV or an avalanche diode.

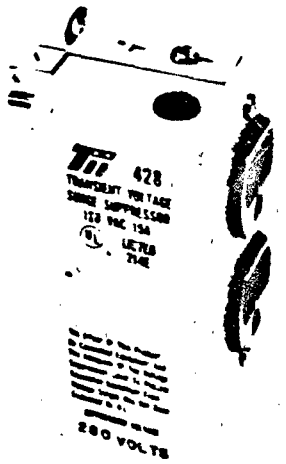
This sharing of surge current again limits the peak voltage seen by the protected equipment. As a final state of protection, many TII protectors also include a thermal circuit breaker that operates in the event of a sustained voltage surge that would exceed the handling capabilities of both the gas tube and the MOV. Operation of the circuit breaker removes both the protection devices and the protected equipment from the line and then automatically restores to normal.

As both industrial and consumer electronic equipment becomes more sophisticated, it has become more obvious that additional protection techniques beyond those used in the past will be required. In some instances products that only limit peak voltages will not be sufficient and additional circuitry will be necessary.

This can be seen today in the need for filters as part of the overall protection scheme of a powerline protector. The TII line of Powerline Surge Protectors includes units both with and without filters and units with and without line cords for a full line of products to meet both end user and OEM applications.

TII 428 Plug-In Powerline Protector

UL Listed



Dimensions 4" x 2¼ x 2¼
Weight 10 oz
Standard Package 24 pieces
Shipping Weight 15 lbs

The TII 428 is a self-contained powerline surge protector which plugs into a standard 120 Vac 15 amp three-prong grounded branch receptacle. The unit incorporates a hybrid protection design including a TII Maximum Duty three-electrode gas tube arrester and three voltage clamping Metal Oxide Varistors (MOVs). The equipment to be protected plugs into the duplex receptacle on the unit. The existing cover plate screw can be used to hold the unit in place by its mounting bracket. When used in a double-duplex branch receptacle, a TII 71200101 mounting adapter is recommended. A long-life pilot lamp lights when normal line voltage is present. The sturdy gray metal enclosure is supplied with a rubber bumper for proper positioning on the wall surface with a branch receptacle.

The TII 428 is recommended for applications where protection from the highest energy content surges on a 15 amp circuit is required.

MODEL	DESCRIPTION
TII 428	Plug-In Powerline Protector, 120 Vac, 15 amp

TII 71200101 Mounting Adapter

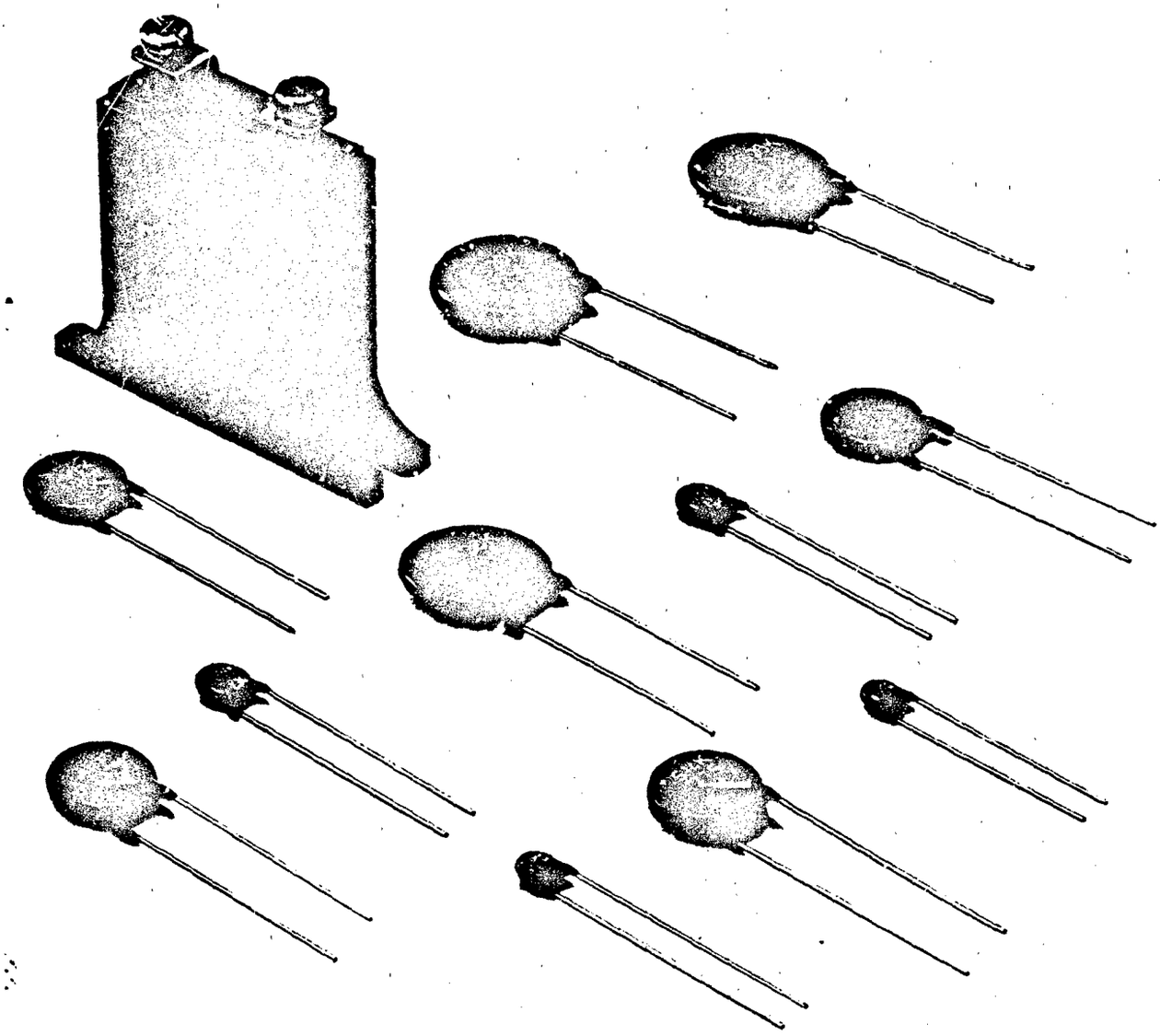
Weight 0 1 oz
Standard Package: 10 Adapters

Designed to assist in providing a more secure mounting when installing TII 428 Powerline Protector into a double duplex branch receptacle. The mounting adapter replaces the screw that secures the cover plate to the duplex receptacle and prevents the receptacle from recessing into the wall box once the 428 is installed or removed from the wall plate.

MODEL	DESCRIPTION
TII 71200101	Mounting Adapter

SIEMENS

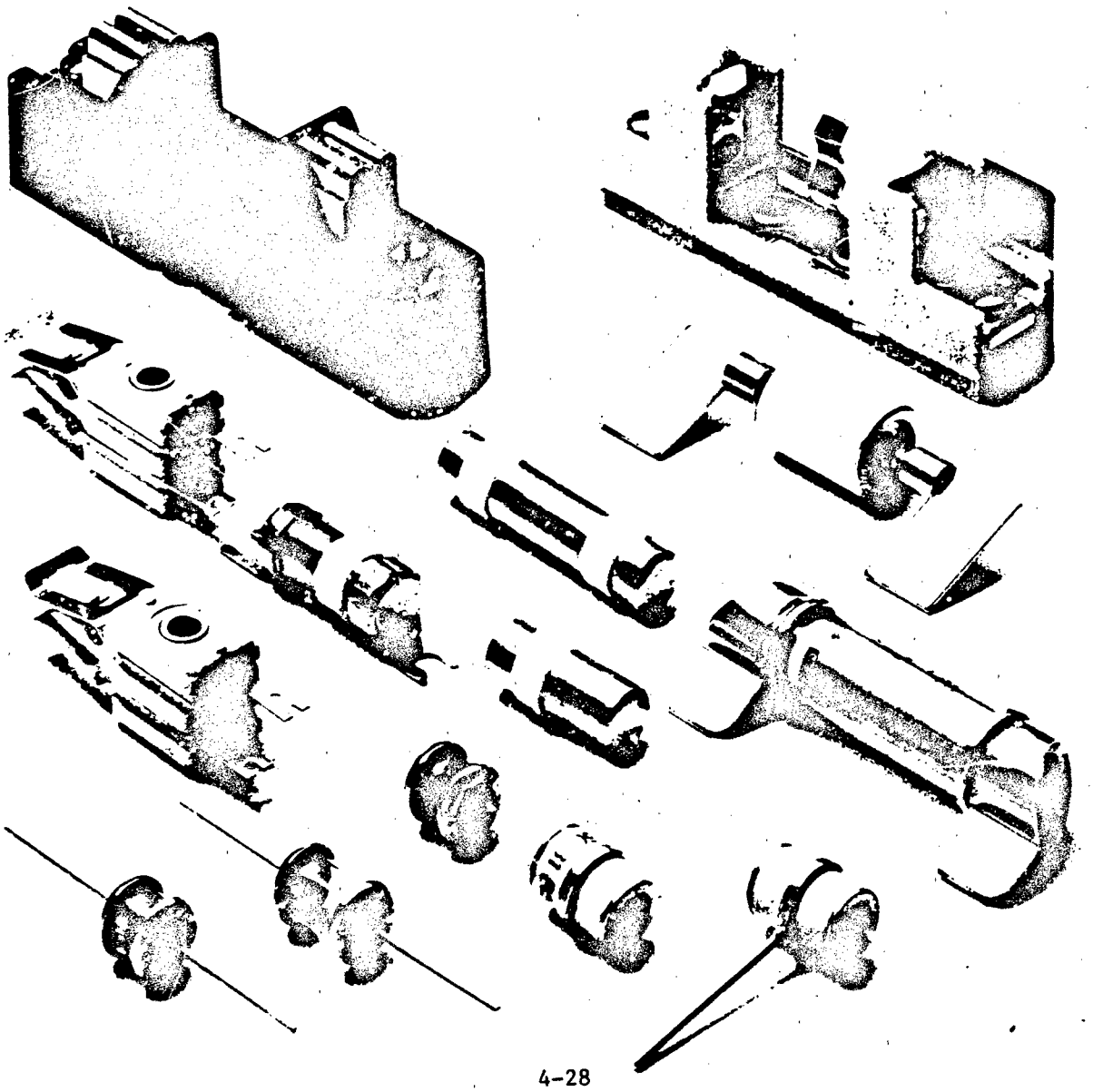
(SIOV)™ Metal Oxide Varistors for Surge Voltage Protection



Part Number	Rated voltage AC Volts (RMS)	Rated voltage DC Volts	Varistor voltage (1 × 10⁻³) Volts	Rated peak single pulse transient current Amps	Rated single pulse transient energy Joules	Rated transient average power dissipation Watts	Maximum clamping voltage Volts	Typical capacitance Picofarads
S05K11				100	0.3	0.1	47@5A	1600
S07K11				250	0.7	0.25	39@5A	3500
S10K11	11	15	18	500	1.8	0.4	40@10A	7500
S14K11				1000	3.4	0.6	36@10A	18000
S20K11				2000	11	1.0	36@20A	37000
S05K14				100	0.3	0.1	56@5A	1300
S07K14				250	0.8	0.25	47@5A	2800
S10K14	14	18*	22	500	2.1	0.4	48@10A	6000
S14K14				1000	4.0	0.6	42@10A	15000
S20K14				2000	16	1.0	44@20A	30000
S05K17				100	0.4	0.1	72@5A	1050
S07K17				250	1.0	0.25	58@5A	2000
S10K17	17	22	27	500	2.6	0.4	58@10A	4000
S14K17				1000	5.0	0.6	52@10A	10000
S20K17				2000	17	1.0	54@20A	22000
S05K20				100	0.5	0.1	86@5A	900
S07K20				250	1.2	0.25	70@5A	1500
S10K20	20	27	33	500	3.2	0.4	70@10A	3000
S14K20				1000	6.0	0.6	65@10A	7500
S20K20				2000	22	1.0	67@20A	17000
S05K25				100	0.6	0.1	102@5A	500
S07K25				250	1.5	0.25	85@5A	1350
S10K25	25	31	39	500	3.8	0.4	85@10A	2600
S14K25				1000	7.2	0.6	75@10A	6500
S20K25				2000	26	1.0	80@20A	15000
S05K30				100	0.7	0.1	127@5A	450
S07K30				250	1.7	0.25	100@5A	1150
S10K30	30	38	47	500	4.4	0.4	100@10A	2200
S14K30				1000	8.8	0.6	90@10A	5500
S20K30				2000	34	1.0	95@20A	13000
S05K35				100	0.9	0.1	143@5A	400
S07K35				250	2.1	0.25	120@5A	950
S10K35	35	45	56	500	5.6	0.4	120@10A	1800
S14K35				1000	10	0.6	110@10A	4500
S20K35				2000	38	1.0	110@20A	11000
S05K40				100	1.1	0.1	175@5A	350
S07K40				250	2.5	0.25	148@5A	700
S10K40	40	56	68	500	6.8	0.4	145@10A	1300
S14K40				1000	13	0.6	135@10A	3300
S20K40				2000	46	1.0	140@20A	7000
S05K50				400	1.8	0.10	143@5A	250
S07K50				1200	6.7	0.25	132@5A	550
S10K50	50	66	82	2500	15	0.40	130@10A	1900
S14K50				4500	27	0.60	125@10A	2900
S20K50				6500	36	1.00	125@20A	5500
S05K60				400	2.2	0.10	172@5A	200
S07K60				1200	8.2	0.25	160@5A	500
S10K60	60	85	100	2500	20	0.40	160@10A	1400
S14K60				4500	30	0.60	155@10A	2400
S20K60				6500	45	1.00	155@20A	4800
S05K75				400	2.6	0.10	210@5A	170
S07K75				1200	10	0.25	200@10A	450
S10K75	75	102	120	2500	24	0.40	215@50A	1100
S14K75				4500	38	0.60	200@50A	1900
S20K75				6500	55	1.00	200@100A	3800
B40K75				16000	130	1.4	220@1000A	15000
S05K95				400	3.2	0.10	260@5A	140
S07K95				1200	12	0.25	250@10A	350
S10K95	95	127	150	2500	26	0.40	270@50A	900
S14K95				4500	45	0.60	250@50A	1500
S20K95				6500	65	1.00	250@100A	3000
S05K130				400	4.2	0.10	355@5A	80
S07K130				1200	15	0.25	340@10A	250
S10K130	130	175	205	2500	32	0.40	365@50A	500
S14K130				4500	55	0.60	340@50A	1000
S20K130				6500	80	1.00	340@100A	2000
B32K130				15000	200	1.20	350@300A	5500
B40K130				30000	420	1.4	360@1000A	8000
S05K140				400	4.4	0.10	375@5A	70
S07K140				1200	15	0.25	360@10A	250
S10K140	140	185	220	2500	36	0.40	385@50A	450
S14K140				4500	60	0.60	370@50A	1000
S20K140				6500	90	1.00	360@100A	2000

*S20K14 will withstand 24 VDC for 15 minutes

Siemens SVP®
Surge Voltage Protectors
and Accessories: 1984-85



ction of SVP's

e to lower cost, 2-electrode SVP's preferred in most applications. trode SVP's are used in cases ring symmetric lines with metallic ges being a particular critical fac- ecause all 3 electrodes of such a are inserted in a common gas arge chamber, conduction be- all 3 electrodes is assured in of a voltage transient in excess of reakdown voltage of the tube.

Breakdown Voltage

pplications:

d 20 percent safety factor to maxum DC supply voltage.

lect an SVP which has a lower tolance limit of DC breakdown ltage greater than the value determined in 1.

heck that extinguishing criteria are et.

pplications:

ultiply AC RMS voltage by 1.4 to tain peak voltage.

ld 20 percent safety factor to peak ltage.

lect an SVP which has a lower tolance limit of DC breakdown ltage greater than the value determined in 2

heck that extinguishing criteria are et.

inguishing Criteria

he normal AC or DC operating ages of a circuit may keep the SVP a conducting mode after the sage of a transient, which can lt in its destruction unless precaus are taken.

or AC applications, the AC follow ent rating must not be exceeded also Definitions, para. 9). In cases re the follow current would be eeded, a varistor should be placed eries with the SVP to limit the ent.

or DC applications, if the normal rating voltage across the tube is ater than the glow voltage and the rent into the SVP while in arc le (10-20 volts across the SVP) does exceed the values listed below, a μfd. capacitor placed in parallel the tube will cause it to extinguish:

ypes:	1A
S1 types:	0.5A
others.	0.2A

the DC current is greater than se values the current must be mentarily interrupted.

utton Type SVP's

Part Number		D.C. Breakdown Voltage (Volts)	Impulse Breakdown Voltage (Volts)		D.C. Holdover Voltage (Volts)	Max. Single Impulse Discharge (K Amp)
w/leads	W.O./leads		100V/μs	10KV/μs		
B1-C75		75 ± 20%	< 700	< 1000	> 60	5
B1-C90/20	A1-C90/20	90 ± 20%	< 700	< 1000	> 60	5
B1-F90		90 - 130	< 700	< 1000	> 60	5
B1-C145	A1-C145	145 ± 20%	< 750	< 1100	> 100	5
B1-A230	A1-A230	230 ± 15%	< 750	< 1200	> 130	5
B1-A350	A1-A350	350 ± 15%	< 750	< 1200	> 150	5
B2-B600		630 ± 15%	< 1200	< 2500	> 180	5
B2-H10		1000 ± 20%	< 1800	< 3000		5
B2-H25		2.5KV ± 20%	< 4000	< 6000		2.5
B2-H45		4.5KV ± 20%	< 5000	< 8000		10
B2-H80X		6.4 KV – 8.8KV	< 10000	< 12500		1
B2-H100X		9KV min.	< 12000	< 14000		1
Special Button Types for A.C. Applications						
B1-C145	A1-C145	145 ± 20%	< 750	< 1100		5
B2-B270		270 ± 15%	< 1000	< 2000		5
B2-B470	A2-B470	470 ± 15%	< 1200	< 2500		5
B2-B800	A2-B800	800 ± 15%	< 1500	< 3000		5

Common to all types: Transition Time: 0.1 μs typ. R_{ins}: ≥ 10,000 megohm
Capacitance: 1 pF typ.

Power Type SVP's

Part Number	D.C. Breakdown Voltage (Volts)	Impulse Breakdown Voltage (Volts)		Max. Single Impulse Discharge (KA)	Impulse Life (# of pulses)
		100V/μs	10KV/μs		
L2-A230	230 ± 15%	< 1100	< 2000	20	> 1000
L2-A350	350 ± 15%	< 1300	< 2000	20	> 1000
L2-A600	600 ± 15%	< 1400	< 2500	20	> 1000
S8-C90	90 ± 25%	< 750	< 1200	20	> 1500
S8-C150	150 ± 20%	< 750	< 1200	20	> 1500
V12-H10	1KV ± 20%	< 1800	< 3000	20	
V12-H30X	3KV $^{+25\%}_{-15\%}$	< 4000	< 7000	20	

Communication Type SVP's

2-electrode Types		DC Breakdown Voltage (Volts)	Impulse Breakdown Voltage (Volts)		DC Holdover Voltage (Volts)	Max. Single Impulse Disch. (K Amp)
w/leads	w/o leads		100V/μsec	10KV/μsec		
B1-A350	A1-A350	350 ± 15%	< 750	< 1200	> 150	5
	A4-A230	230 ± 20%	< 800	< 1200		2.5
	A4-A350	350 ± 20%	< 800	< 1200		2.5
	S1-A350	300 - 420	< 750	< 1200	> 200	20
3-electrode Types						
w/leads	w/o leads					
T61-C350	T60-C350	300-500(L-G)	< 750	< 1200	> 150	2 x 12
		300-650(L-L)	< 1200	< 1800	> 300	N/A
	T1-C350	300-500(L-G)	< 750	< 1200	> 150	2 x 20
		300-900(L-L)	< 1200	< 1800	> 300	N/A

Impulse Life (# of pulses)	A.C Discharge Current (Amps rms)	A.C Follow Current (Amps pk)	SVP Outline Drawing (Fig.)	Dimension "A" (Inches)	Holder Type	Holder Outline Dwg. (Fig.)
> 200	20	20	4	272 ± 012		
> 200	20	20	4	272 ± 012	A1-A1	11
> 200	20	20	4	272 ± 012		
> 200	20	35	4	276 ± 012	A1-A1	11
> 200	20	25	4	238 ± 008	A1-A1	11
> 200	20	25	4	236 ± 012	A1-A1	11
	20	25	4	256 ± 012		
> 200	20	25	4	281 ± 008		
	10		4	433 ± 02		
	0.4			433 ± 02		
			4	433 ± 02		
				455 Max		

> 200	20	35	4	276 ± 012	A1-A1	11
> 200	20	35	4	276 ± 020		
> 200	20	35	4	295 ± 012	A1-A1	11
> 200	20	35	4	315 ± 012	A1-A1	11

A.C. Discharge Current (A. rms)	A.C. Follow Current (A. pk)	Capacitance (pF)	SVP Outline Drawing	Coordinates with Varistor Type	Holder Type	Holder Outline Dwg. (Fig.)
200	100	< 6.8	3	Z1-V2	A2-L1	10
200	100	< 4.5	3	Z1-V2	A2-L1	10
200	100	< 4.5	3	Z1-V2	A2-L1	10
200	80	< 3	8			
200	80	< 3	8			
80		< 1.5	12		A2-L1	10
80		< 1.2	12		A2-L1	10

Common to all types listed above: R_{ins}: ≥ 10,000 megohm
Transition time: 0.1 μs. typ.

AC Discharge Current (A.rms)	Impulse Life (# of pulses)	Insulation Resistance (M Ohm)	Capacitance (pF)	Transition Time (typ) (μsec)	Delay Time (μsec)	Outline Dwg. (Fig.)	Holder Type	Holder Outline Dwg. (Fig.)
20	> 200	≥ 10,000	< 1	< 0.1	N/A	4	A1-A1	11
10		≥ 10,000	< 1	< 0.1	N/A	5	A1-A1	11
10		≥ 10,000	< 1	< 0.1	N/A	5	A1-A1	11
200	> 1500	≥ 10,000	< 3	< 0.1	N/A	7		

2 x 90	> 600	≥ 10,000	2.2	< 0.1	< 2	T60: 2 T61: 1		
N/A	N/A	≥ 10,000	1.2	N/A	N/A			
2 x 200	> 1000	≥ 10,000	3	< 0.1	< 3	6	T1-A1	9
N/A	N/A	≥ 10,000	2	N/A	N/A			

A = Not Applicable

Characteristics of the Different Types of SVP's

Button type SVP's are compact, medium duty 2-electrode tubes which provide adequate protection for most circuit applications. They are readily mounted on PC boards. By means of a patented process, high breakdown speed is a key feature. Buttons are the most economical type of SVP.

Special Button types for AC applications undergo AC burn-in in order to guarantee good extinguishing characteristics at high follow currents. This feature makes them especially suitable for CATV amplifiers and other applications where AC voltage is present.

Power types are maximum duty 2-electrode types for applications where severe current surges may be expected, such as from lightning and back EMF from large motors.

The L2-types, besides having high impulse current ratings, also have high AC follow current carrying capability, making them especially suitable for connection across AC power lines. If the AC follow current may possibly be exceed (due to low AC source impedance), the type Z1-V2 varistor should be connected in series with the SVP, as shown in fig. 13 on page 7. The varistor has low impedance at voltages above the breakdown voltage of the SVP, but higher impedance at lower voltages, such that the follow current is limited, thereby allowing the SVP to extinguish.

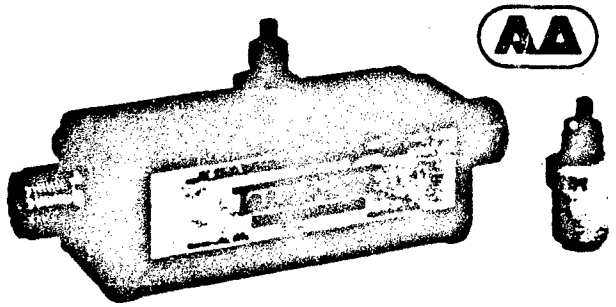
Communication type SVP's have been developed and refined through experience gained from actual use in telecommunications equipment. Most types are designed to meet or exceed the parameters specified in REA Specification PE-80.

A range of current ratings from 5KA to 20KA is available. Selection criteria depend on the level of protection required, and are often established by the end customer for the equipment.

TRANSI-TRAP SURGE PROTECTORS

with the field-replaceable Arc-Plug™ Cartridge

ALPHA DELTA COMMUNICATIONS INC.



Transi-Trap Surge Protectors are gas surge arresters designed to protect sensitive electronic equipment from damage due to excess voltages or currents generated by transient phenomena (lightning or static build-up).

The elements in the Arc-Plug™ Cartridge consist of two metal electrodes hermetically sealed in a rugged gas filled, ceramic cylinder. They perform as voltage-dependent switches which can reliably and repeatedly carry large currents for brief periods of time. In operation, a sufficient voltage across the element causes an arc to form between the electrodes, changing its impedance from greater than 10,000 megohms to a few milliohms in less than 100 nanoseconds time. While conducting in the arc mode, the voltage across the surge arrester is less than 30 volts.

The life of the Arc-Plug Cartridge is a function of the surge current amplitude and duration to which the device is subjected. Transients are by their very nature unpredictable in magnitude and energy level. Life may be many hundreds of operations, depending on surge current wave shape.

After a sufficient number of lightning pulses have been discharged through the Arc-Plug Cartridge, there is a gradual lowering of breakdown voltage and insulation resistance. Therefore, Arc-Plug Cartridge replacement is indicated by an increase in VSWR during transmitter tune-up, or by a "dead" receiver caused by an extremely strong near-miss lightning discharge shorting the Arc-Plug Cartridge. In this case, the short continues to protect the equipment until cleared.

IMPORTANT—Read before installing!

INSTALLATION INFORMATION

Install at rear:

Alpha Delta Transi-Trap Surge Protectors are designed for installation at the rear of the equipment.

Note: Any model must be placed at a point in the coax line where the VSWR does not exceed 2:1 to prevent high R.F. voltages from triggering the units. If outdoor use is planned, it is necessary to coat thoroughly all surfaces (after attaching coax and ground wire) with a good sealer/protector.

2. Ground system:

The unique isolated ground system of Transi-Trap Surge Protectors permits direct earth connection while preventing arc energy from being coupled to the equipment chassis through the coax shields. Lab tests show this method to be best for overall protection. For the system to work, it is absolutely necessary to attach a direct earth ground wire to the nut and washers on the Arc-Plug Cartridge. (A cold water pipe connection is suitable if its ground path is not too long or circuitous.) The surge protectors will not function without this connection as there is no other return path for the arc energy.

For maximum protection, ground the antenna coax shield to an earth ground at the point of entry to the building. This is important since a closer near-miss can cause a high induced voltage on the shield. Also, attach an earth ground to the chassis of the station equipment. Both of these suggestions follow good engineering practice, regardless of the type of protector in use.

OPERATIONAL AND TEST INFORMATION

Test results:

The level of protection provided by Transi-Trap Protectors is remarkable, and our lab tests show outstanding state-of-the-art performance. By using a special wave front generator, simulating fast rise time lightning-type pulses of up to 10 kilovolts, we have observed the performance of Transi-Trap Protectors with semiconductors commonly used in solid state receivers and transceivers. Our own experience in the communications industry has shown that some of the devices most sensitive to lightning-induced surges are certain PIN diodes, including the higher voltage types currently used in the industry. These devices are known to be even more sensitive than many MOSFETs and bipolar transistors in typical use.

Connecting this type of PIN diode directly to the output of the wave front generator, with no protection, the induced pulse will "blow" the diode into a dead short. It should be noted that many PIN diodes fail in equipment when much lower-level surges cause them to become merely "leaky".

When the Transi-Trap Protector is inserted between the generator and the PIN diode, in a typical 50 ohm coaxial configuration, the diodes survive repeated pulses without failure. Other receiver-type components show the same remarkable results.

Nearby or distant lightning surges:

Since many equipment failures occur as a result of lightning-induced surges from distant storm fronts and near-misses, the operator will find a new dimension of protection with the use of Alpha Delta Transi-Trap Surge Protectors.

Lightning-induced surges (transients) have unpredictable energy content, time duration, and ramp speed (wave front) characteristics. For that reason, these protectors are not guaranteed to protect against direct strokes. Also, certain semiconductors are beyond the protection of these devices. For example, some exotic MOS IC memory devices are so sensitive that the discharge caused by the simple touch of a finger will destroy them.

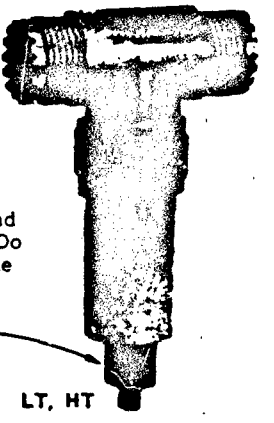
Arc-Plug® Cartridge. Attach ground wire here. (Do not loosen bottom nut.)

Since it makes an internal, solderless, pressure-fit connection, a replacement Arc-Plug Cartridge is installed by screwing it into the same threaded hole. Do not cross-thread or over-tighten. Tighten only until you "feel" the connection.

emove cartridge, ...screw plastic body completely until entire assembly is free from chassis.

R-T, HV

Either connector can be used for input or output.



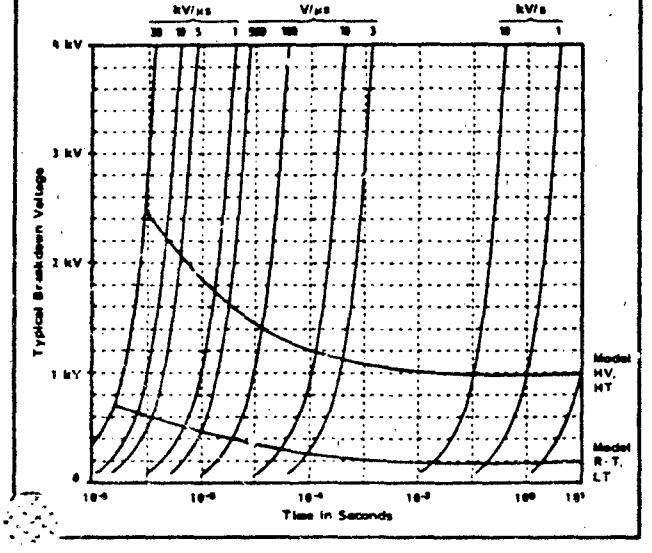
(Low Level Models fire at the lowest lightning pulse level, providing maximum ...tection. For ...ivers and ...sceivers. ...chart.)

Arc-Plug Cartridge. Attach ground wire here. (Do not loosen the nut that is touching the body.)

LT, HT

Typical Voltage Breakdown Characteristics for Arc-Plug Cartridge Elements

Ramp Speeds from 100 V/s to 30 kV/μs



CAUTION: Each Arc-Plug Cartridge has been selected and screened for correct pulse breakdown and rf characteristics for each model. Replace only with proper Arc-Plug from Alpha Delta Communications.

Alpha Delta Transi-Trap Protection Systems are designed to reduce the hazards of lightning-induced surges. These devices, however, will not prevent fire or damage caused by a direct stroke to an antenna or other structure.

INSTALLATION INFORMATION

MODELS AVAILABLE: (with UHF connectors)

Transi-Trap Models R-T & LT

Low Level Protector — for use with solid state receivers, transceivers or transmitters running up to 200 watts output at 50 ohms.

Model LT to 148 MHz, Model R-T to 500 MHz

Transi-Trap Models HV & HT

High Voltage Protector — for use with amplifiers running up to 2 kW output at 50 ohms.

Model HT to 148 MHz, Model HV to 500 MHz

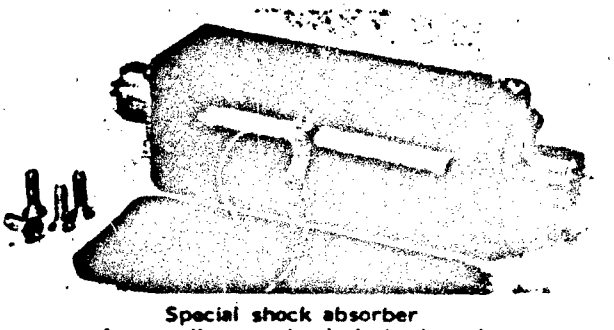
The Models R-T and HV Protector series are special low loss (typ. 0.1 dB at 500 MHz.) models for use through VHF/UHF.

Replacement Arc-Plug Cartridges

For Models R-T & LT and for Models HV & HT.

Note: Models R-T and HV are also available with "N" type connectors. These are Models R-T/N and HV/N.

Models available with BNC connectors on special order.



Special shock absorber for excellent mechanical shock and vibration protection.

Warranty

Seller warrants that each unit sold is manufactured in accordance with seller's specifications, drawings, samples or data in effect on the date of receipt of the order, as they apply to those parts called for on the order, and that each unit is free from defects in material and workmanship.

Seller's liability under this warranty is limited to the repair or replacement of any unit which proves to be defective in material or workmanship under normal use and service provided the unit is returned to the Alpha Delta shipping point (or authorized distributor if purchased through this source) within one year from date of shipment, and will in no case be responsible for special or consequential damages including but not by way of limitation, cost or removal of units from or reinstallation in equipment.

This warranty is in lieu of all other warranties expressed or implied.

Specifications, availability and prices are subject to change without notice.

ALPHA DELTA COMMUNICATIONS

P O Box 571
Centerville Ohio 45459

Telephone
513/435-4772

OEM AC POWER LINE PROTECTORS

Patent Pending

General Semiconductor Industries, Inc. has developed a family of 120 VAC power line protectors specifically for the OEM user. These employ solid state TransZorb® technology, which has proven to be the most effective for protecting electronic equipment against over-voltage transients. Throughout the world, TransZorb transient suppressors can be found in equipment manufactured for aerospace, telecommunications, computer, instrumentation, and military applications. Now this same technology is available for OEM 120 VAC power line protection to IEEE 587 standards.

PROTECTION FEATURES

- **Solid State TransZorb® Technology**
- **Meets IEEE Std. 587-1980 Categories A and B**
- **Sub-nanosecond Response Time**
- **No Voltage Overshoot**
- **Meets IEC 664 Clearance and Creepage Standards**
- **Survives Multiple IEEE 587 Transients**
- **Low Clamping Voltage**
- **Protects 400 V Rated Solid State Components**
- **Differential and Common Mode Protection**
- **Short Circuit Failure Mode**

SPECIFICATIONS @ 25°C

Operating Line Voltage: **130 VAC Max.**
Maximum Line Current: **587B051, 5A**
587B151, 15A
587B201, 20A

MAXIMUM RATINGS

*Transient Voltage: **6000V$_{peak}$**
*Transient Current: **3000A$_{peak}$**
Storage and Operating Case Temperature (Measured at center of mounting surface): **0° to 85°C**
Current Leakage at 120 VAC
Line to Neutral: **1.0mA**
Neutral to Ground: **0.5mA**

RESPONSE TO TRANSIENT VOLTAGES

Clamping		Test Conditions	
PROTECTION MODE	MAXIMUM CLAMPING VOLTAGE	OPEN CIRCUIT VOLTAGE 1.2 x 50μs	SHORT CIRCUIT CURRENT 8 x 20μs
DIFFERENTIAL (Line to Neutral)	295V 350V	1000V 6000V	500A 3000A
COMMON (Neutral to Ground)	500V 650V	1000V 6000V	500A 3000A

*Pulse generator output as per IEEE STD. 587-1980 Category B. See Table A.

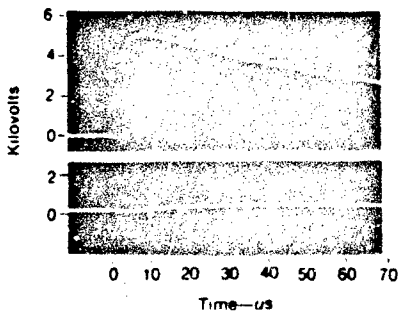


FIGURE 3a
No Protection

TransZorb® Protected

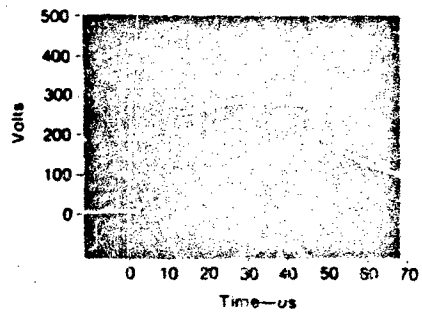


FIGURE 3b
TransZorb® Protected

The above phototgraphs show the typical clamping action of a 15 amp module. A 12 ohm resistor, used to represent the equipment load for a 10A current, is subjected to IEEE STD. 587—Category B test conditions (6000V, 3000A). Figure 3a contrasts the transient effects on equipment with and without the protector. Figure 3b expands the vertical scale to better exhibit the protector's low clamping voltage.

General Semiconductor Industries, Inc. SQUARE D COMPANY
2001 WEST TENTH PLACE • TEMPE, ARIZONA 85281 • (602) 968-3101 • TWX: 910-950-1942

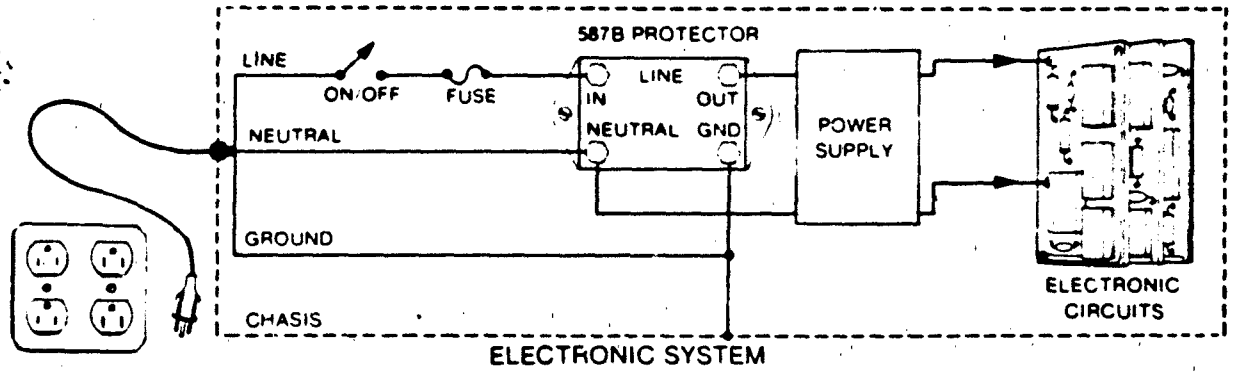


FIGURE 4—Typical Installation

This family of quality AC power line protectors offers a high degree of protection against 120VAC line noise and transients. It is ideal for protecting 400V rated solid state components because TransZorb technology assures that line-to-neutral voltages will not exceed 350 volts.

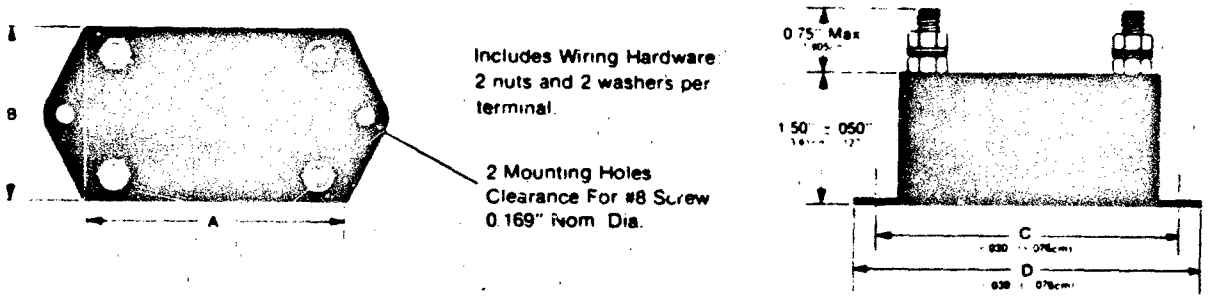
For maximum effectiveness, the protector should be installed directly after the AC line on/off switch and fuse. This will protect the electronics from the AC line switch arcing and the severe transient caused by a fuse clearing.

Some heat is produced when operating at full rated current load, and heat sinking may be required to maintain case temperature below 85°C. Case temperature is measured at the center of the mounting surface. The unit should not be mounted to a low combustion temperature material such as wood.

High energy transients will cause a large circulating current in the AC input line. (2500A is possible!) To prevent electromagnetic coupling, the AC line on the input side of the protector must be dressed away from other wiring, and magnetic shielding may be required. Also, the electrical wall outlet must be connected to a low impedence earth ground.

While the modules are designed for transient voltage protection, the advanced circuitry (patent pending) will also attenuate the amplitude and slow the rate of rise of high frequency line noise. If required, improved damping can be achieved by adding an external R-C network between the line-out and neutral terminals. A 62 ohm resistor in series with a 0.5μF, 400 volt capacitor is suggested.

CASE OUTLINE



PART NUMBER	MAX LINE CURRENT	CASE (INCHES)				CASE (CENTIMETERS)				WEIGHT GRAMS	TERMINAL THREADS
		A	B	C	D	A	B	C	D		
587B051	5 Amps	2.0	2.0	2.5	3.0	5.08	5.08	6.35	7.62	250	#8-32
587B151	15 Amps	3.0	2.0	3.5	4.0	7.62	5.08	8.89	10.16	500	#8-32
587B201	20 Amps	3.0	3.0	3.5	4.0	7.62	7.62	8.89	10.16	750	#10-32

General Semiconductor Industries, Inc.

SQUARE D COMPANY

TRANSZORB TRANSIENT VOLTAGE SUPPRESSOR

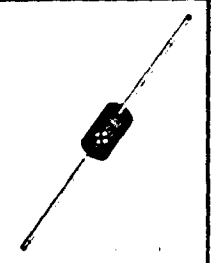
FEATURES

- 1500 watts Peak Pulse Power dissipation
- Available in ranges from 5.0 to 45 volts
- Transient protection for CMOS, MOS, BIPOLAR, ICs, (TTL, ECL, DTL, RTL and Linear Functions).
- Low clamping factor
- Each device 100% tested

APPLICATION

a premium series of trans-ent voltage suppressors specifically designed and tested to protect Bipolar, MOS and Schottky improved integrated circuits from electrical disturbances. Transients and noise pulses are generated by electromechanical switching, electromagnetic coupling, capacitive or inductive load switching, voltage reversals, and electrostatic discharge.

CASE 1



MAXIMUM RATINGS

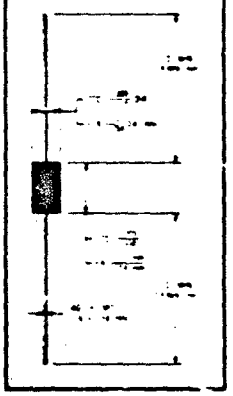
- 1500 Watts of Peak Pulse Power dissipation at 25°C (see derating curve)
- $t_{clamping}$ (0 volts to BV min) Unipolar, Less than 1×10^{-12} second. Bidirectional, Less than 5×10^{-9} second
- Operating and Storage temperatures: -65° to +175°C
- Forward surge rating half cycle 200amps, 1/120 second at 25°C
- Steady State power dissipation 5.0W at T_L = 75°C, Lead Length = 3/8"
- Repetition rate (duty cycle) 05%

DESCRIPTION

The TransZorb is desired over a crowbar circuit, a LC or RC network and a catch or clamping diode, because of fewer components, speed of response high power or energy absorption and low clamping factor

Providing protection for the most popular IC voltage levels, these devices are available for either unidirectional or bidirectional applications. These devices are designed to dissipate 1500 watts of peak pulse power for 1 millisecond

CASE OUTLINE



MECHANICAL CHARACTERISTICS

- Molded Case
- Weight 1.5 grams (approximate)
- Positive terminal marked with band (except Bidirectional types)
- Body marked with Logo and type number

ELECTRICAL CHARACTERISTICS

Clamping Factor 1.33 at full rated power
1.20 at 50% rated power

Clamping Factor: The ratio of the actual V_C (Clamping Voltage) to the BV (Breakdown Voltage) as measured on a specific device

FIGURE 1—Peak Pulse Power vs Pulse Time

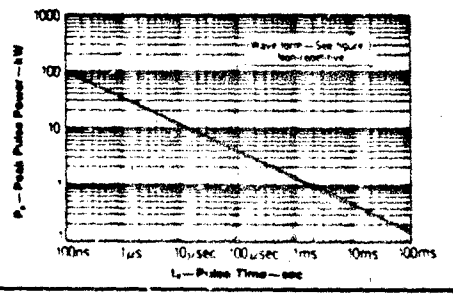
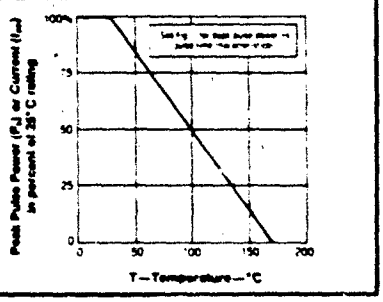


FIGURE 2—Derating Curve



1-40 Detailed Data Sheet Available

ELECTRICAL CHARACTERISTICS @ 25°C

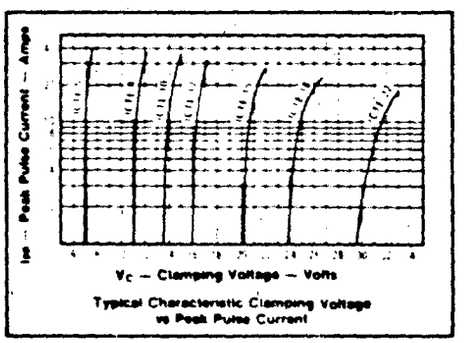
Device Type	Reverse Stand-Off Voltage (Note 1) V_R Volts	Maximum Reverse Leakage @ V_R I_R μA	Minimum Breakdown Voltage @ I_T V_{BR} Volts	Maximum Clamping Voltage @ I_{PP} (Fig. 3) V_C Volts	Maximum Clamping Voltage @ I_{PP} (Fig. 3) V_C Volts	Maximum Peak Pulse Current (Fig. 3) I_{PP} Amps
ICTE-5	5.0	300	6.0	7.1	7.5	180
ICTE-8	8.0	25	9.4	11.3	11.5	100
ICTE-10	10.0	2	11.7	13.7	14.1	90
ICTE-12	12.0	2	14.1	16.1	16.5	70
ICTE-15	15.0	2	17.6	20.1	20.6	60
ICTE-18	18.0	2	21.2	24.2	25.2	50
ICTE-22	22.0	2	25.9	29.8	32.0	40
ICTE-36	36.0	2	42.4	50.6	54.3	23
ICTE-45	45.0	2	52.9	63.3	70.0	19

V_F at 100 amps peak 8.3 msec sine wave = 3.5 volts maximum

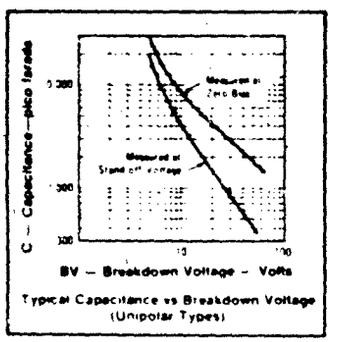
ELECTRICAL CHARACTERISTICS @ 25°C (Test Both Polarities)

Device Type	Reverse Stand-Off Voltage (Note 1) V_R Volts	Maximum Reverse Leakage @ V_R I_R μA	Minimum Breakdown Voltage @ I_T V_{BR} Volts	Maximum Clamping Voltage @ I_{PP} (Fig. 3) V_C Volts	Maximum Clamping Voltage @ I_{PP} (Fig. 3) V_C Volts	Maximum Peak Pulse Current (Fig. 3) I_{PP} Amps
ICTE-8C	8.0	50	9.4	11.4	11.6	100
ICTE-10C	10.0	2	11.7	14.1	14.5	90
ICTE-12C	12.0	2	14.1	16.7	17.1	70
ICTE-15C	15.0	2	17.6	20.8	21.4	60
ICTE-18C	18.0	2	21.2	24.8	25.5	50
ICTE-22C	22.0	2	25.9	30.8	32.0	40
ICTE-36C	36.0	2	42.4	50.6	54.3	23
ICTE-45C	45.0	2	52.9	63.3	70.0	19

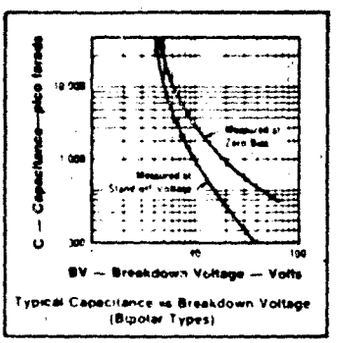
C Suffix indicates Bipolar
ICTE-5 not available as Bipolar
*The minimum breakdown voltage as shown takes into consideration the ±1 volt tolerance normally specified for power supply regulation on most integrated circuit manufacturers data sheets. Similar TransZorb devices are available with reduced clamping voltages where tighter regulated power supply voltages are employed.



Typical Characteristic Clamping Voltage vs Peak Pulse Current



Typical Capacitance vs Breakdown Voltage (Unipolar Types)

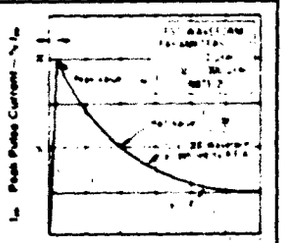


Typical Capacitance vs Breakdown Voltage (Bipolar Types)

TRANSZORB

1

FIGURE 3—Pulse Waveform



NOTES

Note 1: A TransZorb is normally selected according to the reverse Stand-Off voltage (V_R) which should be equal to or greater than the DC or continuous peak operating voltage level.

Note 2: Capacitor Discharge Test Circuit see Figure 5, Page 1-3

ABBREVIATIONS & SYMBOLS

V_R — Stand-Off Voltage: Applied Reverse Voltage to assure a nonconductive condition. See Note 1

BV_{min}: This is the minimum Breakdown Voltage the device will exhibit and is used to assure that conduction does not occur prior to this voltage level at 25°C

$V_{C max}$: Maximum Clamping Voltage: The maximum peak voltage appearing across the TransZorb when subjected to the peak pulse current in a one millisecond time interval. The peak pulse voltages are the combination of voltage rise due to both the series resistance and thermal rise

I_{PP} — Peak Pulse Current — See Figure 3

P_P — Peak Pulse Power

I_R — Reverse Leakage

General Semiconductor Industries, Inc.

SQUARE D COMPANY

FEATURES

- 1500 watts Peak Pulse Power dissipation
- Available in ranges from 6.5 to 170 volts
- Low capacitance ac signal protection
- Each device 100% tested

MAXIMUM RATINGS

- 1500 watts of Peak Power dissipation at 25°C (see derating curve)
- [illegible] (0 volts to BV min) Less than 5×10^{-9} second (theoretical)
- Operating and Storage temperatures -65° to +175°C
- Steady State power dissipation 5.0W at T_L = 75°C, Lead Length = 3.8"
- Repetition rate (duty cycle): 05%

MECHANICAL CHARACTERISTICS

- Molded Case
- Weight: 1.5 grams (approximate)
- Polarity band to be on the cathode end of the TransZorb
- Body marked with Logo and type number

ELECTRICAL CHARACTERISTICS

Clamping Factor: 1.40 at full rated power
1.30 at 50% rated power

Clamping Factor: The ratio of the actual V$_C$ (Clamping voltage) to the BV (Breakdown voltage) as measured on a specific device

Note: When pulse testing, test in TransZorb Avalanche direction. DO NOT pulse in forward direction.

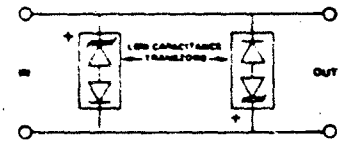
APPLICATION

This specification sheet defines a series of low-capacitance silicon transient suppressors for the protection of ac signal line. This series employs a standard TransZorb® in series with a rectifier with the same transient capabilities as the TransZorb. The rectifier is also used to reduce the effective capacitance up thru 100MHz with a minimum amount of signal loss or deformation. The low-capacitance TransZorb may be applied directly across the signal line to prevent induced transients from lightning, power interruptions, or static discharge.

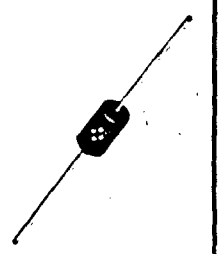
DESCRIPTION

Designed for commercial applications, this series offers pricing advantages. They have the same characteristics as the standard TransZorb, that is, high surge capability and extremely fast response time. If bipolar transient capability is required, two low-capacitance TransZorbs must be used in parallel, opposite in polarity for complete ac protection. For additional reduction in capacitance, these units can be used in conjunction with a bridge network. This will allow a lower capacitance with no change in peak pulse power capability of 1500 watts.

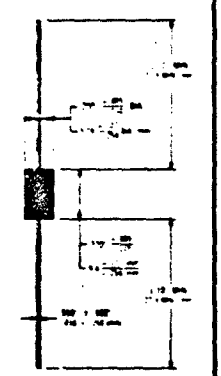
APPLICATION NOTE: Devices must be used with two units in parallel, opposite in polarity as shown in circuit for AC Signal Line protection.



CASE 1



CASE OUTLINE



SCHEMATIC

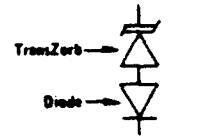


FIGURE 1—Peak Pulse Power vs Pulse Time

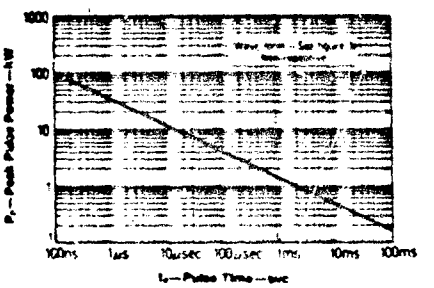
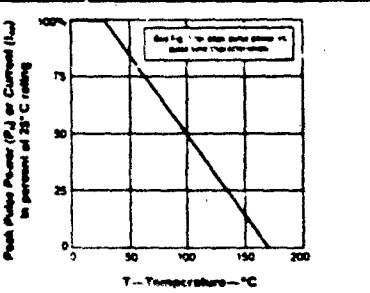


FIGURE 2—Derating Curve

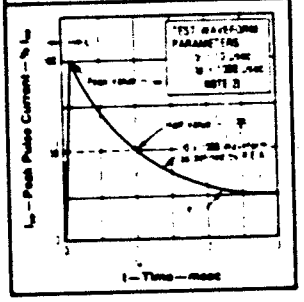


ELECTRICAL CHARACTERISTICS @ 25°C

Device	Reverse Stand-Off Voltage	Breakdown Voltage			Maximum Reverse Leakage	Maximum Clamping Voltage	Peak Pulse Current	Capacitance	Working Inverse Blocking Voltage	Reverse Leakage Current	Peak Inverse Blocking Voltage
	V_R	V_BR			I_R	V_C	I_PP	C	V_WIB	I_R	V_PIB
	Volts	Volts			μA	Volts	Amps	pF	Volts	μA	Volts
		Min	Max	mA							
LCE5.0	5.0	6.40	7.00	10	800	9.2	113	8000	5.0	5.0	8.0
LCE5.0A	5.0	6.40	7.07	10	800	9.2	113	8000	5.0	5.0	8.0
LCE6.0	6.0	6.67	7.37	10	800	10.3	100	6500	6.0	5.0	9.0
LCE6.0A	6.0	6.67	7.37	10	800	10.3	100	6500	6.0	5.0	9.0
LCE6.5	6.5	7.22	7.98	10	500	11.2	93	5500	6.5	5.0	10.0
LCE6.5A	6.5	7.22	7.98	10	500	11.2	93	5500	6.5	5.0	10.0
LCE7.0	7.0	7.78	8.60	10	200	12.0	87	5000	7.0	5.0	10.5
LCE7.0A	7.0	7.78	8.60	10	200	12.0	87	5000	7.0	5.0	10.5
LCE7.5	7.5	8.33	9.21	10	100	12.9	81	4500	7.5	5.0	11.3
LCE7.5A	7.5	8.33	9.21	10	100	12.9	81	4500	7.5	5.0	11.3
LCE8.0	8.0	8.89	9.83	1	50	13.6	76	4000	8.0	5.0	12.0
LCE8.0A	8.0	8.89	9.83	1	50	13.6	76	4000	8.0	5.0	12.0
LCE8.5	8.5	9.44	10.5	1	20	14.4	72	3800	8.5	5.0	12.8
LCE8.5A	8.5	9.44	10.4	1	20	14.4	72	3800	8.5	5.0	12.8
LCE9.0	9.0	10.0	11.1	1	10	15.4	68	3600	9.0	5.0	13.5
LCE9.0A	9.0	10.0	11.1	1	10	15.4	68	3600	9.0	5.0	13.5
LCE10	10	11.1	12.3	1	5	17.0	62	3400	10	5.0	15.0
LCE10A	10	11.1	12.3	1	5	17.0	62	3400	10	5.0	15.0
LCE11	11	12.2	13.5	1	5	18.2	58	3200	11	5.0	16.5
LCE11A	11	12.2	13.5	1	5	18.2	58	3200	11	5.0	16.5
LCE12	12	13.3	14.7	1	5	19.9	53	3000	12	5.0	18.0
LCE12A	12	13.3	14.7	1	5	19.9	53	3000	12	5.0	18.0
LCE13	13	14.4	15.9	1	5	21.5	49	2900	13	5.0	19.5
LCE13A	13	14.4	15.9	1	5	21.5	49	2900	13	5.0	19.5
LCE14	14	15.6	17.2	1	5	23.2	45	2800	14	5.0	21.0
LCE14A	14	15.6	17.2	1	5	23.2	45	2800	14	5.0	21.0
LCE15	15	16.7	18.4	1	5	24.4	43	2700	15	5.0	22.5
LCE15A	15	16.7	18.5	1	5	24.4	43	2700	15	5.0	22.5
LCE16	16	17.8	19.8	1	5	26.0	40	2600	16	5.0	24.0
LCE16A	16	17.8	19.7	1	5	26.0	40	2600	16	5.0	24.0
LCE17	17	18.9	21.0	1	5	27.6	38	2500	17	5.0	25.5
LCE17A	17	18.9	20.9	1	5	27.6	38	2500	17	5.0	25.5
LCE18	18	20.0	22.1	1	5	29.2	36	2400	18	5.0	27.0
LCE18A	18	20.0	22.1	1	5	29.2	36	2400	18	5.0	27.0
LCE20	20	22.2	24.5	1	5	32.4	32	2200	20	5.0	30.0
LCE20A	20	22.2	24.5	1	5	32.4	32	2200	20	5.0	30.0
LCE22	22	24.4	26.9	1	5	35.5	29	2100	22	5.0	33.0
LCE22A	22	24.4	26.9	1	5	35.5	29	2100	22	5.0	33.0
LCE24	24	26.7	29.5	1	5	38.9	27	2000	24	5.0	36.0
LCE24A	24	26.7	29.5	1	5	38.9	27	2000	24	5.0	36.0
LCE26	26	28.9	31.9	1	5	42.1	25	1900	26	5.0	39.0
LCE26A	26	28.9	31.9	1	5	42.1	25	1900	26	5.0	39.0
LCE28	28	31.1	34.4	1	5	45.5	24	1800	28	5.0	42.0
LCE28A	28	31.1	34.4	1	5	45.5	24	1800	28	5.0	42.0
LCE30	30	33.3	36.8	1	5	48.4	23	1700	30	5.0	45.0
LCE30A	30	33.3	36.8	1	5	48.4	23	1700	30	5.0	45.0
LCE33	33	36.7	40.6	1	5	53.3	21	1600	33	5.0	49.5
LCE33A	33	36.7	40.6	1	5	53.3	21	1600	33	5.0	49.5
LCE36	36	40.0	44.2	1	5	58.1	20	1500	36	5.0	54.0
LCE36A	36	40.0	44.2	1	5	58.1	20	1500	36	5.0	54.0
LCE40	40	44.4	49.1	1	5	64.5	18	1400	40	5.0	60.0
LCE40A	40	44.4	49.1	1	5	64.5	18	1400	40	5.0	60.0
LCE43	43	47.8	52.8	1	5	69.4	17	1300	43	5.0	64.5
LCE43A	43	47.8	52.8	1	5	69.4	17	1300	43	5.0	64.5
LCE45	45	50.0	55.3	1	5	72.7	16	1300	45	5.0	67.5
LCE45A	45	50.0	55.3	1	5	72.7	16	1300	45	5.0	67.5
LCE48	48	53.3	58.9	1	5	77.4	15	1200	48	5.0	72.0
LCE48A	48	53.3	58.9	1	5	77.4	15	1200	48	5.0	72.0
LCE51	51	56.7	62.7	1	5	82.4	14	1100	51	5.0	76.5
LCE51A	51	56.7	62.7	1	5	82.4	14	1100	51	5.0	76.5
LCE54	54	60.0	66.3	1	5	87.1	13	1100	54	5.0	81.0
LCE54A	54	60.0	66.3	1	5	87.1	13	1100	54	5.0	81.0
LCE58	58	64.4	71.2	1	5	93.6	12	1000	58	5.0	87.0
LCE58A	58	64.4	71.2	1	5	93.6	12	1000	58	5.0	87.0
LCE60	60	66.7	73.7	1	5	96.8	11	1000	60	5.0	90.0
LCE60A	60	66.7	73.7	1	5	96.8	11	1000	60	5.0	90.0
LCE64	64	71.1	78.6	1	5	103.0	11	900	64	5.0	96.0
LCE64A	64	71.1	78.6	1	5	103.0	11	900	64	5.0	96.0
LCE70	70	77.8	86.0	1	5	113	10	900	70	5.0	105
LCE70A	70	77.8	86.0	1	5	113	10	900	70	5.0	105
LCE75	75	83.3	92.1	1	5	121	9.9	800	75	5.0	112
LCE75A	75	83.3	92.1	1	5	121	9.9	800	75	5.0	112
LCE78	78	86.7	95.8	1	5	126	9.5	800	78	5.0	117
LCE78A	78	86.7	95.8	1	5	126	9.5	800	78	5.0	117
LCE85	85	94.4	104	1	5	137	8.8	700	85	5.0	127
LCE85A	85	94.4	104	1	5	137	8.8	700	85	5.0	127
LCE90	90	100	111	1	5	146	8.2	700	90	5.0	135
LCE90A	90	100	111	1	5	146	8.2	700	90	5.0	135
LCE100	100	111	123	1	5	162	7.4	600	100	5.0	150
LCE100A	100	111	123	1	5	162	7.4	600	100	5.0	150
LCE110	110	122	135	1	5	177	6.8	600	110	5.0	165
LCE110A	110	122	135	1	5	177	6.8	600	110	5.0	165
LCE120	120	133	147	1	5	193	6.2	500	120	5.0	180
LCE120A	120	133	147	1	5	193	6.2	500	120	5.0	180
LCE130	130	144	159	1	5	209	5.7	500	130	5.0	195
LCE130A	130	144	159	1	5	209	5.7	500	130	5.0	195
LCE150	150	167	204	1	5	243	4.9	400	150	5.0	225
LCE150A	150	167	185	1	5	243	4.9	400	150	5.0	225
LCE160	160	178	219	1	5	259	4.6	400	160	5.0	240
LCE160A	160	178	197	1	5	259	4.6	400	160	5.0	240
LCE170	170	189	231	1	5	304	4.9	400	170	5.0	255
LCE170A	170	189	209	1	5	275	5.4	400	170	5.0	255

TransZorb

FIGURE 3—Pulse Waveform



NOTES

Note 1: A TransZorb is normally selected according to the reverse Stand Off voltage (V_R) which should be equal to or greater than the DC or continuous peak operating voltage level.

Note 2: Capacitor Discharge Test Circuit see Figure 5 Page 4-43

ABBREVIATIONS & SYMBOLS

V_R — Stand-Off Voltage Applied Reverse Voltage to assure a nonconductive condition. See Note 1.

BV_{min} — This is the minimum Breakdown Voltage the device will exhibit and is used to assure that conduction does not occur prior to this voltage level at 25°C.

V_{Cmax} — Maximum Clamping Voltage The maximum peak voltage appearing across the TransZorb when subjected to the peak pulse current in a one millisecond time interval. The peak pulse voltages are the combination of voltage rise due to both the series resistance and thermal rise.

I_{PP} — Peak Pulse Current — See Figure 3

P_{PP} — Peak Pulse Power

I_R — Reverse Leakage

General Semiconductor Industries, Inc.

SQUARE D COMPANY

TRANSZORB® TRANSIENT VOLTAGE SUPPRESSORS BIDIRECTIONAL

PHP5.4 THRU PHP500 AND PIP5.4 THRU PIP500

FEATURE

- 7,500 and 15,000 watts Peak Pulse Power dissipation
- Available in ranges from 8.4 to 500 volts
- Designed for Military (PHP series) ‡ and commercial (PIP series)
- UL Recognized (PIP120)
- Each device 100% tested

MAXIMUM RATINGS

- 7,500 and 15,000 watts Peak Pulse power dissipation at the 1 msec pulse and 25°C (see derating curve)
- Operating and Storage temperatures -65° to +175°C
- Average Steady State power dissipation at 50°C 7.5 watts
- (0 volts to BV) Less than 1×10^{-9} seconds

MECHANICAL CHARACTERISTICS

- Molded Case
- Weight .46 grams (approximate)
- Bipolar for AC Applications
- Body marked with Logo and type number

‡ Military Applications PHP SERIES Modules can have design consistency with the following MILITARY requirements as controlling specifications

- MIL-STD-1399
- MIL-E-16400
- MIL-STD-704
- MIL-S-19500/507

APPLICATION

PHP/PIP series is designed for applications requiring "across-the-line" AC power protection. These TransZorb® modules are used in applications where extreme voltage transients can permanently damage voltage sensitive systems or components. These devices are most often used when discrete TransZorbs do not have high enough power requirements to suppress large power surges.

DESCRIPTION

TransZorb modules can be used to protect equipment from induced lightning, power surges and transients originating from inductive switching or power interrupt. The modules have been successfully used for both commercial and military applications, including telecommunications, aircraft, shipboard, central office switching and PABX, CATV distribution, computers, distributed data processing, and power supplies.

For military applications, the PHP module sub-assemblies are packaged in a hermetically sealed glass-to-metal package. Also available screened in accordance with MIL-S-19500/507.

CASE 22

FIGURE 1—Peak Pulse Power vs Pulse Time

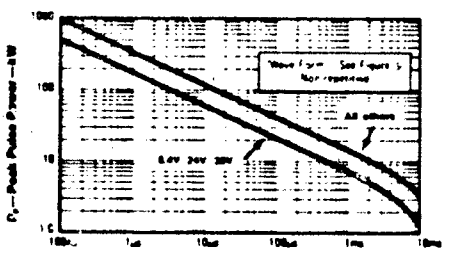
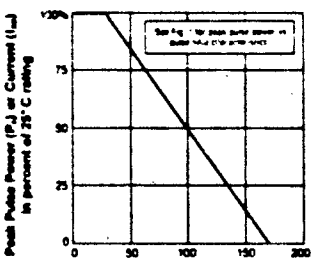


FIGURE 2—Derating Curve



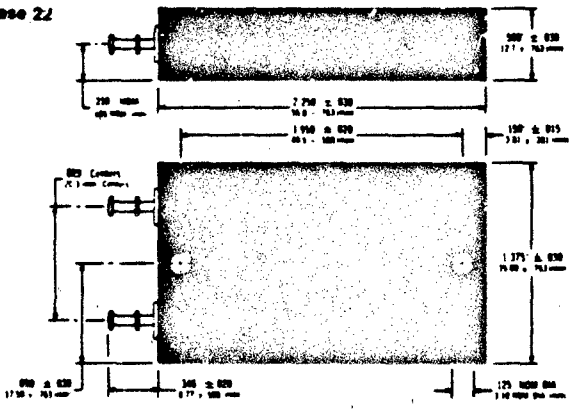
ELECTRICAL CHARACTERISTICS @ 25°C

GENERAL SEMICONDUCTOR PART NUMBER	REVERSE STAND-OFF VOLTAGE VOLTAGE VOLTS AC	REVERSE STAND-OFF VOLTAGE (NOTE 1) V_R VOLTS DC	MINIMUM BREAKDOWN VOLTAGE BV VOLTS @ I mA	MAXIMUM REVERSE LEAKAGE @ V_R I_R MICRO AMPERES	MAXIMUM CLAMPING VOLTAGE V_C @ I_{PP} VOLTS DC	MAXIMUM PEAK PULSE CURRENT (FIG. 3) I_{PP} A	MAXIMUM PEAK PULSE POWER (1 MSEC) P_P KILOWATTS
PHP 8.4	8.4	12.0	14 10	250	22	341	7.5
PHP 24	24.0	34.0	40 10	250	67	112	7.5
PHP 30	30.0	42.5	50 1.0	250	84	90	7.5
PHP 60	60.0	85.0	100 1.0	250	167	90	15.0
PHP 120*	120.0	170.0	200 1.0	250	319	47	15.0
PHP 208	208.0	295.0	347 1.0	250	536	28	15.0
PHP 250*	250.0	354.0	418 1.0	250	652	23	15.0
PHP 440	440.0	623.0	735 1.0	250	1138	13.2	15.0
PHP 500*	500.0	708.0	835 1.0	250	1292	11.6	15.0
PIP 8.4	8.4	12.0	14 10	250	22	341	7.5
PIP 24	24.0	34.0	40 10	250	67	112	7.5
PIP 30	30.0	42.5	50 1.0	250	84	90	7.5
PIP 60	60.0	85.0	100 1.0	250	167	90	15.0
PIP 120*	120.0	170.0	200 1.0	250	319	47	15.0
PIP 208	208.0	295.0	347 1.0	250	536	28	15.0
PIP 250*	250.0	354.0	418 1.0	250	652	23	15.0
PIP 440	440.0	623.0	735 1.0	250	1138	13.2	15.0
PIP 500*	500.0	708.0	835 1.0	250	1292	11.6	15.0

Special Voltages available from factory. *Recommended for marine applications

CASE OUTLINE

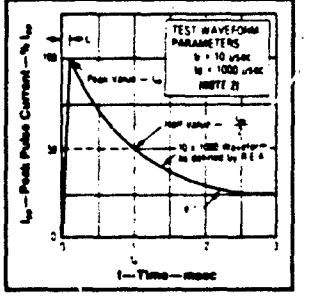
Case 22



MILITARY APPLICATIONS: PHP series sub-assemblies are packaged in a hermetically sealed glass-to-metal package, available with design consistency to MIL-S-19500/507.

COMMERCIAL APPLICATIONS: PIP series sub-assemblies are packaged in a molded epoxy case.

FIGURE 3—Pulse Waveform



NOTES

Note 1: A TransZorb is normally selected according to the reverse Stand Off Voltage (V_R) which should be equal to or greater than the DC or continuous peak operating voltage level

Note 2: Capacitor Discharge Test Circuit see Figure 5, Page 1-3

ABBREVIATIONS & SYMBOLS

V_R Stand-Off Voltage Applied Reverse Voltage to assure a nonconductive condition (See Note 1)

BV(min) This is the minimum Breakdown Voltage the device will exhibit and is used to assure that conduction does not occur prior to this voltage level at 25° C

V_C(max) Maximum Clamping Voltage The maximum peak voltage appearing across the TransZorb when subjected to the peak pulse current in a one millisecond time interval The peak pulse voltages are the combination of voltage rise due to both the series resistance and thermal rise

I_{PP} Peak Pulse Current — See Figure 3

P_P Peak Pulse Power

I_R Reverse Leakage

General Semiconductor Industries, Inc.

SQUARE D COMPANY

BIDIRECTIONAL SURGE SUPPRESSORS

GHV-2 THRU GHV-18

MAXIMUM RATINGS

- Steady State Power: 1 Watt at 50°C.
- $t_{clamping}$ (0 volts to BV min): Less than 1×10^{-9} second (theoretical)
- Operating and Storage temperatures: -65° to +150°C
- Surge: 30 Amps, 8.4 msec
  100 Amps, 1.0 msec
  (capacitance, decay to 50%)

MECHANICAL CHARACTERISTICS

- Molded case
- Solderable leads
- Body marked with Logo and type number

APPLICATION

The GHV series devices are silicon transient voltage suppressors designed for protection against large voltage transients on signal lines. They are low capacitance, low noise devices which can be used directly across the input of analog and digital circuitry with minimum signal loss.

Their small size and high surge current capability make them ideal suppressors for telephone and CATV repeaters, replacing typical varistor series "strings" which consume much needed space. The device has been proven effective in lightning environments.

DESCRIPTION

The GHV series products combines the technology of forward biased P-N junction varistor, stacked to provide

DESCRIPTION CONT'D

symmetrical voltage characteristics of a non-biased resistor. An additional feature of this method of manufactured low voltage protection, is the reduction of capacitance for low voltage signal line protection.

FIGURE 1-Voltage Current Characteristic Curves

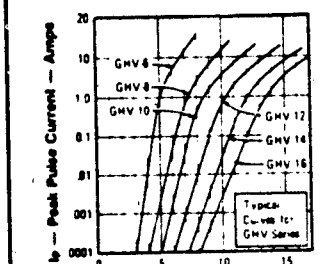
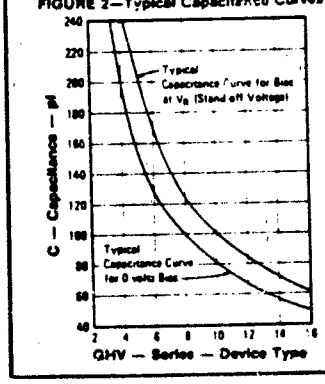
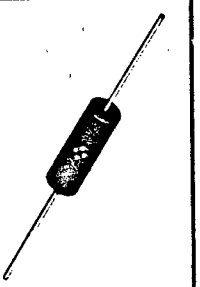


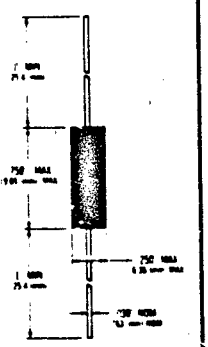
FIGURE 2—Typical Capacitance Curves



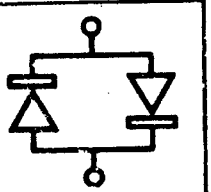
CASE 19



CASE OUTLINE



SCHEMATIC



ELECTRICAL CHARACTERISTICS @ 25°C Unless Otherwise Noted

AS PART NUMBER	BREAKDOWN VOLTAGE @ 1.0 mA BV=5%	STAND-OFF VOLTAGE VR	MAXIMUM LEAKAGE CURRENT @ VR	MAXIMUM CAPACITANCE @ 0 V, 1MHz	TYPICAL TEMP. COEFF. OF BV
	VOLTS	VOLTS	μA	pf	mv/°C
GHV-2	1.33	8	10	517	—4
GHV-3	2.0	1.2	10	319	—6
GHV-4	2.7	1.6	10	259	—8
GHV-5	3.3	2.0	10	191	—10
GHV-6	4.0	2.4	10	159	—12
GHV-7	4.7	2.8	10	140	—14
GHV-8	5.4	3.2	10	130	—16
GHV-9	6.0	3.6	10	114	—18
GHV-10	6.7	4.0	10	102	—20
GHV-11	7.3	4.4	10	93	—22
GHV-12	8.0	4.8	10	86	—24
GHV-13	8.7	5.2	10	79	—26
GHV-14	9.4	5.6	10	74	—28
GHV-15	10.0	6.0	10	67	—30
GHV-16	10.7	6.4	10	62	—32

General Semiconductor Industries, Inc.

SQUARE D COMPANY

BIDIRECTIONAL VARISTOR GSV SERIES

MAXIMUM RATINGS

- Steady State Power: 1 Watt at 50°C
- $t_{clamping}$ (0 volts to 8V min): Less than 1×10^{-8} second (theoretical)
- Operating and Storage temperatures: -65° to +175°C
- Surge: 30 Amps, 8.4 msec at 25°C. 70 Amps, 1.0 msec at 25°C.

MECHANICAL CHARACTERISTICS

- Molded Case
- Bidirectional
- Body marked with Logo and type number

APPLICATION

These varistors consist of two matched silicon junctions connected in parallel and opposite in polarity. They are designed to replace copper oxide varistors in telephone equipment and for numerous applications ranging from fractional voltage regulators, negative temperature coefficient resistors, signal limiters and expandors and meter protection. The GSV varistors are packed in a plastic encapsulated material. Higher voltage devices are also available from the factory. They are ideal for zener diode compensation meter/galvanometer protection, threshold limiters and wave shaping.

DESCRIPTION

The term varistor defines a voltage resistor that is symmetrical. The GSV varistor is a PN junction device employing a pair of parallel-connected, matched, oppositely-poled, silicon

DESCRIPTION CONT'D

diodes. They are packed in a plastic encapsulated material exhibiting exceptional durability and reliability.

GSV devices are designed for controlled protection at various current levels in addition to the peak pulse current rating of 70 amps.

FIGURE 1—Ambient Temperature Coefficient of Voltage vs Varistor Current

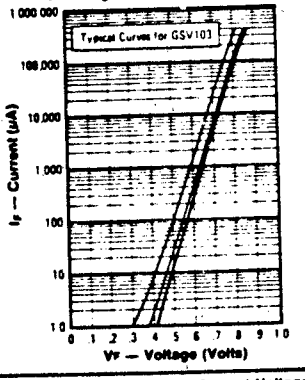
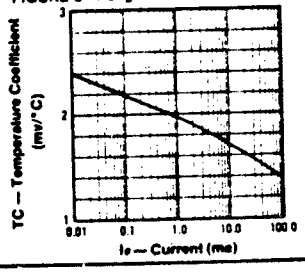
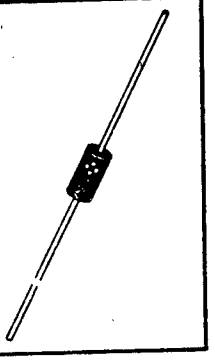


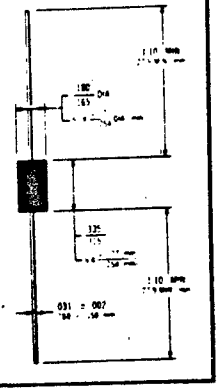
FIGURE 2—Range Curve, Current-Voltage



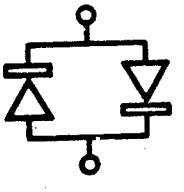
CASE 21



CASE OUTLINE

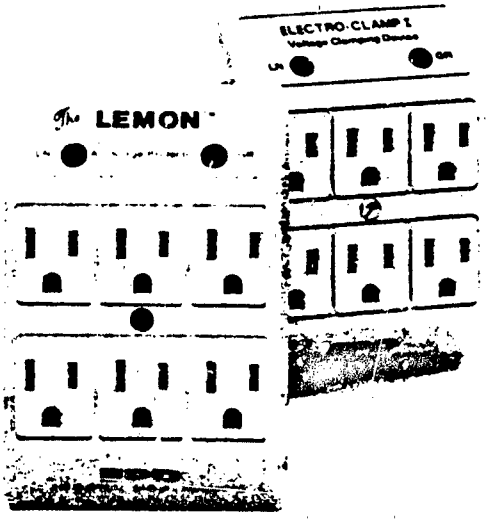


SCHEMATIC



ELECTRICAL CHARACTERISTICS @ 25°C (Both Polarities)

TYPE	SYMBOL	CONDITIONS	LIMITS min.	LIMITS max.	UNITS
GSV101	V_F	10 μAmps	.35	.50	Volts
	V_F	100 mAmps	.74	.85	Volts
GSV102	V_F	100 m Amps	.74	.95	Volts
	I_F	.2 Volts		.10	μAmps
GSV103	V_F	1 μAmps	.30	.45	Volts
	V_F	10 μAmps	.40	.50	Volts
	V_F	100 μAmps	.48	.58	Volts
	V_F	1 mAmps	.56	.66	Volts
	V_F	10 mAmps	.65	.74	Volts
	V_F	100 mAmps	.75	.82	Volts
GSV201	V_F	20 μAmps	.70	1.00	Volts
	V_F	100 mAmps	1.48	1.70	Volts

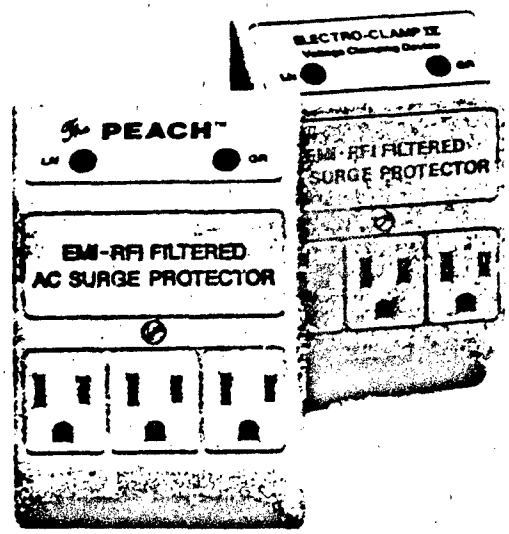


The Fruits Of Our Labor

A bushel of surge protection products for every need. All are UL pending and CSA listed and contain solid state circuit technology. Two LED lights are your visual assurance that full protection is provided. The red light indicates normal mode or line to line protection while the green light indicates common mode or ground protection is being provided. When on, they indicate that the unit is functioning properly.

The LEMON™ and EC-I™
AC Surge Protector

- Forward surge rating at 25°C—1440 Amps for 1/120 sec.
- Peak pulse power dissipation at 25°C—10,800W for one ms
- Steady state heat dissipation at 25°C—40W
- Clamping voltage—line to line (normal mode) ground (common mode)
- Duty cycle—01% at above rating
- Clamping response time 5 nanoseconds (5×10^{-9} sec.)
- Dielectric test—3000 VAC 60 sec
- Operating temperature—−40°C to +75°C
- 15 Amp, 125 VAC
- 6 outlets



The PEACH™ and EC-IV™

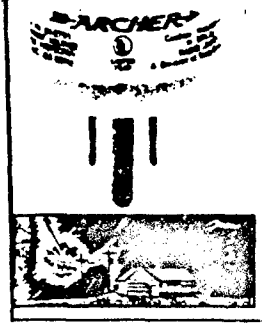
EMI-RFI Filtered
AC Surge Protector

- Forward surge rating at 25°C—1440 Amps for 1:120 sec
- Peak pulse power dissipation at 25°C—10,800W for one ms
- Clamping voltage—line to line (normal mode) ground (common mode)
- Duty cycle—01% at above rating
- Clamping response time 5 nanoseconds (5×10^{-9} sec.)
- Dielectric test—3000 VAC 60 sec
- Operating temperature—−40°C to + 75°C
- 15 Amp, 125 VAC, 1875 Watts
- Mode noise protection—normal and common
- Noise rejection—frequency 150KHZ-30MHZ
- Attenuation—5db-37db continuous duty
- 3 outlets

ARCHER® ACCESSORIES FOR HOME OR WORKSHOP

Voltage Spike Protector With Status Indicator Light

7.95 NEW FOR '85



- Guards Against Brief High-Voltage Surges in Electrical Systems
- Protects Electronic Components

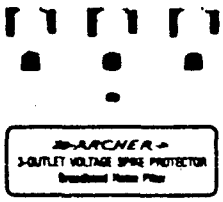
Acts as safety valve by absorbing damaging high-voltage transients without interfering with normal current flow. Easy to use, no wiring necessary, just plug it in. Built-in light indicates protection circuit is functioning properly. Rated 15 amps. U.L. listed.
61-2791 ..... 7.95

Noise Filter/Voltage Spike Protecter

21.95

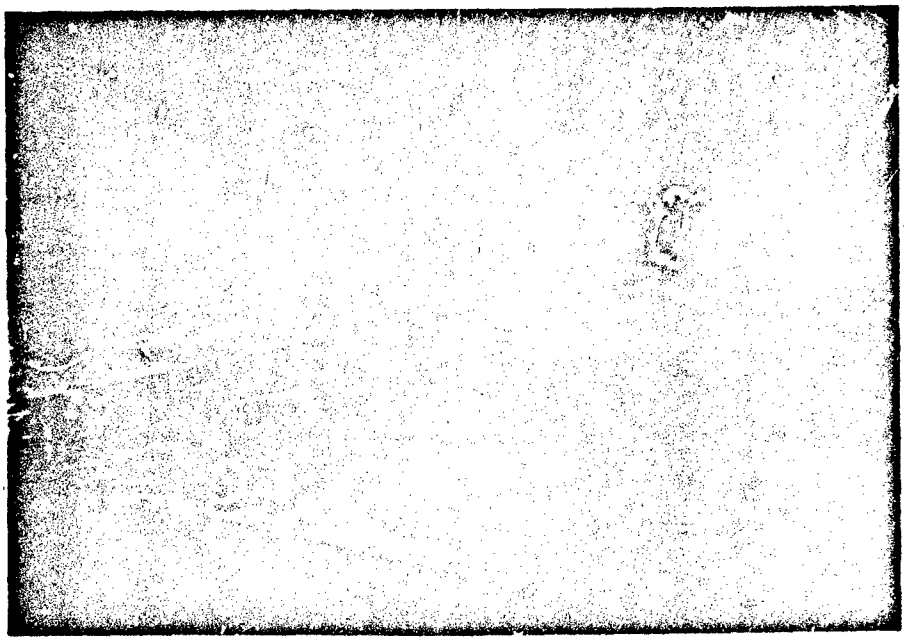
- Ideal for Expensive Audio, Video and Computer Systems
- Plugs into Existing Grounded AC Outlet

Guards sensitive equipment from line noise and harmful spikes. Toroid coil filter protects electronic equipment from noise in 0.5 to 5 MHz range, and prevents equipment-generated noise from entering line. MOV spike protecter absorbs power surges that could damage ICs. Neon indicator shows all circuits functioning. Three-wire. Rated 10A at 120VAC. U.L. listed. 61-2785 ..... 21.95



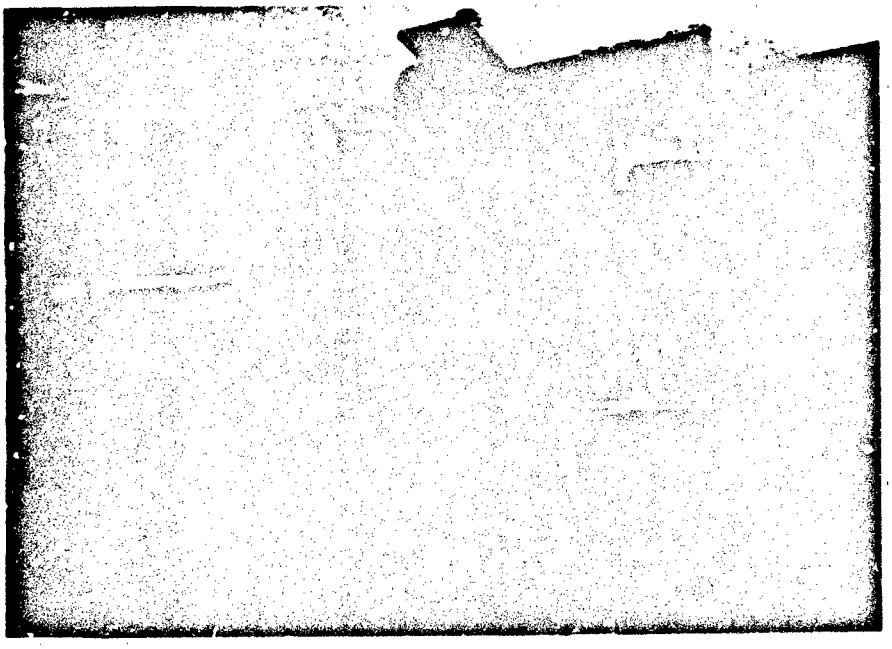
SECION 5

Test Photographs

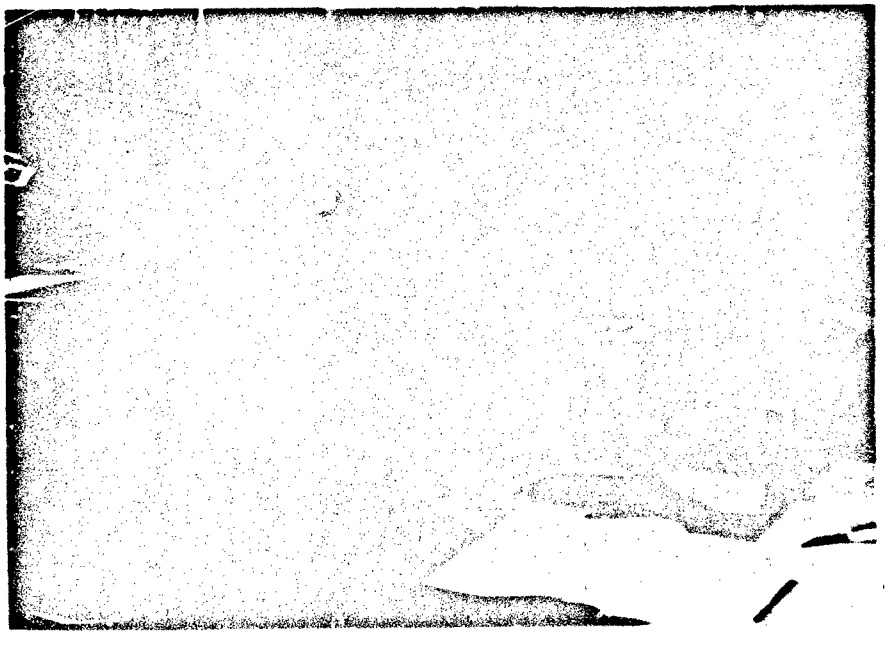


Large Pulser – Used for 25,000 Volt Test

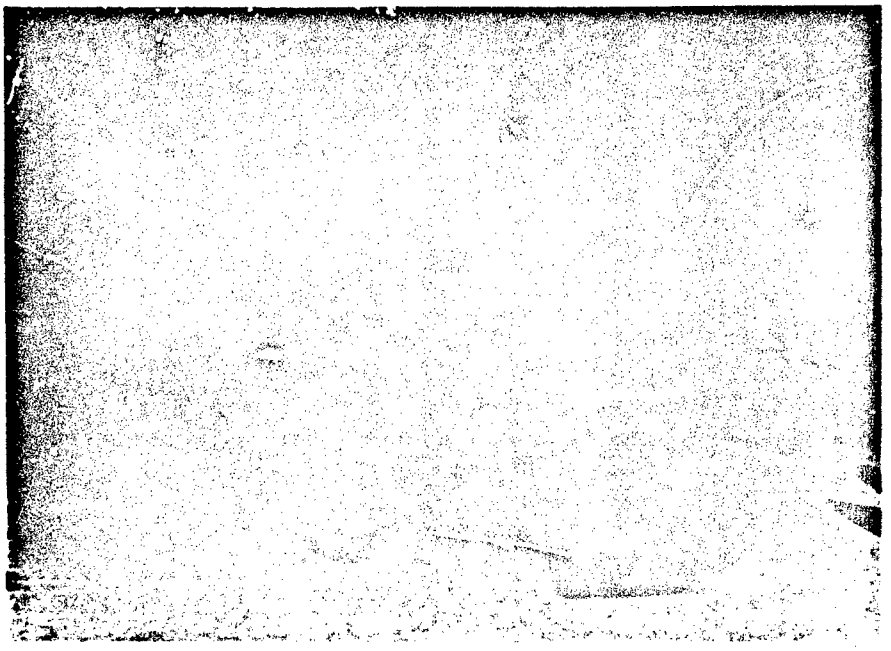
Large Pulser Trigger Circuitry and Varistor in Test Configuration



Small Pulser Used for 600 Volt and 4,500 Volt Test

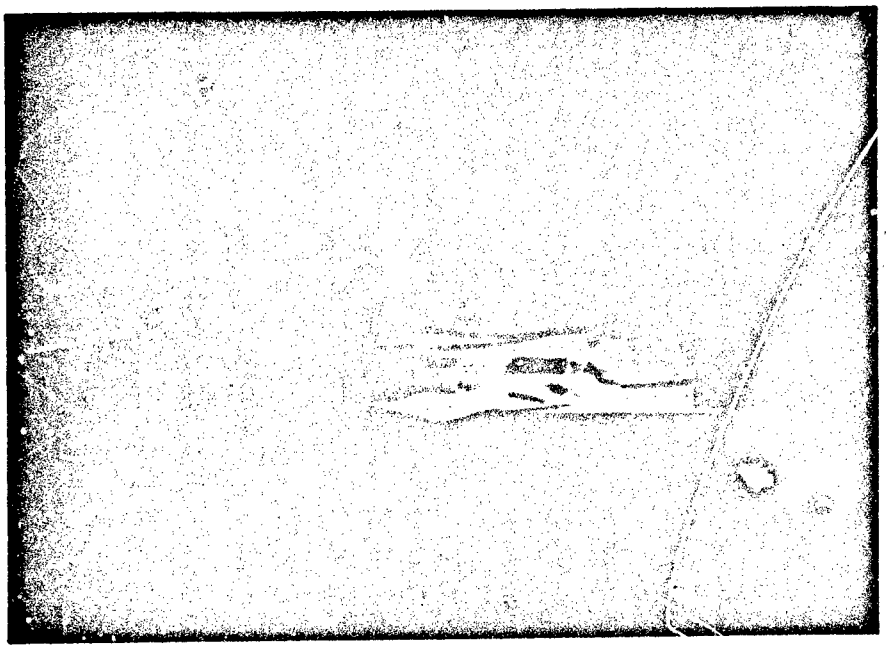


Small Pulser, Pulse Trigger, Oscilloscope and Camera

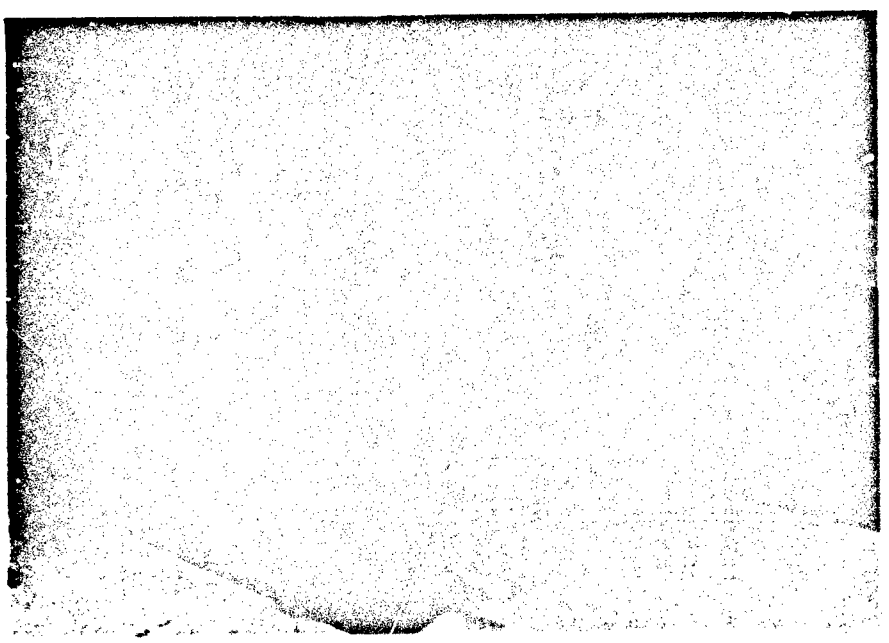


Small Pulser in Configuration to Take Reference Pulse for AC Power Suppression Test

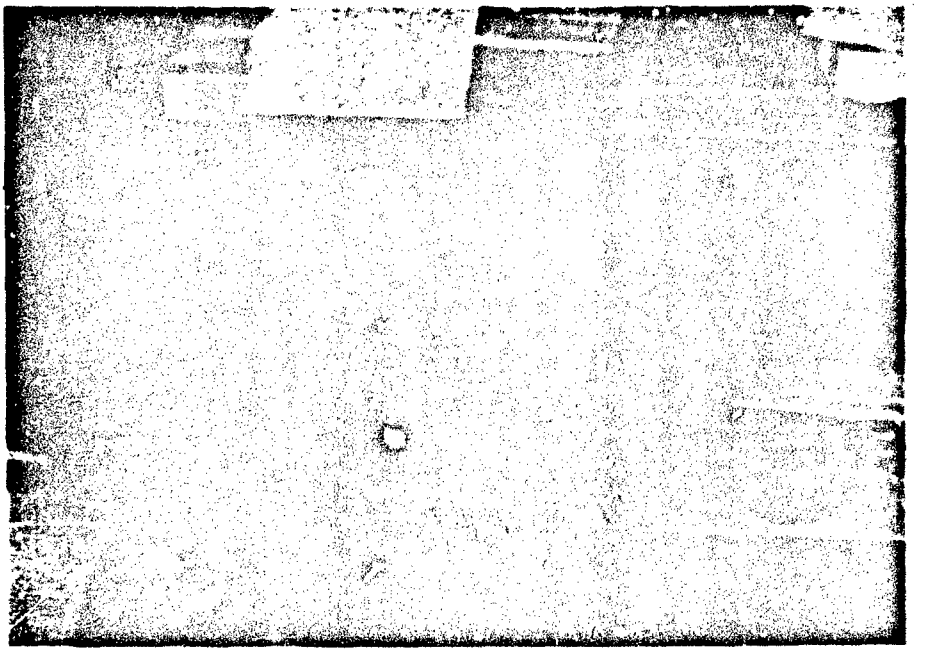
Copper Sulfate Resistors – 50 Ohms



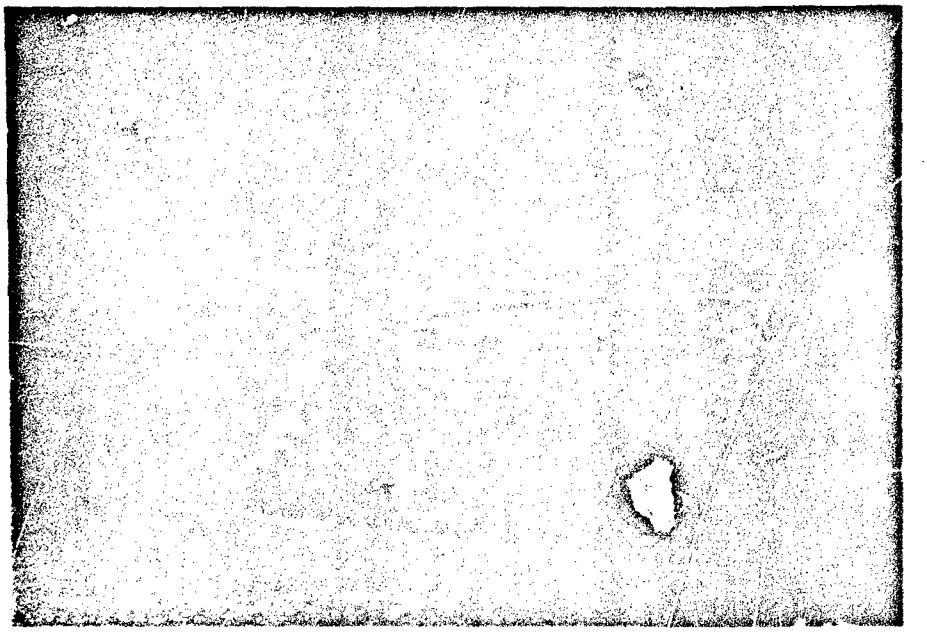
Test Bench, DC Power Supply, Small Pulser



Small Pulser with AC Power Suppression Device in Test Configuration



Network Analyzer and Special Test Rig



Special Test Rig with Varistors and Ferrite Beads

Section 6

TEST PLAN
FOR
TRANSIENT THREAT TESTING OF
AMATEUR RADIO EQUIPMENT

July 25, 1985

Contents

OVERVIEW

There exists a generally recognized need for transient protection of all communication equipment deemed essential to carrying out the command and control function of the government in any natural or man-made disaster. While existing government programs have addressed the protection problem for government owned equipment, only limited organized effort has been made to protect privately owned radio equipment which could be pressed into such emergency service. This program has initiated the definition of survivability procedures and inexpensive transient protection packages suitable for use by radio amateurs in protecting their equipment against fast-rising pulses, and tested the suitability of package components. This phase of the test program should demonstrate that the procedures and protection packages will reduce the chance of equipment failure under transient threat. Sixteen standard radio station configurations will be tested, with and without protection, by exposure to fast-rising pulses, and the results of testing reported.

BACKGROUND

With the increasing incorporation of minature solid state devices in commercial radio equipment used by the American radio amateur, the vulnerability of the equipment to such fast-rising transients as EMP has also increased. An earlier phase of this test program was conducted to "qualify" an inexpensive selection of transient protective devices for use in protection packages by radio amateurs, with specific packages to be designed and tested in this phase of the program.

Several EMP test and assessment programs conducted by the government have enabled reasonable bounds to be assigned to currents and voltages generated as a result of exposure of typical radio antennas and power lines to simulated or calculated EMP. Use of these bounding values, appropriately scaled to the threat field chosen for this program, will enable substitution of directly injected transients into the equipment ports instead of requiring the entire station configuration to be placed within the simulated threat field. The actual volume of the test simulation will then be reduced to a size convenient for indoor testing.

In this phase of the program, survivability recommendations and protection packages are being considered for sixteen amateur radio configurations, including both tube-type and solid-state HF station equipment, hand-held transceivers, and satellite transceivers. Criteria for selection of devices for the packages include price, qualification against a simulated EMP through an earlier phase of this test program, and suitability for the required application. If the recommended procedures and assembled protection packages can be proven effective by testing in a simulated EMP field, then the benefits of their use by the ameteur radio community can be easily demonstrated.

CONCEPT

The planned concept for this phase of the test program was previously developed.

Sixteen standard configurations will be subjected to transient threat fields of 25 and 50 kilovolts per meter to determine:

a) susceptibility of the equipment to the fields in an unwired and switched "off" mode.

b) susceptibility of the equipment to the fields with interconnecting wiring in place, but still switched "off".

c) susceptibility of the equipment to the fields with interconnecting wiring in place and equipment switched "on," but no external peripheral devices attached.

d) susceptibility of the equipment to the fields with all wiring and peripherals in place and protected by transient protection packages, equipment switched "on," and external connection ports driven by injected signal appropriate to the threat level, with equipment orientation varied within the field.

e) susceptibility of the equipment to the fields with all wiring and peripherals in place and not protected at all, equipment switched "on," and external connection ports driven by injected signal appropriate to the threat level.

A standard objective test is described to determine that a system remains functional during all aspects of testing.

THREAT DEFINITION

Field Requirement:

Other than the case of a direct lightning stroke, EMP is generally considered a more stringent threat to electrical systems than lightning. Consequently, the verification test fields must rise to full strength in fewer than 10 nanoseconds and decay exponentially in about one microsecond. Theoretical current peaks in excess of thousands of amperes have been predicted as response to EMP. Similarly, voltages may reach hundreds of kilovolts. Expected values for injection into the systems under test will be scaled in proportion to the expected field levels and practical limitations imposed by the typical amateur station. Testing will be conducted at the expected threat level for each configuration.

The maximum electric field level expected from transients in this program has been established as fifty kilovolts per meter. Using the free space relationship between electric and magnetic fields would require a corresponding magnetic field of 133 amps per meter. Either quantity, electric or magnetic field, may be utilized to determine field acceptability.

Injection Limitations:

Normal coaxial cables available to amateur station operators are limited in voltage handling capacity by their dielectric breakdown levels in the insulation and by air gaps in connectors. DC strikeover in the range of 4 to 6 kilovolts is considered normal performance for such cables, and will be verified for the radio equipment under test. In the case of fast rising pulses, the strikeover values will be higher, but it is considered highly unlikely that voltages in excess of twice the DC strikeover could be delivered through normal cables. Therefore, injection pulses for coax connectors on the equipment will be designed to exceed twelve kilovolts (240 amperes into a 50 ohm load) at the antenna end before any installed protection as a practical worst case.

In a similar manner, residential wiring practices and circuit branch panels impose a practical limit on the response of AC power wiring to a transient pulse. It has been predicted by Boeing Aerospace Company that six kilovolts is a reasonable worst case for an EMP transient through military branch circuits. Because a 50 ohm impedance to high frequency current is considered reasonable in the AC power system, an injection pulse of 120 amperes is considered sufficient to impose a practical transient threat to a home radio station power system.

Each protection configuration will be subjected to more than one pulse at the maximum determined levels, in order to ensure that protection is not circumvented by the first threat transient received. When it is apparent that damage to the radio equipment has been caused by the transient, that equipment and any similar equipment will be immediately withdrawn from testing until suitable protective devices have been installed.

Injection Pulse Sources

The previously defined stress pulses for injection into equipment configurations before protection may be obtained by utilization of a suitable pickup antenna within the test volume. The injection pulses will be verified to ensure their magnitude and rise time are within criteria for EMP transient response and the practical limitations previously cited. Actual home radio station antennas are available in the test program for insertion in the test volume. Output from these, if sufficient in magnitude, may be used as one or more of the injection pulses.

EQUIPMENT CONFIGURATION

Each radio system under test will be configured in a realistic manner with a simple antenna and power supply connection. There is no assurance that a typical amateur radio station will receive any inherent electromagnetic shielding from the building structure, so these tests will be conducted with the radio equipment exposed to the full field unless it is determined that shielding is required as part of the protection package. Maximum electrical stress of the equipment will occur when differential voltages rise between components within each circuit. Such differential voltages are maximized when the equipment chassis is held at or near ground potential while the transient is imposed on the circuit. This effect will be ensured by locating the equipment under test directly on the metal floor (ground plane) of the simulator, with a low impedance ground strap connecting each chassis to the ground plane.

Connection of AC power will be by means of the standard cords supplied by the radio manufacturer to a circuit distribution box within the test volume. AC power for the radio equipment may be totally isolated from that supplying the simulation apparatus to minimize undesireable effects on test instrumentation. If the radio power is isolated, both the neutral (white) and the safety ground (green) wire must be connected to the simulator ground plane at the circuit distribution box. This grounding is done to ensure maximum potential difference between the hot (black) lead and any other point within the circuit under test. Because of such grounding, the power injection pulse will be imposed only on the hot wire, but every protective power device validated under test must contain a circuit providing equivalent protection between neutral and ground to that provided between hot and ground.

Connection of DC power will be achieved by utilization of a six foot cord provided by the manufacturer connected to a fully charged automobile battery within the test volume. No additional signal will be injected onto the DC power supply other than its response to the actual simulator field.

Handheld units with self-contained power supplies will be tested within the simulator isolated from any conductors. Surviving units may also be tested in a charging mode, powered from the AC power source previously described, with injection of the power transient into the AC terminal of the charger.

EQUIPMENT CALIBRATION

Baseline Testing:

One of the most important aspects of this test program is the determination of acceptable performance by each of the amateur radio systems under test. Depending on its utilization in the radio system, a specific item of equipment could require differing power levels or sensitivities. For the purposes of this testing, therefore, an objective measurement series will be used to characterize the performance of each item of radio equipment. A measurement of output power (in watts) into a dummy load will be made for every band of each transmitting device. A sensitivity measurement for each receiver will be accomplished by determining the input signal required (in decibels) to obtain a calibrated signal strength as measured by the receiver's signal meter. Many of the systems under test have special features for ease of operation; these features will not be measured unless their absence severely limits the utility of the equipment.

This series of baseline measurements will be recorded for each of the sixteen amateur radio systems at the test site before any testing begins, and completely repeated after any transient pulsing of the system. Narrative comments will discuss any significant failures of system features which are observed.

Determination of Failure:

Equipment will not be removed from the test series unless it is considered totally incapable of performing its designed function. Such equipment will be immediately delivered to a repair facility to determine and replace the failed components, and suitable protection provided for those components before further testing of that equipment. In cases where the system under test is merely degraded in performance, the test series will be continued unless the test engineers determine that repairs are required before proceeding in order to preserve test integrity.

System upset is defined as a temporary malfunction of the system which may require operator intervention before the system can function again, e.g. cycling the power switch to restore memory to a microchip. System upset which can be easily overcome by an amateur operator without any physical repair will not be regarded as a system failure.

DATA ORGANIZATION

Equipment Control:

It is imperative that the various systems under test be carefully inventoried and managed to ensure that each transient exposure and its effect are properly recorded.

Reporting Requirements:

Field strength measurements will be required for every transient pulse imposed on equipment. After calibration of the field, a single scope photograph of the field sensor response of every pulse, suitably annotated, will suffice for this requirement.

When determining the magnitude of currents or voltages for injection pulses or antenna responses, the field sensor response will be simultaneously recorded to ensure that pulser output was of the intended magnitude.

Baseline results will be recorded in a standardized format for each system, with frequencies chosen to adequately represent each band available while allowing efficient completion of the intermediate baseline testing. Narrative comments of observations during each level of testing will be recorded both in the test log and on the baseline measurement sheets.

Sequence of Testing:

Testing will be performed in the sequence listed in the Concept section of this plan. If systems reach the final test phase (full field without protection), care will be taken to ensure that failure of a single peripheral will not eliminate a particular system from further testing. Any systems which appear to survive the full field without protection will be tested under load as a complete, powered system (either AC generator or DC battery) within the test volume.

Final Report:

A final report will be prepared which contains the data previously described, and provides a narrative characterization of the results of the test program for each system, including its observed susceptibility, and the effect of protective devices and procedures. A complete description of applicable protection will be included in the report.

TEST PROGRAM COORDINATION

Laboratory Responsibility:

Lab scientists of IRT Corporation will have sole responsibility for operation of the transient pulse sources and data recorders in a manner which provides maximum safety for personnel and government property not under test, including previously recorded test data.

Repair Facility:

Representatives of ESI will be responsible for obtaining any needed repairs to systems under test in a timely fashion. When repairs are made, they will be documented thoroughly for inclusion in the final report of testing.

TEST PROGRAM COORDINATION (continued):

Program Engineer(s):

Program engineers representing Electrospace Systems, Incorporated will assist the Lab Scientists in conducting the test program, including management of the equipment inventory and preparation of systems for testing. These personnel are responsible for baseline testing and review of results to determine additional tests required, with appropriate guidance from IRT scientists. Program engineers shall arrange for custody and transportation of test materials owned by the government, ESI or its other contractors, and for obtaining and safeguarding unclassified test data. No classified information will be utilized or generated by this program.

Section 7

Description of Equipment

YAESU FP-757HD
HEAVY DUTY POWER SUPPLY

FOR THE FT-757GX HF TRANSCEIVER

(ALSO FT-180, FT-180A, FT-77, FT-707)

The FP-757HD is an external AC power supply and speaker for use with the FT-757GX and other HF transceivers requiring 13.5 VDC at up to 20 amperes for extended periods.

Excellent regulation and conservative design assure the owner of many years of trouble-free operation, even in heavy duty applications, such as full power AM, FM or RTTY transmission. A thermally-switched cooling fan automatically activates during long periods of high current demand, to maintain safe operating temperature in the power supply.

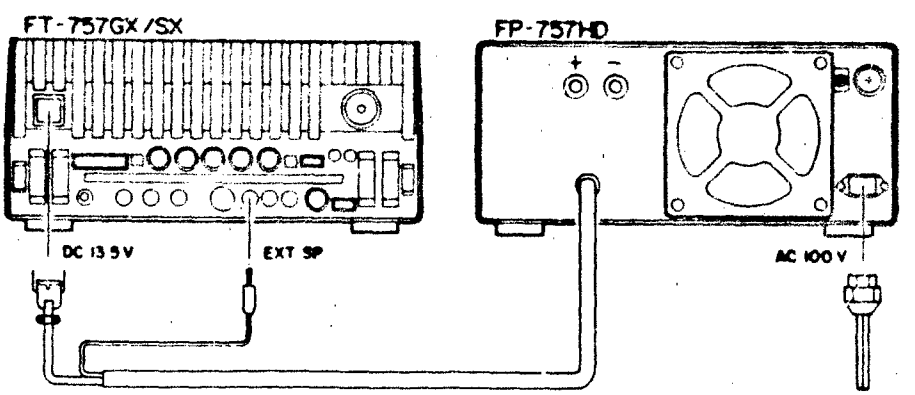
SPECIFICATIONS

Output voltage:	13.5 VDC
Output current:	20 amps extended duty cycle (30 minutes on/30 minutes off)
Ambient temperature:	0° to +40°C
Input voltage:	100/110/117/200/220/234 VAC, 50/60 Hz
Case dimensions:	93(H) x 240(W) x 235(D) mm
Weight:	Approx. 6.9 kg
Speaker output:	3 watts at 4 ohms

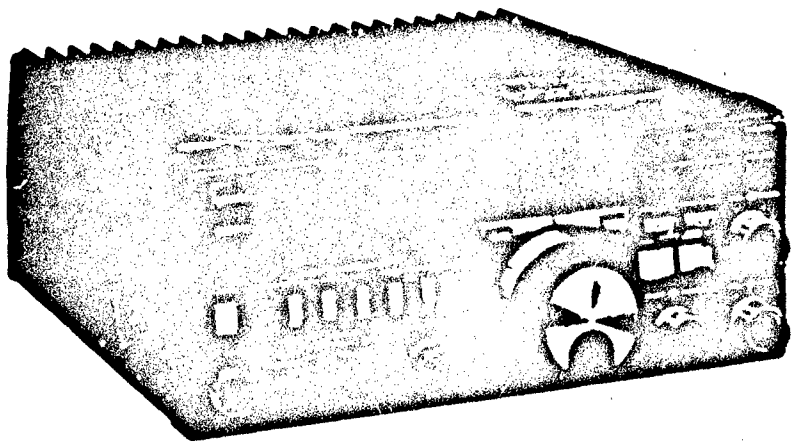
INSTALLATION

Before connecting the FP-757HD to any power source, be absolutely certain that the voltage specification on the rear panel matches your local supply voltage. The FP-757HD is manufactured for use around the world, from a variety of AC power sources, and the power transformer primary must be connected properly as shown on the reverse side of this page to prevent damage to the internal circuitry.

Also, be absolutely certain to use a fuse of the proper rating. For 100/110/117 VAC, use only a 6-amp fuse. For 200/220/234 VAC, use only a 3-amp fuse.



FT—757GX
HF ALL MODE
COMPUTER AIDED TRANSCEIVER



GENERAL DESCRIPTION

The FT-757GX incorporates the finest features of the latest developments in Amateur transceiver design, with the most recent advances in microprocessor technology and computer-aided manufacturing techniques, to provide full performance all mode operation as standard on all HF amateur bands, as well as continuous general coverage reception from 0.5 to 30 MHz.

Yaesu's famous IF Shift/Width passband control system allows the operator an almost infinite variety of selectivity settings for minimizing interference during SSB, CW and ECSS reception of AM signals. Wideband AM and narrowband CW filters are also included – as standard accessories. A switchable RF amplifier and 20 dB attenuator are provided to optimize sensitivity and dynamic range under any conditions, while the noise blanker has its own AGC adjustable from the front panel, from narrow (ignition-type) to wide (woodpecker) blanking pulse widths.

The diecast top half of the FT-757GX provides a glimpse of the revolutionary engineering concepts behind the unique transmitter design, which utilizes a new Duct Flow Cooling system to force air throughout the entire transceiver. The thermodynamic efficiency of this sytem makes the FT-757GX by far the smallest transceiver of its kind, yet easily capable of full power (100 W output nominal) RTTY and FM transmission when used with an appropriate heavy duty power supply.

The FT-757GX offers full break-in QSK CW operation plus Yaesu's new custom-designed iambic electronic keyer with dot memory using a 4-bit microprocessor built in, as a standard feature. When operating split-frequency QSK, the FT-757GX provides an automatic momentary check of the transmitting frequency before jumping to the receive frequency, so the operator can watch both frequencies for activity at the same time.

For SSB and AM signal punch, the AF speech processor circuit in the FT-757GX is a combination AF clipper and compressor designed to provide the optimum possible increase in average speech power with minimum distortion of the signal. Careful filtering before the modulator assures clean output, with a substantial increase in average power.

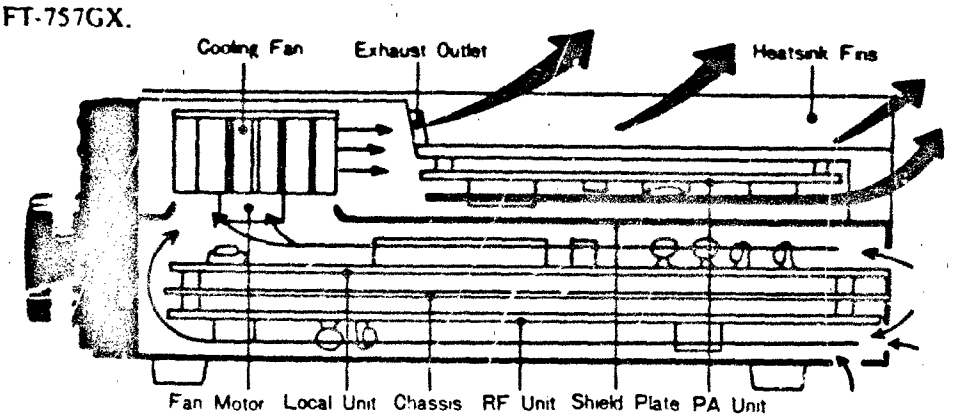
The completely new dual PLL synthesis scheme provides tuning steps of 10 Hz, incorporating an 8-bit microprocessor which the operator controls from the tuning knob, optional scanning microphone buttons or external home computer (via the CAT System optional Interface Unit). Front panel keys and buttons are also provided for accessing and interchanging eight memory channels plus two VFOs (A/B) and a clarifier with unlimited frequency range, as well as the PMS (Programmable Memory Scan) system, which allows automatic scanning between two memory channel frequencies with auto stop on those above a preset signal level. All of these features can also be controlled through the CAT system. An internal lithium battery provides complete backup for the memories and VFOs, for 5 years or more.

The three internal microprocessors perform many of the functions that previously required large numbers of discrete components and controls, so that the simplicity of the FT-757GX, inside and out, belies the highly advanced features available to the operator. The CAD/CAM systems used to lay out and assemble the circuit boards provides a clean, orderly design that is uncluttered and easy to service, while reducing the possibility of human assembly errors to almost nil.

Optional accessories include your choice of the MD-1B8 Desktop Scanning microphone or MH-1B8 Handy Scanning microphone. Also, Yaesu has designed the FC-757AT Fully Automatic Antenna Tuner to match the FT-757GX perfectly in all respects. Incorporating its own microprocessor and lithium-backed memory, the FC-757AT can quickly tune your antenna system for minimum SWR at the transmitting frequency with just the touch of a button, and then store the settings in memory for almost instant recall at a later time. The FC-757AT accepts two antennas – or as many as five when used with the FAS-1-4R Remote Antenna Selector.

Special high duty-cycle power supplies designed for the FT-757GX include the ultra-compact FP-757GX Switching Power Supply and the FP-757HD Heavy Duty Series Regulator Power Supply with forced-air cooling and automatic thermal fan control. For light-duty applications, the FP-700 standard power supply may be used.

Please read this manual carefully to obtain optimum performance and enjoyment from the FT-757GX.



FT-757GX Duct Flow Cooling System

SPECIFICATIONS

TRANSMITTER

Frequency range:

160 m band	1.5 to 1.99999 MHz
80 m band	3.5 to 3.99999 MHz
40 m band	7.0 to 7.49999 MHz
30 m band	10.0 to 10.49999 MHz
20 m band	14.0 to 14.49999 MHz
17 m band	18.0 to 18.49999 MHz
15 m band	21.0 to 21.49999 MHz
12 m band	24.5 to 24.99999 MHz
10 m band	28.0 to 29.99999 MHz

Tuning steps:
10 Hz and 500 kHz (band step)

Emission types:
LSB, USB (A3J/J3E*), CW (A1/A1A*), AM (A3/A3E*), FM (F3/G3E*)
* New emission designation per WARC '79

Power output:

SSB, CW, FM	100 W (PEP/DC) w/slightly less on 10 m
AM	25 W (Carrier)

Carrier suppression:
better than 40 dB below peak output

Unwanted sideband suppression:
better than 50 dB below peak output (1 kHz tone)

Spurious radiation:
better than 50 dB below peak output

Audio response:
less than -6 dB from 300 - 3000 Hz

3rd order intermodulation distortion:
better than -35 dB below peak output (14 MHz, 100 W)

Frequency stability:
better than ±10 ppm from 0 – 40°C after 15 min. warm up

Modulation type:
A3J: Balanced Modulator
A3: Low Level Modulator
F3: Variable Reactance Modulator

Maximum FM deviation:
±5 kHz

Output impedance:
50 ohms (nominal), unbalanced

Microphone impedance:
Low (500 to 600 ohms)

RECEIVER

Frequency range:
500 kHz to 29.99999 MHz (continuous)

Circuit type:
Triple conversion superheterodyne

Clarifier range:
Unlimited

Sensitivity:
(CW, SSB and AM figures measured for 10 dB S+N/N)
*1.5~30 MHz **500 kHz~1.5 MHz
SSB, CW(W), FSK
*better than 0.25 μV **better than 2.0 μV
CW(N)
*better than 0.16 μV **better than 1.25 μV
AM
*better than 1.0 μV **better than 8.0 μV
FM
better than 0.6 μV for 12 dB SINAD

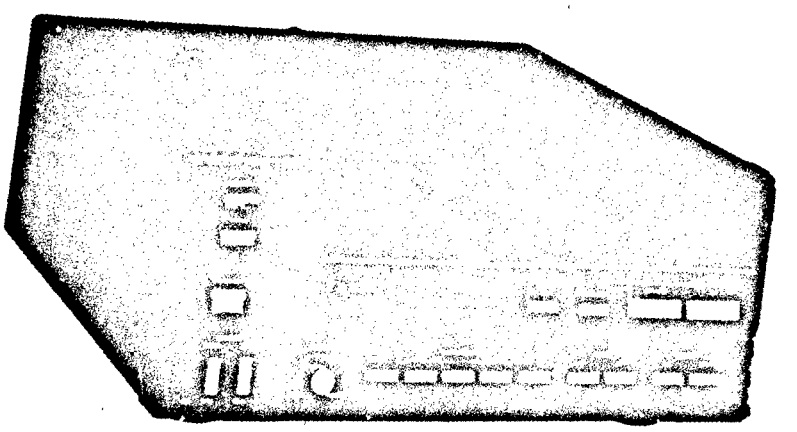
Intermediate frequencies:

1st IF:	47.060 MHz
2nd IF:	8.215 MHz
3rd IF:	455 kHz
FM IF:	455 kHz

Image rejection:
better than 70 dB

IF rejection:
better than 70 dB for all frequencies

THE FC-757AT
FULLY AUTOMATIC HF ANTENNA TUNER



The FC-757AT is a multi-functional microprocessor-controlled RF handling device designed to provide for all of the antenna switching, impedance matching and RF metering requirements of an amateur station, with maximum power handling capability of 150 watts.

Designed to match the FT-757GX All Mode HF Transceiver, which provides automatic band-switching and power control functions via the supplied control cable, the FC-757AT can also be automatically controlled by the FT-980 Transceiver via an optional control cable. Manual power and bandswitching controls are also provided for use when the FC-757AT is powered by an independent DC source and used with any other HF transceiver, transmitter or receiver.

The 4-bit microprocessor allows for fast, accurate automatic impedance matching utilizing a modified pi-L network. A directional CM coupler at the transmitter side of the network and an RF pickup at the antenna side ensure a wide range of SWR acceptance, and final SWR to the transmitter better than 1.5:1 for impedances in that range. Manual matching is also possible for particularly difficult situations, or when matching for receiving only.

Two antenna jacks are provided, along with controls for remote automatic and manual selection of up to five antennas in total when the FC-757AT is used with the optional FAS-1-4R Remote Antenna Selector. An internal 50-ohm dummy load is included in the FC-757AT, along with an in-line RF wattmeter and a self-calculating (automatic) SWR meter.

The particular antenna selected for operation on a particular band, along with the settings of the matching network, are digitally encoded and stored in lithium-backed RAM by the micro-processor, so that when that band is selected again, the same antenna and matching settings are automatically reset quickly. Thus no extra time is required for rematching.

During operation, any change in frequency that causes the SWR to rise above 1.5:1 will cause the auto-tune system to automatically rematch the load if desired, and the new settings will then be automatically written into memory for that band.

Please read this manual carefully before operating your FC-757AT, to ensure optimum

SPECIFICATIONS

MATCHING SECTION

Frequency range (TX, w/auto band select):

1.8 – 2.0 MHz
3.5 – 4.0 MHz
7.0 – 7.5 MHz
10.0 – 10.5 MHz
14.0 – 14.5 MHz
18.0 – 18.5 MHz
21.0 – 21.5 MHz
24.5 – 25.0 MHz
28.0 – 29.9 MHz

Input impedance:
50Ω

Output impedance range:
10 – 250Ω
25 – 100Ω (1.8 – 2.0 MHz)

Maximum RF power:
150W

Insertion loss:
less than 0.5 dB

Motor stop SWR:
1.5:1 or better

SWR meter scale range:
1:1 – 3:1

In-line power meter ranges:
15W, 150W f/s

DUMMY LOAD

Impedance:
50Ω

Power dissipation:
100W CW (less than 30 sec.)

POWER REQUIREMENTS

Supply voltage:
13.5V DC ±10%

Current:
300 mA max.
(400 mA w/FAS-1-4R)

Size:
(W) 238 x (H) 94 x (D) 241 mm

Weight:
Approximately 3.7 kg

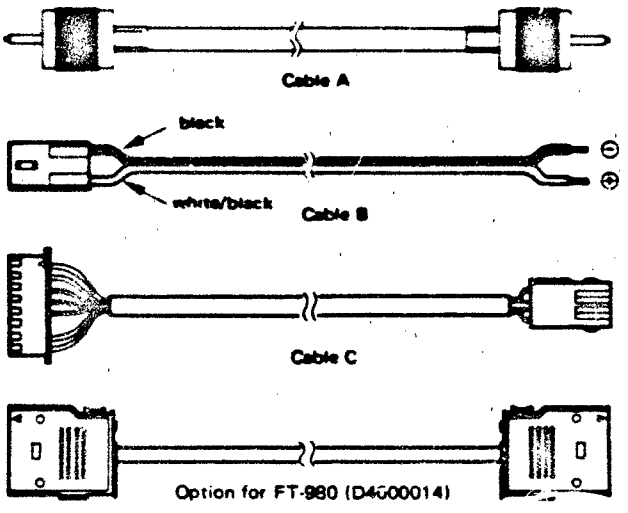
Specifications subject to change without notice or obligation

Supplied Accessories

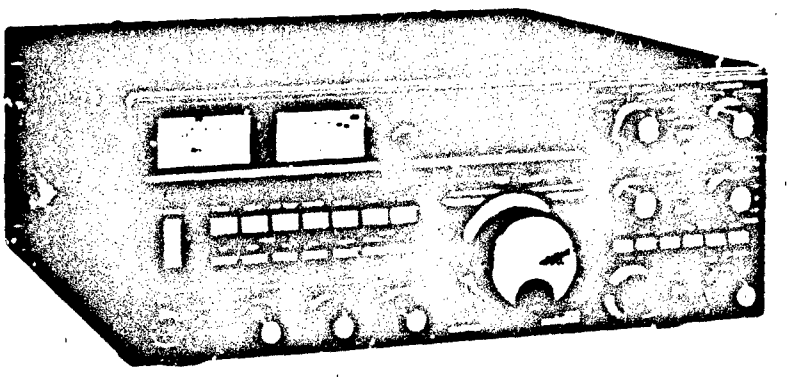
Connection Cable A	(T9100160A)	1
5D-2V Coax w/type M connectors		
Connection Cable B	(T9015099)	1
Control Cable C for FT-757GX	(T9101292)	1

Optional Accessories

Control Cable for FT-980	(D4000014)	1
FAS-1-4R Remote Antenna Selector	(D3000198)	1



FT-726R
ALL MODE TRIBANDER



GENERAL DESCRIPTION

The FT-726R is designed for the V/UHF amateur operator who requires every conceivable operating feature necessary for unlimited single and multi-band all mode operation with one convenient package. Interchangeable plug-in RF modules for each band allow the operator to install the bands of his choice. Each module provides 10 watts of RF output in all modes, and up to three modules can be installed at one time. Other modules can be installed or exchanged in a matter of minutes, and each includes a connector for controlling an external RF power amplifier.

A new degree of operating flexibility is made possible by a custom designed 8-bit NMOS microprocessor, coupled with a careful combination of front panel key buttons and controls that allows straightforward convenience even for the most exotic types of operation, such as reverse odd shift repeater testing or full duplex crossband splits for amateur satellite QSOs.

Special features are provided for each mode of operation, such as a discriminator center tuning meter and independent channel step tuning knob for FM, IF shift and width controls for CW and SSB, an AF SSB speech processor, and provision for an optional narrow CW filter. All modes can be tuned or scanned in 20 Hz steps, and both the tuning knobs and scanning system have selectable tuning rates.

All of the features that are considered extras on monoband transceivers are included, such as priority channel checking, programmable repeater shift, programmable limited band scanning, eleven memories storing both frequency and mode, memory scanning, and lithium memory backup retaining the memories, VFOs, programmed odd shift and clarifier offset.

In addition to the shift/width system, other functions previously unavailable except on HF transceivers include selectable AGC rates, RF gain control, fully independent multimode, multiband dual VFOs, and memory clarifier with separate display. Yaesu's unique dual multimeter system is include for expanded monitoring capability in both transmit and receive, or full duplex.

Options include the Satellite IF Unit, 600 Hz CW narrow filter, DC cable for 13.5V mobile or emergency operation, and a growing selection of RF modules for various bands.

Please study this manual carefully in order to become familiar with the many convenient features and

SPECIFICATIONS

GENERAL

Frequency coverage:
50 – 53.99998 MHz (option)
144 – 145.99998 MHz or
144 – 147.99998 MHz
430 – 439.99998 MHz (option)
440 – 449.99998 MHz (option)

Frequency steps:
20 200 Hz for SSB/CW/FM
5 10 kHz or 12.5/25 kHz for FM-CH mode
(per local requirements)

Repeater shifts:
±1 MHz for 50 MHz
±600 kHz for 144 MHz
±5 MHz, ±1.6 MHz or ±7.6 MHz for 430 MHz
(Programmable repeater shift also included)

Operating modes:
USB, LSB, CW, FM

Power requirements:
100, 110, 117, 200, 220, or 234 VAC
50/60 Hz
or 13.8 VDC (w/optional cable)

Power consumption:
Receive: 45 VA (AC), 1.5 A (DC)
Transmit: 120 VA (AC),
4.5 A (DC) for 10 W RF

Dimensions:
334 (W) x 129 (H) x 315 (D) mm

Weight:
Approx. 11 kg
(w/o optional modules, Satellite Unit)

TRANSMITTER

Power input:
6 m : 20 W PEP/DC for 10 W out
2 m : 30 W PEP/DC for 10 W out
70 cm : 30 W PEP/DC for 10 W out

Carrier suppression:
Better than 40 dB

Spurious radiation:
Better than −60 dB

Unwanted sideband suppression:
Better than 40 dB

Transmitter audio response:
300–2,700 Hz at −6dB (SSB)

Maximum deviation:
5 kHz (FM)

Modulation types:
A3J : Balanced modulator
F3 : Variable reactance modulator

Frequency stability:
6 m : Better than ±10 ppm
2 m : Better than ±10 ppm
70 cm : Better than ±5 ppm

Microphone impedance:
500–600 ohms

Tone call frequency:
1,800 Hz or 1,750 Hz
(per local requirements)

RECEIVER

Sensitivities:

6 m SSB	: Less than 0.15 μV for 10 dB (S+N)/N
2 m SSB	: Less than 0.15 μV for 10 dB (S+N)/N
70 cm SSB	: Less than 0.15 μV for 12 dB (S+N)/N
6 m FM	: Less than 0.25 μV for 12 dB SINAD
2 m FM	: Less than 0.25 μV for 12 dB SINAD
70 cm FM	: Less than 0.20 μV for 12 dB SINAD

(CW sensitivity is same as SSB if the optional CW filter is not installed)

Selectivity (−6 dB/−60 dB):
SSB : 2.4 kHz/4.0 kHz (adjusts continuously from 1.2 kHz to 2.4 kHz at −6 dB)
CW : 600 Hz/1.2 kHz
(with optional CW filter)
FM : 15 kHz/30 kHz
(CW selectivity is same as SSB if the optional CW filter is not installed)

Image rejection:
Better than 60 dB

AF output:
1.5 W min. @ 8 ohms, 10% THD

AF output impedance:
4–16 ohms

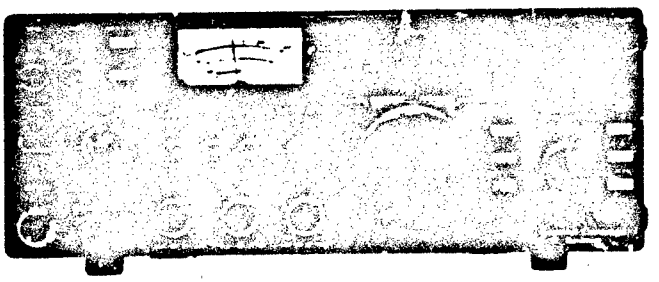
IF frequencies:
10.810 MHz
10.750 MHz
455 kHz
67.615 MHz (70 cm units only)

IC-745

D TRANSCEIVER

GENERAL COVERAGE RECEIVER

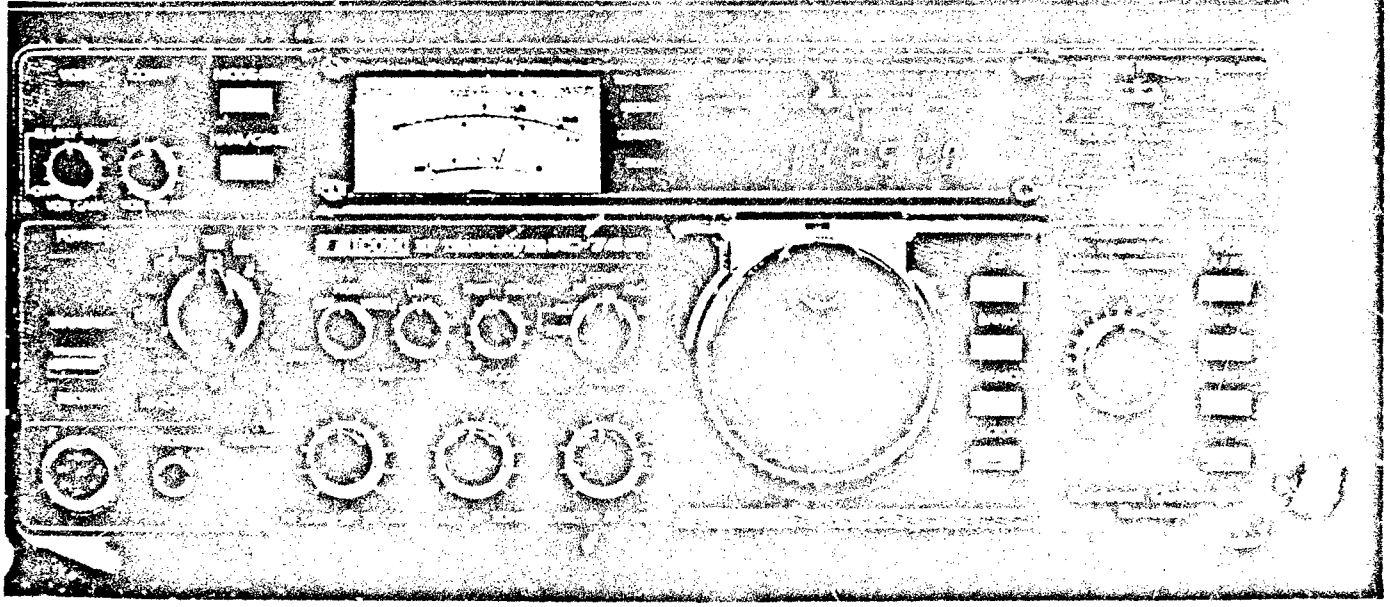
INSTRUCTION MANUAL



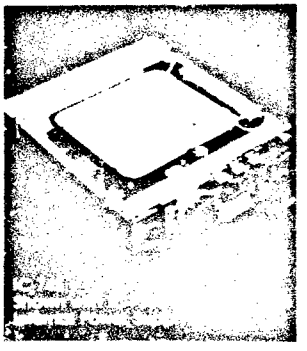
ICOM

ICOM IC-745

160-10 MTR 100W XCVR / 01-30 MHz RCVR



Filter	-6dB Width	Center Freq MHz
FL45	500 Hz	9.000
FL53A	270 Hz	9.000
FL44A	2.4 KHz	0.455
FL52A	500 Hz	0.455
FL54	250 Hz	0.455



The World System

SECTION 11 SPECIFICATIONS

GENERAL

Frequency Coverage:

Ham Band 1.8 MHz ~ 2.0MHz
3.45MHz ~ 4.1MHz
6.95MHz ~ 7.5MHz
9.95MHz ~ 10.5MHz
13.95MHz ~ 14.5MHz
17.95MHz ~ 18.5MHz
20.95MHz ~ 21.5MHz
24.45MHz ~ 25.1MHz
27.95MHz ~ 30.0MHz

General Cover (Receive Only)
0.1MHz ~ 30.0MHz
Thirty 1MHz Segments (or Continuous)

RIT.XIT Coverage ±1.0KHz

Frequency Control:
CPU based 10Hz step Digital PLL synthesizer.
Independent Transmit-Receive Frequency Available.

Frequency Readout:
6 digit 100Hz readout.

Frequency Stability:
Less than ±500Hz after switch on 1 min to 60 mins, and less than ±100Hz after 1 hour. Less than ±1KHz in the range of $-10^{\circ}C \sim +60^{\circ}C$.

Power Supply Requirements:
DC 13.8V ±15% Negative ground Current drain 20A max. (at 200W input)
AC power supply is available for AC operation.

Antenna Impedance:
50 ohms Unbalanced

Weight
8.0Kg (11Kg, when optional power supply is installed)

Dimensions:
111(123) mm(H) x 280(304) mm(W) x 355(383) mm(D)
*( ), including projections

TRANSMITTER

RF Power:

SSB (A_3J)	200 Watts PEP input
CW (A_1), RTTY (F_1)	200 Watts input
FM (F_3)*	200 Watts input

Continuously Adjustable Output power 10 Watts ~ Max.

Emission Mode:

A_3J	SSB (Upper sideband and Lower sideband)
A_1	CW
F_1	RTTY (Frequency Shift Keying)
F_3	FM

Harmonic Output:
More than 60dB below peak power output

Spurious Output:
More than 60dB below peak power output

Carrier Suppression:
More than 40dB below peak power output

Unwanted Sideband:
More than 55dB down at 1000Hz AF input

Microphone:
Impedance 600 ohms
Input Level 12 millivolts typical
Dynamic or Electret Condenser Microphone
(Optional desk mic IC SM6 can be used.)

RECEIVER

Receiving System:
SSB, CW, RTTY, AM
Triple Conversion Superheterodyne with continuous Bandwidth Control.
FM* Triple Conversion Superheterodyne

Receiving Mode:
A_1, A_3J (USB, LSB) F_1 (Output FSK audio signal), A_3 (Receive only) F_3*

IF Frequencies:

1st	70.4515MHz
2nd	9.0115MHz
3rd	455KHz

Sensitivity:

SSB, CW, RTTY	0.1 ~ 1.6MHz	Less than 3.2μV for 10dB S/N
	1.6 ~ 30MHz	Less than 0.15μV for 10dB S/N
AM	0.1 ~ 1.6MHz	Less than 20μV for 10dB S/N
	1.6 ~ 30MHz	Less than 1μV for 10dB S/N
FM*	1.6 ~ 30MHz	Less than 0.3μV for 12dB SINAD

Squelch Sensitivity:
1.6 ~ 30MHz Less than 0.5μV

Selectivity:
SSB, CW, RTTY
2.2KHz (Adjustable to 0.8KHz Min) at −6dB
4.2KHz at −60dB
AM 2.4KHz at −6dB, 4.8KHz at −60dB
(When Filter switch ON)
4.0KHz at −6dB, 15KHz at −60dB
FM* 15KHz at −6dB, 30KHz at −60dB

Notch Filter Attenuation:
More than 30dB

Spurious Response Rejection Ratio:
More than 60dB

Audio Output:
More than 2.8 Watts

Audio Output Impedance:
8 Ohms

* When optional FM unit is installed.

Specifications are approximate and are subject to change without notice or obligation.

ICOM

INSTRUCTION MANUAL

IC-PS35

INTERNAL POWER SUPPLY UNIT

(DC 13.8V 20A SWITCHING REGULATOR)

This instruction manual gives descriptions and installation instructions for the optional power supply unit for ICOM's HF transceiver IC-745 and IC-751. It also provides information you need while using them. Please read all the instructions carefully before installation so you will get maximum performance and full value from the set.

SPECIFICATIONS

Number of Semiconductors	Transistor	5
	IC	2
	Diode	4
Input Voltage	110 220V AC (50 60Hz)	
Allowable Voltage Fluctuation	±10% of input voltage (suitable line voltage)	
Input Capacity	550VA (at 20A load)	
Output Voltage	13.8V DC Negative ground	
Max. Load Current	20A (10 mins ON 10 mins OFF)	
Dimentions	194(W) x 50(H) x 186(D) mm	
Weight	Approx. 2.3kg	
Kit Included	Main Unit	1
	Insulation Spacer	1
	Power Socket Unit	1
	AC Power Cord	1
	Spare Fuse	2
	Installation Screws	6
	Insulation Washers	6

ICOM

ELECTRET CONDENSER TYPE
DESK MICROPHONE
WITH BUILT-IN PREAMPLIFIER

IC-SM6
INSTRUCTION MANUAL

Congratulations on the purchase of DESK MICROPHONE IC-SM6 for new ICOM's transceiver.

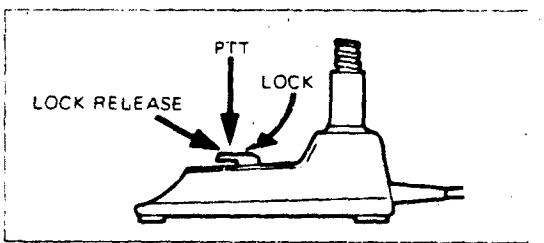
This microphone will increase your operating convenience and make operation of the transceiver more enjoyable with clear tone and good pick-up capability.

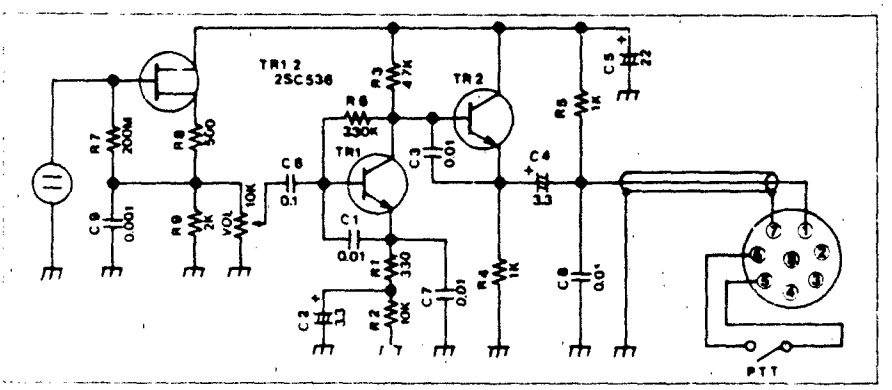
IC-SM6 is an electret condenser type desk microphone with a built-in preamplifier. So, a DC voltage should be applied to the preamplifier. In the IC-SM6 the DC voltage is superimposed on the AF output line.

ICOM transceiver has an 8 pin microphone connector, to accept the IC-SM6 microphone.

HOW TO USE

1. A sensitivity control is installed on the bottom of the mic stand. By turning it to the "H" or "L" position, the sensitivity will increase or decrease, respectively. Adjust the control so as to get the proper sensitivity considering the distance to the mic, the loudness of your voice and the environmental conditions.
2. The wind screen not only prevents background noise due to wind, but also protects the mic. Unless required, do not remove the screen from the mic.
3. In order to operate the microphone, connect its plug to the mic socket on a transceiver (or transmitter).
4. To transmit, press the PTT switch downward. When it is released, the transceiver will return to the receive condition. For a long transmission, pull the PTT switch backwards, while pressing it down until the switch is locked and it will remain in that position until it is pushed forward and released. Refer to the following chart.





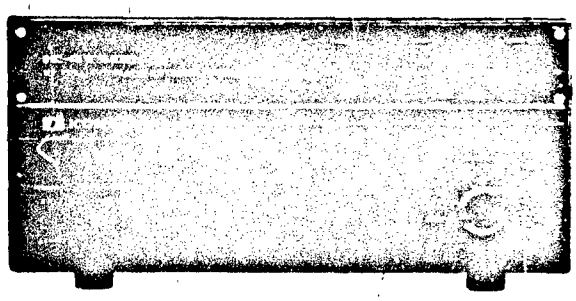
ICOM INCORPORATED

Printed in Japan

IC-AT500
IC-AT100

HF FULL AUTOMATIC ANTENNA TUNER

INSTRUCTION MANUAL



ICOM

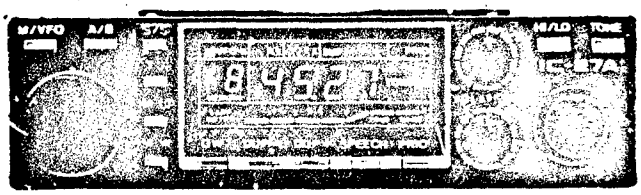
SECTION 8 SPECIFICATIONS

Number of Semiconductors	Transistor	36
	IC	10
	Diode	55 (IC-AT100:49)
Frequency Range	1.8 ~ 2.0 MHz (IC-AT100: tuner is bypassed)	
	3.5 ~ 4.0 MHz	
	7.0 ~ 7.3 MHz	
	10.0 ~ 10.5 MHz	
	14.0 ~ 14.5 MHz	
	18.0 ~ 18.5 MHz	
	21.0 ~ 21.5 MHz	
	28.0 ~ 30.0 MHz	
	(Auto band switching with IC-701/720/720A/730)	
Power Capability	500W (continuous)/1 kW (PEP) (IC-AT100: 100W/200W PEP)	
Impedance Matching	16.7 ~ 150Ω to 50Ω resistive	
Output Terminals	4 coaxial connectors	
Minimum Tune-up Power	50W (IC-AT100: 8W)	
Tune-up Time	4 ~ 7 seconds (when operating band has been changed) Less than 3 seconds (on the same band)	
Matching Accuracy (VSWR)	Less than 1.2 (when auto-tuning)	
Insertion Loss	Less than 0.5 dB (when tuned up)	
Power Supply Requirements	13.8V DC (negative ground) ±15% 0.5A max 117V AC or 230V AC ±10% 13W max	
Usable Condition	Temperature −10°C ~ 60°C	
Dimensions	241(W) × 111(H) × 300(D) mm	
Weight	6.4 kg (IC-AT100: 5.0 kg)	

IC-27A/E

144MHz FM TRANSCEIVER

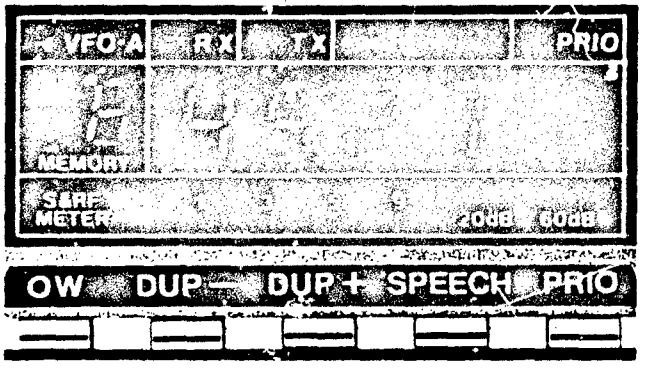
INSTRUCTION MANUAL

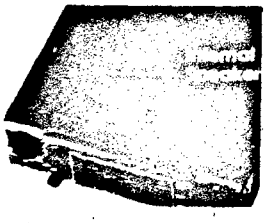


ICOM

ICOM IC-27H

Now ICOM offers the best choices in compact 2-meter FM mobiles...the IC-27H 45-watt compact (1¾"H x 5½"W x 9⅛"D) and the IC-27A 25-watt super compact mobile. The IC-27A and IC-27H are the smallest full-featured 2-meter mobile transceivers available, and feature an internal speaker for easy installation. For the ultimate portable station, the IC-37A 220MHz and IC-47A 440MHz 25 watt compact mobiles are also available.





The IC-27H provides 45 watts of output power while the IC-27A provides 25 watts of output power.

The IC-27A and IC-27H come complete with 32 PL frequencies ready to go and are controlled from the front panel knob. Each PL frequency may be selected by the main tuning knob and stored into memory for easy access along with frequency and offset.

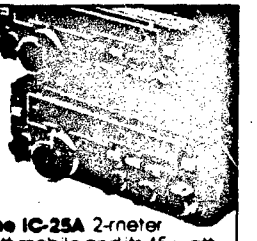
The IC-27A and IC-27H have nine memories available to store receive frequency, transmit offset, offset direction, and PL tone. Memories are backed up by a lithium backup battery, which will store memories for up to seven years.

Speech Synthesizer. As an added plus, the IC-27A/H features an optional speech synthesizer to verbally announce the receiver frequency of the transceiver through the simple touch of a button.

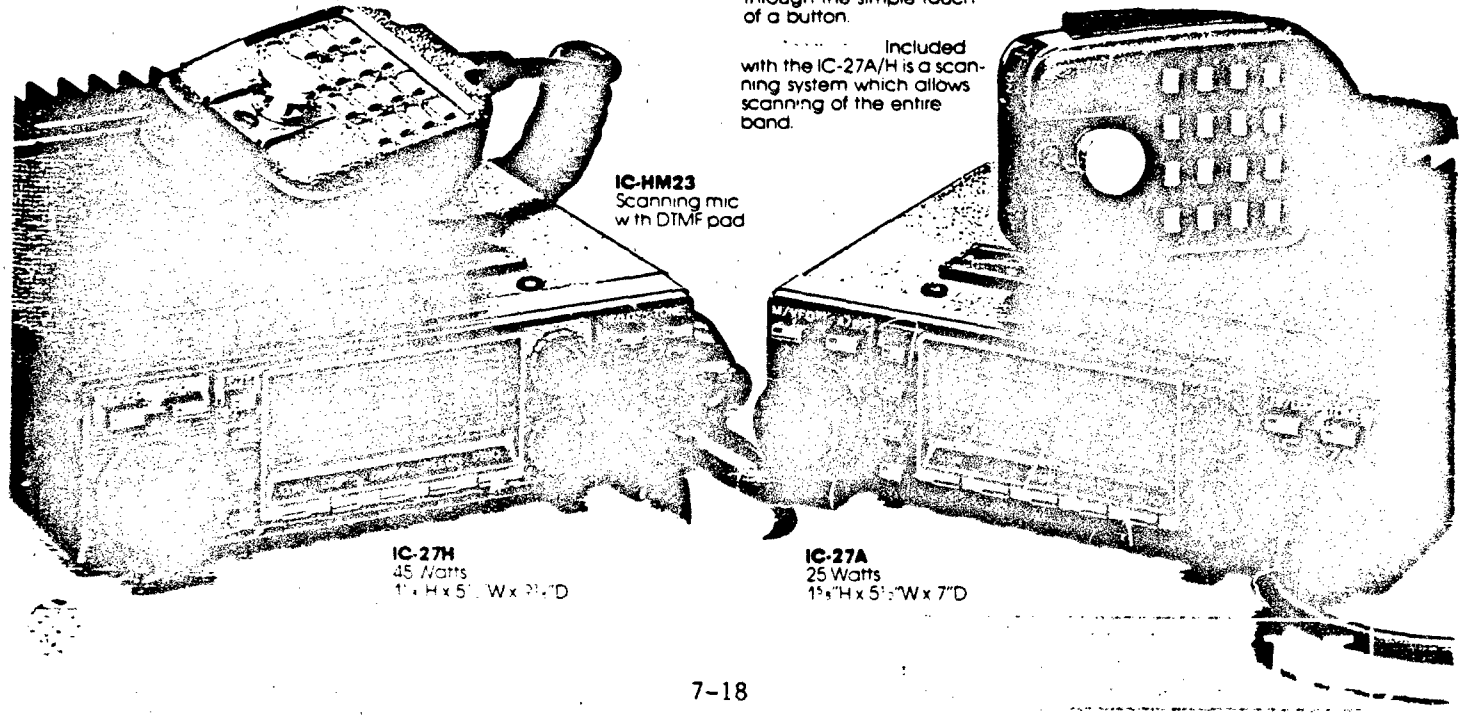
Scanning. Included with the IC-27A/H is a scanning system which allows scanning of the entire band.

Priority may be selected to be either a memory channel or a VFO channel. By using sampling techniques, the operator can determine if a frequency of interest is free or busy.

compact mobile transceivers at your local ICOM dealer. For superb performance, reliability, and the ultimate in a VHF mobile radio, your only choice is an ICOM.



The IC-25A 2-meter 25-watt mobile and its 45-watt companion, the **IC-25H**, are also available.



IC-HM23
Scanning mic with DTMF pad

IC-27H
45 Watts
1¾"H x 5½"W x 9⅛"D

IC-27A
25 Watts
1⅝"H x 5½"W x 7"D

Also Available: IC-37A 220MHz and IC-47A 440MHz Compact Mobiles

The World System

SECTION 11 SPECIFICATIONS

GENERAL

Numbers of semiconductors	:	Transistor 57 FET 6 IC 24 Diode 110
Frequency coverage	:	IC-27A: 144MHz ~ 148MHz IC-27E: 144MHz ~ 146MHz
Frequency resolution	:	IC-27A: 5KHz/15KHz steps (Australian version: 5KHz/25KHz) IC-27E: 12.5KHz/25KHz steps
Frequency control	:	Microcomputer based 5KHz step (or 12.5KHz step) Digital PLL synthesizer Independent Dual VFO Capability.
Frequency stability	:	Within ±1.5KHz
Memory channels	:	9 channels with any inband frequency programmable
Usable conditions	:	Temperature: −10°C ~ 60°C (14°F ~ 140°F) Operational time: Continuous
Antenna impedance	:	50 ohms unbalanced
Power supply requirement	:	13.8V DC ±15% (negative ground) 6A Max.
Current drain (at 13.8V DC)	:	Transmitting; High (25W) Approx. 6.0A Low (5W) Approx. 3.0A Receiving; At max audio output Approx. 0.6A Squelched Approx. 0.4A
Dimensions	:	38(41)mm(H) x 140mm(W) x 177(191)mm(D) ( ): Shows the dimensions including projections
Weight	:	Approx. 1.2kg

TRANSMITTER

Output power	:	HIGH 25W LOW 5W
Emission mode	:	16F_3 (F3E 16K0)
Modulation system	:	Variable reactance frequency modulation
Max. frequency deviation	:	±5KHz
Spurious emission	:	More than 60dB below carrier
Microphone	:	600 ohm electret condenser microphone with push-to-talk and frequency UP/DOWN switches. (IC-27A: with 16 key dual-tone pad.) (IC-27E: with 1750Hz tone burst unit.)
Operating mode	:	Simplex, Duplex (Any offset in-band in 100KHz increments programmable)

RECEIVER

Receiving system	:	Double-conversion superheterodyne
Modulation acceptance	:	16F_3 (F3E 16K0)
Intermediate frequencies	:	1st: 10.695MHz 2nd: 455KHz
Sensitivity	:	Less than 0.2μV for 12dB SINAD Less than 0.4μV for 20dB Noise quieting
Squelch sensitivity	:	Less than 0.15μV
Spurious response rejection ratio	:	More than 60dB
Selectivity	:	More than 15KHz at −6dB point Less than 30KHz at −60dB point
Audio output power	:	More than 2.0W
Audio output impedance	:	4 ~ 8 ohms

ICOM's IC-02A

Digital Readout, Scanning, Memories and...

ICOM introduces the new top-of-the-line IC-02A and IC-02AT to compliment its existing line of popular handheld transceivers and accessories. The new direct entry microprocessor controlled IC-02A is a full-featured 2-meter handheld.

Some of its many features are: Scanning, 10 memories, duplex offset storage in memory, odd offsets, 32 keyboard selectable PL tones which store in memory and internal lithium battery backup.

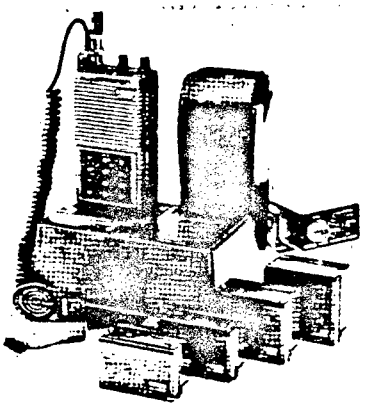
Keyboard entry through the 16 button pad allows easy access of frequencies, duplex, memories, memory scan, priority, dial, lock, PL tones and [illegible] the IC-02AT.

An easy-to-read custom LCD readout [illegible]

The new IC-02A [illegible]

for superior heat sinking when the IC-02A is run at the standard 3 watt level or 5 watts (optional battery pack).

A variety of batteries are available for the IC-02A and IC-02AT, including the new long-life 8.4 volt IC-BP8 and 13.2 volt IC-BP7. The IC-BP7 and BP8 may be charged from a top panel connector for 13.8 volts which will also power transceiver operation.



ICOM's IC-2A(T) [illegible]

The World System

[illegible] (206)454-8155 [illegible] Dallas TX 75234 (214)620 2780

SPECIFICATIONS: IC-02A(T)

GENERAL	
Frequency coverage	144.00 — 147.995MHz
Frequency resolution	5, 10, 15, 20, or 25KHz steps
Frequency control	Digital PLL synthesizer, with keyboard entry
Scanning system	Priority, memory, programmable
Frequency readout	LCD display (with switchable back light)
Frequency stability	Within ±1.5KHz
Memory channels	10 (with internal lithium battery backup)
Usable condit ons	-10°C — 60°C (14°F — 140°F)
Antenna impedance	50 ohms unbalanced
Power supply requirement	13.8VDC or attendant batteries
Current drain (at 8.4VDC)	Transmitting: High (3.0w) approx. 1.0A Low (0.5w) approx. 450mA Receiving: At maximum audio approx. 140mA Squelched approx. 35mA
Dimensions	116.5mm(H) x 65mm(W) x 35mm(D) without battery case
Weight	515g including IC-BP3 battery pack and flexible antenna
TRANSMITTER	
Output power	High: 3.0w (at 8.4VDC); 5.0w (at 13.2VDC) Low: 0.5w (at 8.4VDC)
Emission mode	16F3
Modulation system	Variable reactance frequency modulation
Max. frequency deviation	±5KHz
Spurious emission	More than 60dB below carrier
PL tones	32 built-in subaudible tones, standard
Operating mode	Simplex or duplex with programmable offset
Microphone	Built-in electret condenser microphone Optional IC-HM9 speaker/mic can be used.
RECEIVER	
Receiving system	Double conversion superheterodyne
Receiving mode	16F3
Intermediate frequencies	1st: 16.9MHz; 2nd: 455KHz
Sensitivity	Less than 0.32 μV for 20dB quieting
Squelch sensitivity	Less than 0.1 μV
Spurious response rejection ratio	More than 60dB
Selectivity	±7.5KHz at -6dB ±15KHz at -60dB
Audio output power	More than 500mW
Audio output impedance	8 ohms

BATTERY PACKS

BATTERY PACK MODEL	HEIGHT	CHARGER REQUIRED	BATTERIES	VOLTAGE	TYPICAL OUTPUT (IN WATTS)	REPLACE-ABLE BATTERIES	NOTES
IC-BP2	39mm	BC-30 or BC-35	N-425 AR (x6)	7.2	3.0	No	Low Power/Quick Charge (1.5h) Long Life/Overcharge protected
IC-BP3	39mm	BC-25U or BC-30 or BC-35	N-250 AA (x7)	8.4	3.0	No	Standard Power/ Standard Charge (15h)
IC-BP4	49mm	**	UM-3 (x6)	9.0	3.0	Yes	Standard Power/No Recharge capability
		BC-30 or BC-35	NiCd AA (x6)	7.2	3.0	Yes	Low Power/Long Life* Standard Charge (15h)
IC-BP5	60mm	BC-30 or BC-35	N-425 AR (x9)	10.8	4.0	No	Medium Power/Long Life Quick Charge (1.5h)/overcharge protected
IC-BP7	79.5mm	BC-16U or BC-35	N-425AR (x11)	13.2	5.0	No	High Power/Quick or Slow Charge
IC-BP8	79.5mm	BC-16U or BC-30 or BC-35	N-800AR (x7)	8.4	3.0	No	Standard Power/Long Life (800mAh)

*With 450 mAh NiCd Batteries **Do not attempt to recharge regular or alkaline batteries

ACCESSORIES

IC-CP1 Cigarette Lighter Cord
Plugs into lighter socket to charge IC-BP3 or into IC-DC1 to operate unit from car battery

BC-35 Drop-in Charger
Charges all ICOM battery packs. Charges IC-BP2 in 1.5 hours, IC-BP3 in 1.5 hours, IC-BP5 and BP7 in 1.5 hours, and the IC-BP8 in 2.5 hours.

IC-HM9 Speaker/Microphone
Plugs into transceiver and clips on lapel or pocket. Has PTT button.

Leather Case
High quality case to protect your transceiver

BC-25U Wall Charger
Charges IC-BP3 pack, standard with transceiver.

BC-16U Wall Charger
Charges IC-BP7 & BP8 Packs, only.

HS-10 Headset

HS-10SB PTT Switchbox
To be used with HS-10.

HS-10SA VOX Unit
To be used with HS-10. For IC-02A(T) and IC-04A(T) only.

OPTIONAL IC-ML1

Number of Semiconductors

Transistors	6
Diodes	10
IC	1

Frequency Coverage
144 — 148MHz

Acceptable Modulation
FM

Power Supply Requirements
13.8VDC ±15% Negative Ground 3A Max.

Current Drain
Approx. 2.0A at 10W Output
Approx. 30mA at stand by

Drive Power Requirements
2.3 Watts

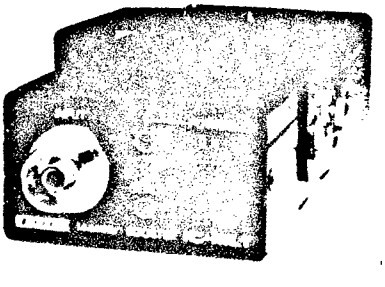
Output Power
10 Watts

Input Impedance
50Ω Unbalanced

Output (Load) Impedance
50Ω Unbalanced

Dimensions
35mm(H) x 63mm(W) x 160mm(D)

Weight
Approx. 320g



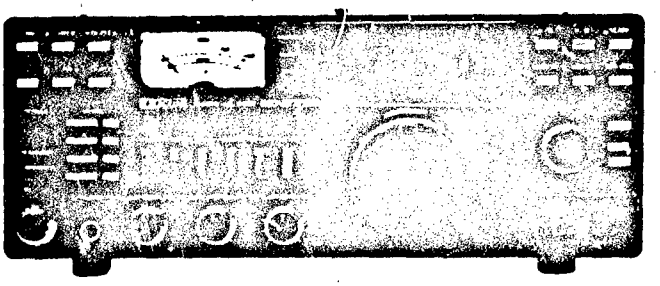
NOTE: Do not exceed 3w input to ML1.

ICOM

IC-271A/E

VHF ALL MODE TRANSCEIVER

INSTRUCTION MANUAL



ICOM

COM presents the most advanced all mode two meter base station available today the C 271A

25 watts of power from 12 VDC or from 117 VAC with the optional internal power supply 32 full function memories multimodes subaudible tones PLL locked to 10Hz high visibility multi-color flourescent display RIT readout scanning dual VFO s new size

Subaudible tones

memories

The C 271A

memories

Dual

memories

The World System

(206)454-8155 (214)620-2780

SECTION 11 SPECIFICATIONS

GENERAL

Number of Semiconductors:

Transistors	89
FET	14
IC (Includes CPU)	50
Diodes	160

Frequency Coverage:
144.0 ~ 146.0MHz
(IC-271A: 143.8 ~ 148.2MHz)

Frequency Control:
CPU based 10Hz step PLL synthesizer.
Independent Transmit-Receive Frequency Capability
32 Memory Channels provided
Programmed Scan, Memory Channel Scan and Mode-Selective Scan Capability

Frequency Resolution:
SSB 10Hz steps (Automatic 100Hz steps shift)
FM 5KHz steps
1KHz steps with TUNING RATE switch depressed

Frequency Readout:
7 digit Luminescent display 100Hz readout

Frequency Stability:
Within ±1.5KHz in the range of −10°C ~ +60°C

RIT Frequency Coverage:
±9.9KHz from displayed receive frequency

Power Supply Requirements:
DC 13.8V ±15% Negative ground Current drain 6A max.
AC power supply is available for AC operation.

Current Drain (at 13.8V DC):

Transmitting	25 watts output	Approx.	6.0A
	1 watt output	Approx.	2.0A
Receiving	At max. audio output		1.4A
	Squelched		1.2A

Antenna Impedance:
50 ohms Unbalanced

Weight:
5.2 Kg

Dimensions:
110mm(H) x 285mm(W) x 275mm(D)

TRANSMITTER

RF Output Power:

SSB (A_3J)	25 Watts PEP
CW (A_1), FM (F_3)	25 Watts

Continuously Adjustable Output power 1 watt ~ Max.

Emission Mode:
SSB (A_3J USB/LSB), CW (A_1), FM (F_3)

Modulation System:
SSB: Balanced modulation
FM: Variable reactance frequency modulation

Max. Frequency Deviation:
±5KHz

Harmonic Output:
More than 60dB below peak power output

Spurious Output:
More than 60dB below peak power output

Carrier Suppression:
More than 40dB below peak power output

Unwanted Sideband:
More than 40dB down at 1000Hz AF input

Microphone:
600 ohm electret condenser microphone with push-to-talk switch and scanning buttons.

Operating Mode:
Simplex, Duplex (Any in-band 10KHz steps frequency separation programmable)

RECEIVER

Receiving System:

SSB, CW	Single conversion superheterodyne
FM	Double conversion superheterodyne

Receiving Mode:
A_1, A_3J (USB, LSB), F_3

IF Frequencies:

SSB, CW	10.75MHz
FM	10.75MHz, 455KHz

Sensitivity:

SSB, CW	Less than 0.5 microvolts for 10dB S+N/N
FM	Less than 0.3 microvolts for 12dB SINAD
	Less than 0.6 microvolts for 20dB noise quieting

Squelch Sensitivity:

SSB, CW	Less than 0.6 microvolts
FM	Less than 0.4 microvolts

Spurious response rejection ratio:
More than 60dB

Selectivity:

SSB, CW	More than 2.4KHz at −6dB point
	Less than 4.8KHz at −60dB point
FM	More than 15KHz at −6dB point
	Less than 30KHz at −60dB point

Audio Output Power:
More than 2.0 watts (at 8 ohm 10% distortion)

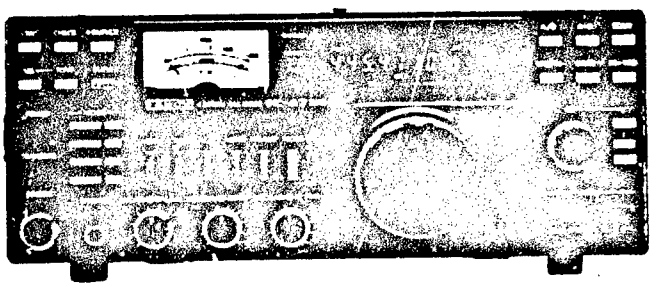
Audio Output Impedance:
8 ohms

Specifications are approximate and are subject to change without notice or obligation.

IC-471A/E

430MHz ALL MODE TRANSCEIVER

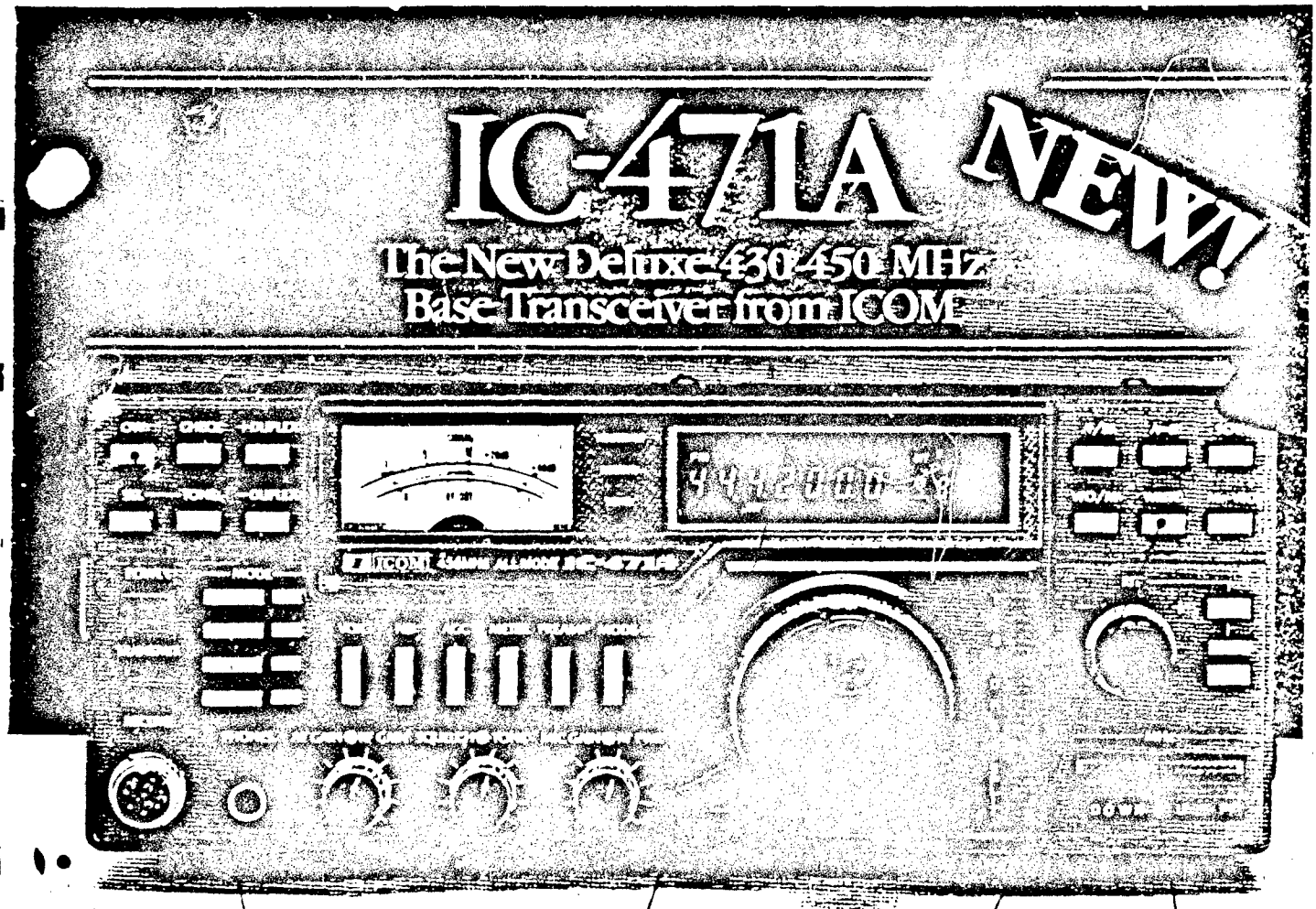
INSTRUCTION MANUAL



ICOM

IC-471A NEW!

The New Deluxe 430-450 MHz Base Transceiver from ICOM



WRITE OFFSET INTO MEMORY

NEW DISPLAY

32 CHANNEL MEMORY

1 MHz UP/DOWN FOR FAST QSY

32 full function memories subaudible tones PLL locked to 10 Hz two color fluorescent display RIT readout scanning new size

32 Memories Each

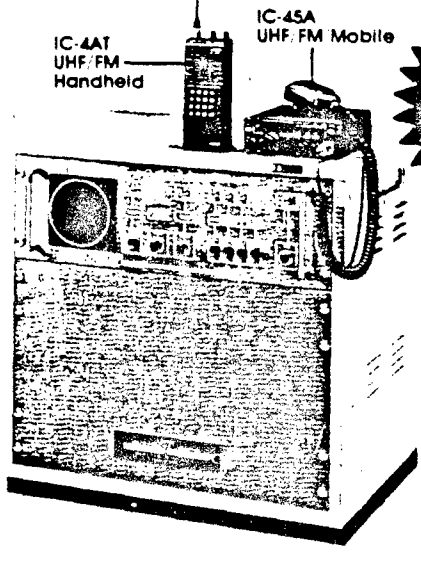
Subaudible Tones

Phase Lock Loop Extreme

New Display

Scanning Scanning of

New Size



NEW 440 MHz Repeater

Now a 10 watt 440 MHz FM repeater from the leader in UHF communications The C-RP3010 features high stability crystal controlled channels CTCSS system Tone remote control through a DTMF decoder and microprocessor controlled circuitry

ICOM

The World System

ICOM America Inc 2112 116th Ave N.E. Bellevue WA 98004 (206) 454-8155 2380 Tarpenwood Drive Suite 307 Dallas TX 75234 (214) 620-2780

SECTION 8 SPECIFICATIONS

GENERAL

Number of Semiconductors:

Transistors	108 (IC-471A 110)
FET	10
IC (Includes CPU)	55 (IC-471A 59)
Diodes	174 (IC-471A 178)

Frequency Coverage:
430.0 ~ 440.0MHz
(IC-471A 430.0 ~ 450.0MHz)

Frequency Control:
CPU based 10Hz step PLL synthesizer
Independent Transmit-Receive Frequency Capability
32 Memory Channels provided
Programmed Scan, Memory Channel Scan and Mode-Selective Scan Capability

Frequency Resolution:
SSB 10Hz steps (Automatic 100Hz steps shift)
FM 5KHz steps
1KHz steps with TUNING RATE switch depressed

Frequency Readout
7 digit Luminescent display 100Hz readout

Frequency Stability
Within 0.001% in the range of -10°C ~ +60°C

RIT Frequency Coverage
±0.9KHz from displayed receive frequency

Power Supply Requirements:
DC 13.8V ±15% Negative ground Current drain 8A max.
AC power supply is available for AC operation.

Current Drain (at 13.8V DC):

Transmitting	25 watts output	Approx. 8.0A
	1 watt output	Approx. 2.5A
Receiving	At max. audio output	1.4A
	Squelched	1.2A

Antenna Impedance
50 ohms Unbalanced

Weight:
6.0 Kg

Dimensions:
110mm(H) x 285mm(W) x 275mm(D)

TRANSMITTER

RF Output Power:

SSB (A_3J)	25 Watts PEP
CW (A_1), FM (F_3)	25 Watts

Continuously Adjustable Output power 1 watt ~ Max.

Emission Mode:
SSB (A_3J USB/LSB), CW (A_1), FM (F_3)

Modulation System:

SSB	Balanced modulation
FM	Variable reactance frequency modulation

Max. Frequency Deviation:
±5KHz

Harmonic Output:
More than 60dB below peak power output

Spurious Output:
More than 60dB below peak power output

Carrier Suppression:
More than 40dB below peak power output

Unwanted Sideband:
More than 40dB down at 1000Hz AF input

Microphone:
600 ohm electret condenser microphone with push-to-talk switch and scanning buttons (IC-471E: with 1750Hz tone-burst unit)
(IC-471A: Supplies an 8-pin plug instead of the microphone.)

Operating Mode:
Simplex, Duplex (Any in-band 10KHz steps frequency separation programmable)

RECEIVER

Receiving System:

SSB, CW	Double conversion superheterodyne
FM	Triple conversion superheterodyne

Receiving Mode:
A_1, A_3J (USB, LSB), F_3

Intermediate Frequencies:

SSB, CW	70.4515MHz, 10.75MHz
FM	70.4515MHz, 10.75MHz, 455KHz

Sensitivity:

SSB, CW	Less than 0.3 microvolts for 10dB S+N/N
FM	Less than 0.3 microvolts for 12dB SINAD
	Less than 0.5 microvolts for 20dB noise quieting

Squelch Sensitivity:

SSB, CW	Less than 1.0 microvolt
FM	Less than 0.3 microvolts

Spurious response rejection ratio:
More than 60dB

Selectivity:

SSB, CW	More than 2.4KHz at –6dB point
	Less than 4.8KHz at –60dB point
FM	More than 15KHz at –6dB point
	Less than 30KHz at –60dB point

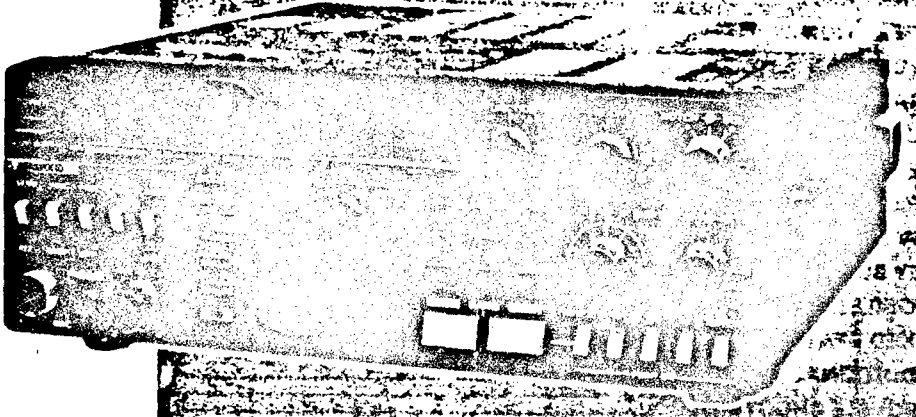
Audio Output Power:
More than 2.0 watts (at 8 ohm 10% distortion)

Audio Output Impedance:
8 ohms

Specifications are approximate and are subject to change without notice or obligation.

KENWOOD

Model TS-430S



INSTRUCTION MANUAL

SECTION 1. SPECIFICATIONS

[GENERAL]

Transmitter Frequency Range: 160, 80, 40, 30, 20, 17 , 15, 12 , 10 meter Amateur bands
Receiver Frequency Range: 150 kHz to 30 MHz
Mode: A3J (LSB, USB), A1 (CW), A3 (AM), F3 (FM)
Antenna Impedance: A3J (LSB, USB), A1 (CW), A3 (AM), F3 (FM..... OPTION)
Power Requirement: 12.0 to 16.0 V DC (13.8 V nominal)
Power Consumption: 20A approx. in transmit mode
1.2A approx. in receive mode
Dimensions: 270 (10.6)W x 96 (3.8)H x 257 (10.1) D mm (inch)
Weight: 6.5 kg (14.3 lbs.)

[TRANSMITTER]

Final Power Input:

Band \ Mode	SSB	CW	FM	AM
160m – 15m band	250WPEP	200WDC	–	60W
10m band	250WPEP	200WDC	120W	60W

Modulation: SSB = Balanced Modulation
FM = Variable Reactance Direct Shift (with FM-430 optional accessory)
AM = Low Level Modulation (IF stage)
Carrier Supression: Better than 40 dB
Unwanted Sideband Suppression: Better than 50 dB
Harmonic Content: Less than –40 dB
Maximum Frequency Diviation (FM): ± 5 kHz (with FM-430 optional accessory)
Microphone Impedance: 500Ω to 50 kΩ

[RECEIVER]

Circuitry: SSB, CW, AM = Double conversion Superheterodyne
FM = Triple Conversion Superheterodyne
Intermediate Frequency: 1st IF = 48.055 MHz
2nd IF = 8.83 MHz
3rd IF = 455 kHz (FM only)

Sensitivity:

Mode \ Frequency	150kHz – 500kHz	500kHz – 1.8MHz	1.8MHz – 30MHz
SSB/CW(10 dB S/N)	Less than 1 μV	Less than 4 μV	Less than 0.25 μV
AM(10 dB S/N)	Less than 13 μV	Less than 40 μV	Less than 2.5 μV
FM (30 dB S/N)	–	–	*Less than 1 μV
FM (12 dB SINAD)	–	–	*Less than 0.7 μV

* with FM-430 optional accessory

Image Ratio: More than 70 dB (1.8 to 30 MHz)
More than 50 dB (FM-3rd image ratio)
IF Rejection: More than 70 dB (1.8 to 30 MHz)
Selectivity:

Mode \ Selectivity	–6 dB	–60 dB
SSB/CW	2.4 kHz	4.4 kHz
AM *1	6 kHz	12 kHz
FM *2	15 kHz	32 kHz

* 1 with YK-88A optional filter
* 2 with FM-430 optional accessory

Frequency Stability: Better than ± 30×10^{-6} (0°C to +50°C), Within ± 200 Hz from 1 to 60 minutes after turn-on: within ± 30 Hz any 30 minute period thereafter
Frequency Accuracy: Better than 10×10^{-6}
RIT Variable Range: More than ± 1 kHz
Audio Output Impedance: 4Ω to 16Ω
Audio Output Power: More than 1.5W across 8Ω (at 10% distortion)

Note: Circuit and ratings subject to change without notice due to developments in technology.

KENWOOD

PS-430

DC POWER SUPPLY

The PS-430 DC Power Supply has been carefully engineered and manufactured under rigid quality standards, and should give you satisfactory and dependable operation for many years.
Before placing the equipment in service, we suggest you read through this manual to become acquainted with correct operation. Should any trouble arise with the unit, please contact your dealer.

■ AFTER UNPACKING

Save the boxes and packing in the event your unit needs to be transported for operation at a remote location, maintenance, or service.

■ INTRODUCTION

The Model PS-430 is a regulated DC power supply designed to match the KENWOOD TS-430S transceiver and provide reliable fixed-station operation. External output terminals (10 A max.) for operation of additional equipment are also provided.

■ BEFORE USING

The following accessory items are included

Operating manual (B50-4014-00)	1 copy
Fuse (6A) (F05-6021-05)	1 piece
Fuse (4A) (F05-4022-05)	1 piece
AC power cord	1 piece

■ INSTALLATION

When using the bail, swing it fully forward to place the TS-430 at the same height as that of the transceiver.

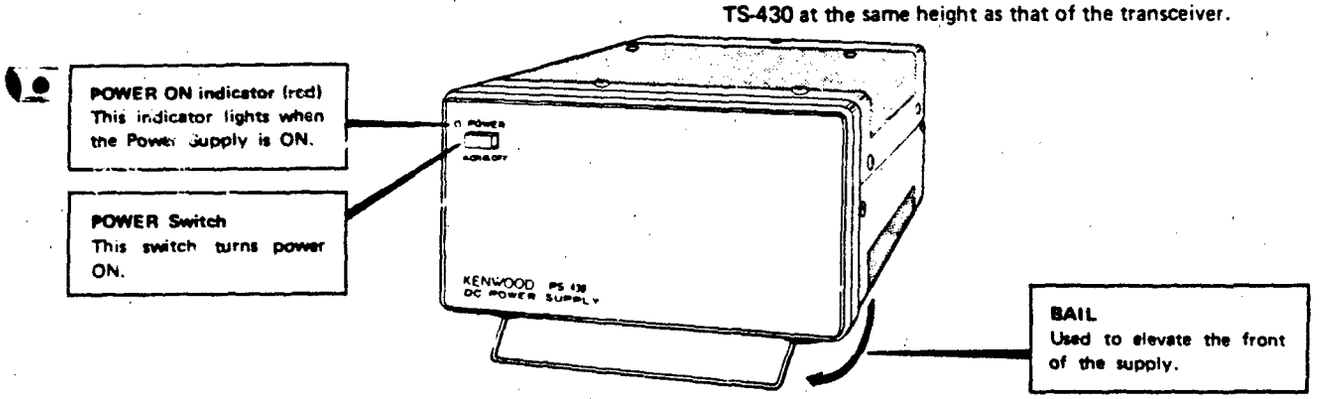
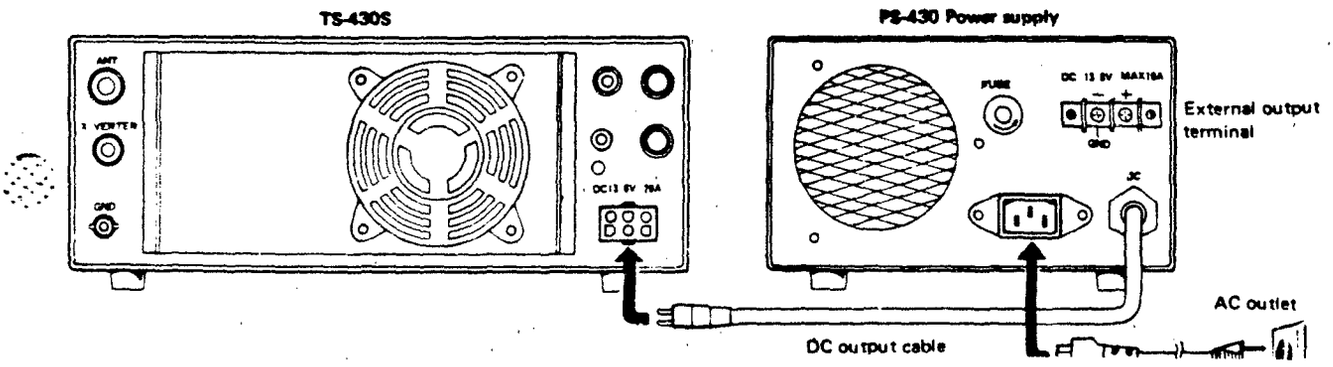


Fig. 1

Turn the Power Switch OFF before making connections.
Connect the AC power cord as shown in Fig. 2.

Note: When connecting the unit to the TS-430V (10-W model), use the DC cable supplied with the transceiver.



■CAUTIONS

1. The PS-430 will not operate if the output terminals are shorted.
   Before the PS-430 power switch is turned on, make certain the transceiver's power switch is OFF; otherwise, current greater than 2A may flow into the transceiver if it is in transmit mode. Secondly, the PS-430 may not operate if switched on with the transceiver in transmit mode because the protection circuit may operate. Turn the transceiver on after the PS-430 is turned on.
2. The fuses will blow if the unit is overloaded.
3. Allow sufficient space behind the unit and install in a well-ventilated location. Do not place any objects on top of this unit.
4. Use the heaviest and shortest DC power cable possible from the accessory terminals.
   If power cable length is excessive the output voltage will drop or induced RF energy may cause premature power supply protective shutdown.
5. When connecting two or more transceivers to the unit or when using the supply for any other purpose, check that the total operating current is below the rated current limit.

■ADDITIONAL INFORMATION

1. GENERAL INFORMATION

Your PS-430 has been factory adjusted and tested to specification before shipment. Under normal circumstances, it will operate in accordance with these operating instructions.

If your power supply fails to work, contact the authorized dealer from which you purchased it. for quick, reliable repair.

All adjustments were preset at the factory and should only be readjusted by a qualified technician with proper test equipment.

Attempting service or adjustment without factory authorization can void the power supply's warranty.

2. ORDERING SPARE PARTS

When ordering replacement or spare parts for your equipment, be sure to specify the following:

Model and serial number. Schematic number of the part. Printed circuit board number on which the part is located. Part number and name, if known, and Quantity desired.

3. SERVICE

Should it ever become necessary to return the equipment for repair, pack in its original box and packing, and include a full, detailed description of the problems involved.

You need not return accessory items unless they are directly related to the service problem.

NOTE:

When claiming warranty service, please include a photocopy of the bill of sale, or other proof of purchase showing the date of sale.

■MAINTENANCE

1. The supply is equipped with a 6-A AC fuse and a 20-A DC fuse. If either one or both blow, DISCONNECT the AC power cable and check for the cause before replacing the defective fuse.
   (Replacement fuses are available from your authorized KENWOOD dealer.)

CAUTION: NEVER use a fuse of higher rating.

2. The unit is designed to deliver 13.8V DC at 15 A. If, at some future date, the supply should require adjustment, consult your dealer.

When changing an AC operating voltage, select the desired voltage with the selector switch located on the bottom of this unit. In this case, the correct fuse must be installed, referring the table as shown.

AC voltage	Fuse
120V	6A
220V 240V	4A

NOTE:

Before changing the AC operating voltage, always disconnect the AC power cord from the AC line outlet.

■SPECIFICATIONS

Input voltage:	120/220/240V AC ± 10%, 50/60 Hz
Output voltage:	13.8V DC (standard voltage)
Output current:	20 A (25% duty cycle) 15 A (50% duty cycle)
Continuous load current:	10 A max. (including external output terminal)
Output voltage fluctuation:	Within ± 0.7 V at AC 120V, 220V, 240V ± 10% (Load current: 15 A) Within 0.7 V between 2–15 A load. (No-load output voltage: Less than 16 V at 120/220/240V AC)
Ripple voltage:	Less than 20 mV (rms) at 13.8 V, output current 15 A.
Power consumption:	Approx. 480 W (at load current DC, 20 A)
Dimensions:	173 (6-13/16) W x 95 (3-3/4) H x 245 (9-5/8) D mm (inch)
Weight:	Approx. 7 kg (15.4 lbs.)

- Circuit design and ratings are subject to change for improvement without notice.

KENWOOD

COMMUNICATION MICROPHONE

MC-80

INSTRUCTION MANUAL

■ FEATURES

The MC-80 is designed for use with a wide range of communication equipment.

UP/DOWN frequency switching and a preamplifier are provided. The silver and dark gray colors of the microphone match other communication equipment.

■ BEFORE OEPRATION

1. **Power supply**

Since the MC-80 uses an electret condenser microphone, power is required for operation.

(1) Obtain four (4) common "AA" cells.

(2) Remove the lid as shown in Fig. 2. Install the batteries observing correct polarity. Replace the lid.

(3) After the batteries are installed, place the POWER switch ON and verify that the LED lights.

2. **Connection to transceiver**

As shown in Fig. 1, the MC-80 has a standard Kenwood 8-pin MIC connector. Fig. 3 shows the connection between the transceiver and the microphone. Connecting the microphone to a transceiver with 4-pin or 6-pin MIC jack requires an optional adapter plug. Connection with equipment other than Kenwood may require either reconnection of the plug, or a different type plug. Refer to the instruction manual for necessary wiring details.

3. **Operation**

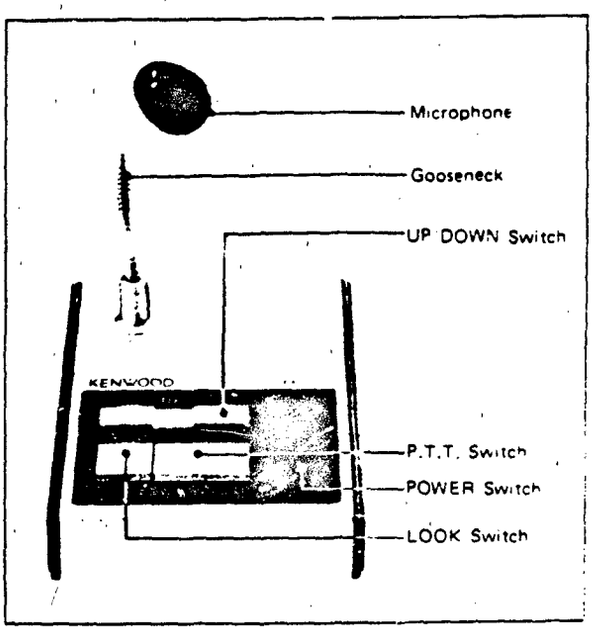
Turning the POWER switch on lights the POWER ON LED to show the mic is operating.

(1) Volume adjustment

A potentiometer to control the sound output level is located at the rear of the mic stand panel.

Adjusting the POT varies the output from 0 to 10 mV. A −50 dB setting (approx. 3.3 mV output) is preset at the factory. For normal operation, use this setting.

Transceiver	Mic jack	Mic connection and adapter	Power supply
TS-430, TS-930 TM-201, TM-401 TS-660, TW-4000 TS-780	8 pin	Adapter not needed. Direct.	Use 4 "AA" batteries.
TR-9000 series TR-7700/8400 series	6 pin	Use MJ-86 adapter.	
TR-7200/7500 series TS-120/130 series TS-520/530 series TS-820/830 series	4 pin	Use MJ-84 adapter.	
Transceiver of another manufacturer	Refer to the transceiver owners manual change the wiring or use an adapter		



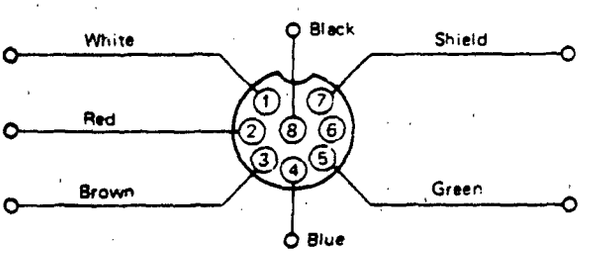


Fig. 1.

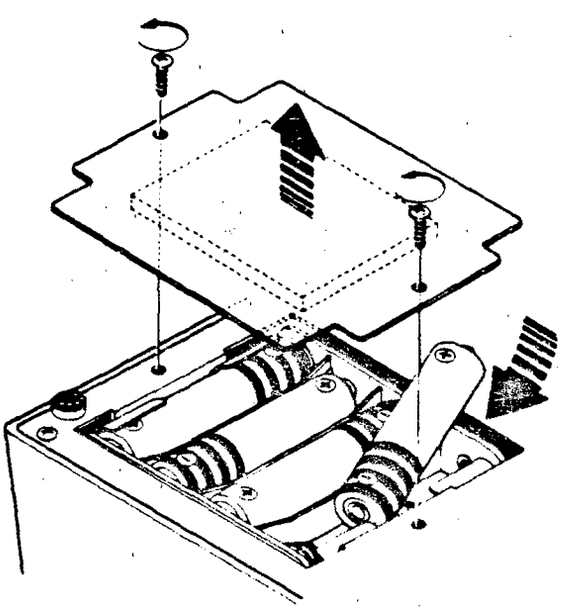


Fig. 2 Battery installation

(2) PTT and LOCK switch operation

Use the PTT or LOCK switch to transmit. Holding the PTT switch depressed allows transmission and releasing the switch returns operation from transmission to reception. Depressing the LOCK switch once allows transmission. The transmit mode remains ON after the switch is released. Depressing the switch again switches from the transmit mode to receive mode. The PTT switch is used for rapid QSO exchanges. The LOCK switch is used for relatively long transmissions.

(3) VOX operation

Switching from the receive mode to the transmit mode by your voice is called VOX (voice operated transmit) operation.

There is no need to touch the PTT or LOCK switch. Whether or not the VOX operation is possible depends upon whether the transciever or transmitter used is VOX-equipped. For VOX operation, set up the transceiver and turn on the MC-80 power.

Speaking into the microphone automatically switches the associated transceiver to transmission. When you stop speaking, the transceiver automatically returns to the receive mode. Usually, a relay is used in the transceiver for switching between transmission and reception. Relay "click" may be heard from the transceiver when switching from transmit to receive or vise-versa. For VOX operation details, refer to the transceiver instruction manual.

(4) Modulation level

Since the MC-80 employs an electret condenser microphone, speaking close to the microphone may sometimes result in reduced clarity. For normal operation, maintain 10–15 cm distance to the microphone. The optimum modulation level may vary depending upon the transceiver and operating conditions. Adjust the transceiver MIC level control, referring to the transceiver instruction manual.

(5) Output impedance

The following are typical impedance of Kenwood communications equipment:

HF equipment ..... 50k ohms
VHF & UHF equipment ..... 500 ohms

The MC-80 is set for 680 ohms so it can be used with all equipment types.

(6) UP/DOWN switch operation

Equipment having a remote UP and DOWN tuning system can be controlled from the UP/DOWN microphone. For equipment without remote tuning, the mic UP/DOWN switches are not used.

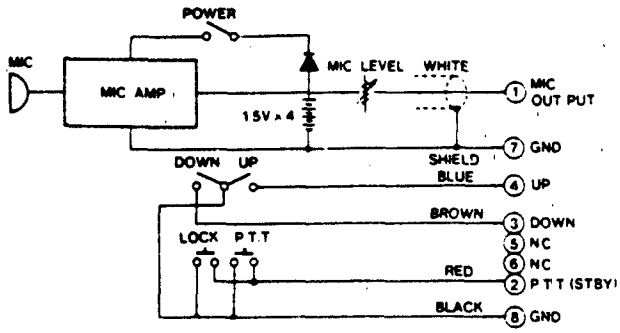


Fig. 3. MC-80 block diagram & mic plug connection

■ PRECAUTIONS

1. Do not disassemble or otherwise modify the mic assembly, or the original mic characteristics may be altered.
2. The microphone is delicate. Be sure not to jar or shock the microphone element.
3. Ensure that power is turned off when the mic is not used.
4. When the battery voltage drops due to depletion, the power output will drop and distribution may occur. Replace the battery for these indications.

■ SPECIFICATIONS

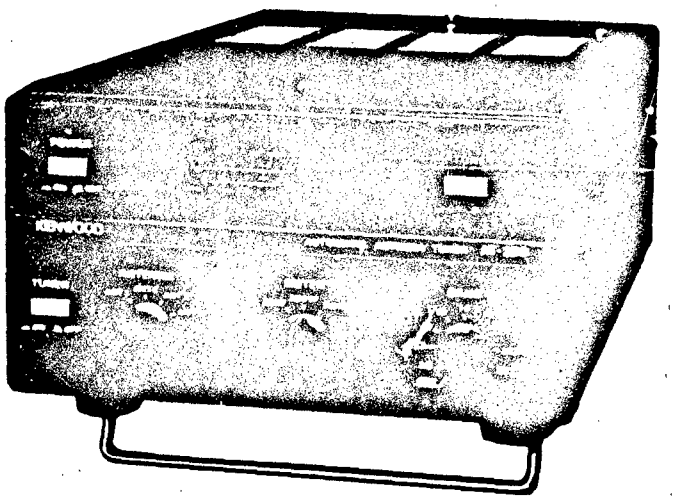
Mic unit	Omnidirectional electret condenser.
Output impedance	Approx. 700 ohms ± 30% at 1,000 Hz
Sensitivity (0 dB = 1 V/μ bar, 1,000 Hz)	–40 dB ± 6 dB (VR MAX.)
Sensitivity when shipping	– 50dB ± 6 dB
Frequency characteristic	200 ~ 7,000 Hz (± 6 dB)
Power supply	Batteries 6V (1.5 V x 4) (Batteries not supplied)
Current comsumption	Approx. 10mA (Batteries can be used more than 500 hours)
Weight	700 g

A product of
TRIO-KENWOOD CORPORATION
17 5 2 chome shibuya shibuya ku Tokyo 150 Japan

TRIO-KENWOOD COMMUNICATIONS
TRIO-KENWOOD COMMUNICATIONS, GmbH
TRIO-KENWOOD ELECTRONICS, N.V.
TRIO-KENWOOD (AUSTRALIA) PTY. LTD.

AT-250

AUTOMATIC ANTENNA TUNER



CAUTION

1) The AT-250 is capable of sustaining 100W continuous operating input power. However, during auto tuning, very high voltage appears in the tuning circuit and the reflected impedance for the transceiver varies greatly. Therefore, to protect the transceiver, adjust the transmit output to less than 50W before tuning.
2) The antenna tuner is capable of matching a 20–150 ohm load, or approximately up to 2.5:1 SWR. If the antenna and feed system exceed this range, the tuner may not stop, since it is beyond the auto tuner's capability. In this case, do not attempt further auto-tuner operation.
   To perform auto-tuner operation, first adjust the antenna and feed system.

You are the owner of our latest product, the new AT-250 Automatic Antenna Tuner. Please read this instruction manual carefully before placing your unit in service. The unit has been carefully engineered and manufactured to rigid quality standards, and should give you satisfactory and dependable operation for many years.

FEATURES

1. **All amateur bands covered in the HF range**
   Covers all amateur bands including the new WARC band from 1.8 through 28 MHz.
2. **Automatic band selection**
   When connected to the TS-430, the operating band is automatically selected from the transceiver.
3. **Dual power source capability**
   Operation from either 120, 220, or 240 V AC or 13.8V DC.
4. **POWER-SWR meter**
   Up to either 20 W or 200 W is indicated by the built-in POWER-SWR meter. When the METER switch is set to SWR, SWR is autoamtically calculated and indicated on the scale.
5. **Four antenna jacks**
   Four antennas cover a broad frequency range. Any of these antennas can be selected by the ANTENNA switch on the front panel.
   In normal operation (with the RX switch OUT), only the

SPECIFICATIONS

1.	**Frequency range**	All amateur bands from 1.8 – 29.7 MHz
2.	**Input impedance**	50 ohms unbalanced
3.	**Output impedance**	20 – 150 ohms unbalanced
4.	**Insertion loss**	0.8 dB or less
5.	**Pass through power**	100W (200W PEP)
6.	**SWR value for motor stop**	1.2:1 or less
7.	**Min. power for activation**	3W
8.	**Max. tuning time**	Within 15 seconds
9.	**Power meter (peak value reading)**	± 10% at 100W (Meter Switch 200W Position) ± 10% at 100W (Meter Switch 20W Position)
10.	**Power consumption (current)**	15W AC 13.8V DC 600 mA
11.	**Power requirement**	120V, 220V, or 240V AC selectable 13.8V (12–16) DC
12.	**Dimensions**	W174 (174) x H96 (107) x D257 (289) mm ( ) shows projections included.
	Weight	4.2 kg (9.24 lb.)
13.	**Package dimensions**	W385 x H167 x D264 mm Capacitance: 0.017 m^3
14.	**Semiconductors**	ICs 13 FETs 2 Transistors 31 Diodes 77

ACCESSORIES

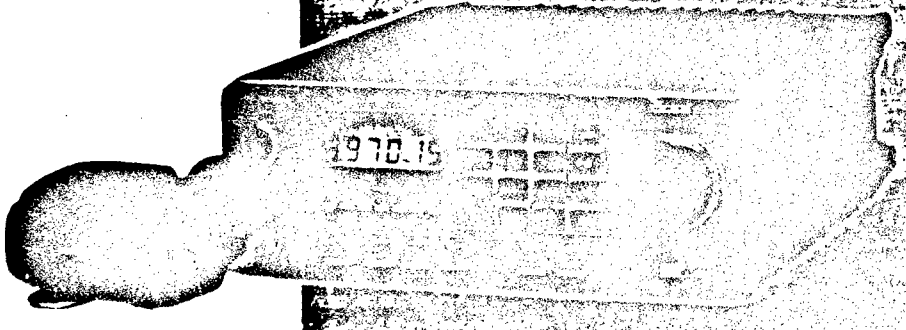
Remote cable (A) 1
Remote cable (B) 1
AC power cable 1
Grounding wire 1
Instruction manual 1

Specifications may be subject to change without notice for technical improvement.

KENWOOD

2m FM TRANSCEIVER

Model TR-7950



INSTRUCTION MANUAL

SPECIFICATIONS

[General]

Semiconductors	MPU 1
	ICs 19
	Transistors 43
	FETs 5
	Diodes 61
Frequency range	144.0 to 148.0 MHz
Frequency synthesizer	Digital control, phase locked VCO
Mode	FM (F3)
Anntenna impedance	50 ohms
Power requirement	13.8V DC ± 15%
Grounding	Negative
Operating temperature	-20°C to +50°C
Current drain	0.5V in reverive mode with no input singal
	Max. 9.5A in HI transmit mode (TR-7950)
	3.0A in LOW transmit mode (TR-7950)
	Max. 6.5A in HI tramsmit mode (TR-7930)
	2.5A in LOW transmit mode (TR-7930)
Dimension	175 mm (6 – 7/8) wide
	64 mm (2 – 1/2) high
	220 mm (8 – 11/36") deep (TR-7950)
	206 mm (8 – 1/16") deep (TR-7930)
	(projections excluded)
Weight	1.9 kg (4.18 lb) (TR-7950)
	1.8 kg (3.96 lb) (TR-7930)

[Transmitter]

RF output power (at 13.8V DC, 50Ω load)	HI 45 Watts min. (TR-7950)
	Note
	TX duty cycle: One minite TX
	Three minutes RX
	HI 25 Watts min. (TR-7930)
	LOW 5 Watts approx. (not adjustable)
Modulation	Phase sift
Frequency tolerance (-20°C ~ +50°C)	Less than $\pm 15 \times 10^{-6}$
Spurious radiation	HI Less than -70 dB
	LOW Less than -60 dB
Maximum frequency deviation (FM)	± 5 kHz
Audio response	Within +1/-3 dB of 6 dB/oct pre-emphais
	characteristic from 300 to 3000 Hz.
Audio distortion	3% max.
Microphone	Dynamic microphone with PTT switch, 500Ω

[Receiver]

Circuitry	Double superheterodyne
Intermediate frequency	1st 10.695 MHz
	2nd 455 kHz
Receiver sensitivity	Better than 12 dB for 0.25 μV SINAD
	Better than 50 dB for 1 mV S+N/N
Receiver selectivity	More than 12 kHz (-6 dB)
	Less than 24 kHz (-60 dB)
Spuriour response	Better than 70 dB
Squelch sensitivity	Less than 0.16 μV (threshold)
Auto scan stop level	Less than 0.2 μV (threshold)
Audio output	More than 2.0 watts across 8 ohms load (5% dist.)

Note: Circuit and ratings are subject to change without notice due to developments in technology.

KENWOOD

TR-2600A

144 MHz FM SYNTHESIZED HAND-HELD TRANSCEIVER

INSTRUCTION MANUAL

SPECIFICATIONS

[GENERAL]

Frequency Range	144 – 148 MHz
Memory Channels	10 CH
Mode	FM (F3), (F2 in DCS mode)
Operating voltage	8.4 V DC ±25%
Power Requirement	8.4 V, 450 mAH (Ni-Cd battery pack) 9 V manganese or alkaline (not Ni-Cd) 6 pcs. battery case (option)
Back-up Power Requirement	CR-2032 Lithium battery
Current Drain	Approx. 35mA in receive mode with no input signal Less than 800mA in HI transmit mode (at 8.4 V) Less than 400 mA in Low transmit mode (at 8.4 V) Less than 1μA for memory back-up
Grounding	Negative
Operating Temperature	– 20°C to + 50°C
Antenna Impedance	50 Ω
Dimensions	With Ni-Cd battery: 66(2.6)W × 168(6.7)H × 40(1.6)D mm(inch) With manganese battery: 66(2.6)W × 176(7.0)H × 40(1.6)D mm(inch)
Weight	With Ni-Cd battery 520 g (1.2 lbs.) With manganese battery: 510 g (1.2 lbs.)

[TRANSMITTER]

RF Output Power	HI = 2.5 W LOW = 0.3 W approx.
Modulation	Variable reactance direct shift
Frequency Tolerance	Less than ±20 × 10^{-6} (– 10°C – + 50°C)
Maximum Frequency Deviation	±5 kHz
Spurious Radiation	Less than – 60 dB

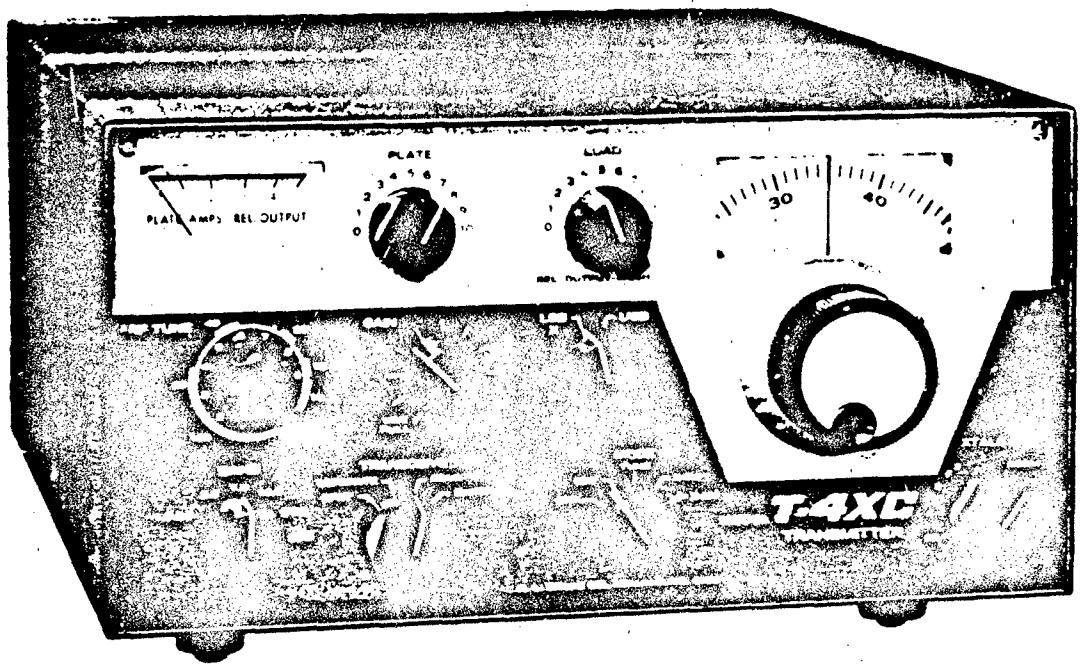
[RECEIVER]

Circuitry	Double conversion superheterodyne
Intermediate Frequency	1st IF = 10.7 MHz 2nd IF = 455 kHz
Sensitivity	Better than 1μV for S/N 30 dB Less than 0.2μV for 12 dB SINAD
Pass-Band Width	More than 12 kHz (– 6 dB)
Selectivity	Less than 24 kHz (– 40 dB)
Spurious Response	Better than 50 dB
Squelch Sensitivity	Less than 0.2μV (threshold)
Audio Output Power	More than 400 mW (at 10% distortion and 8 Ω load)

NOTE: Circuit and ratings may change without notice due to advances in technology.

DRAKE

INSTRUCTION MANUAL



MODEL **T·4XC**

TRANSMITTER

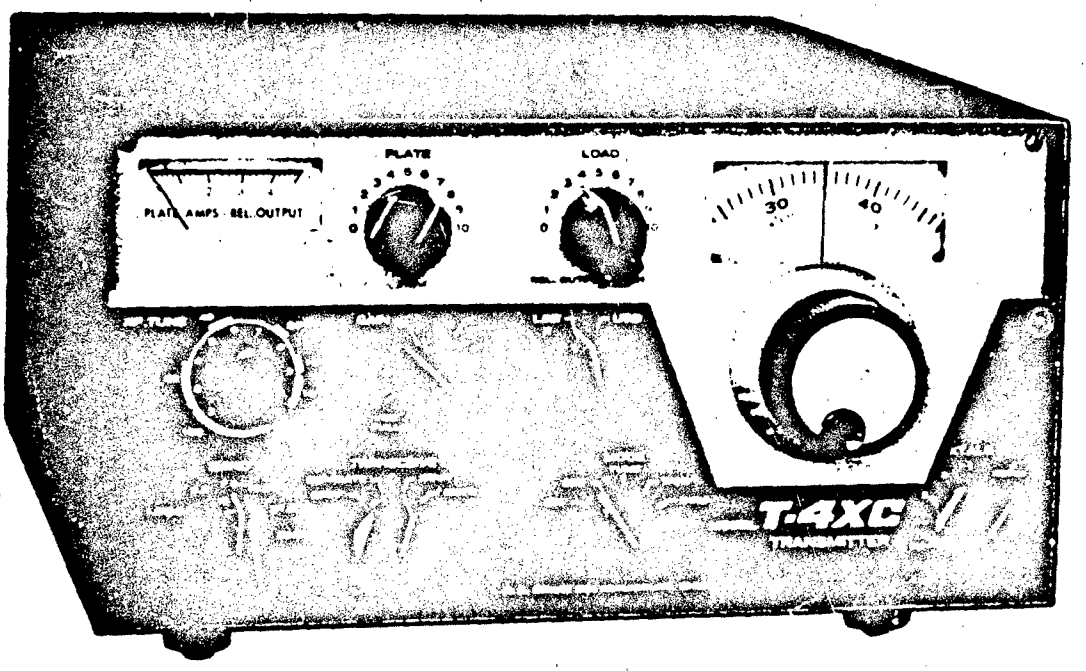


Figure 1–1. T–4XC Transmitter

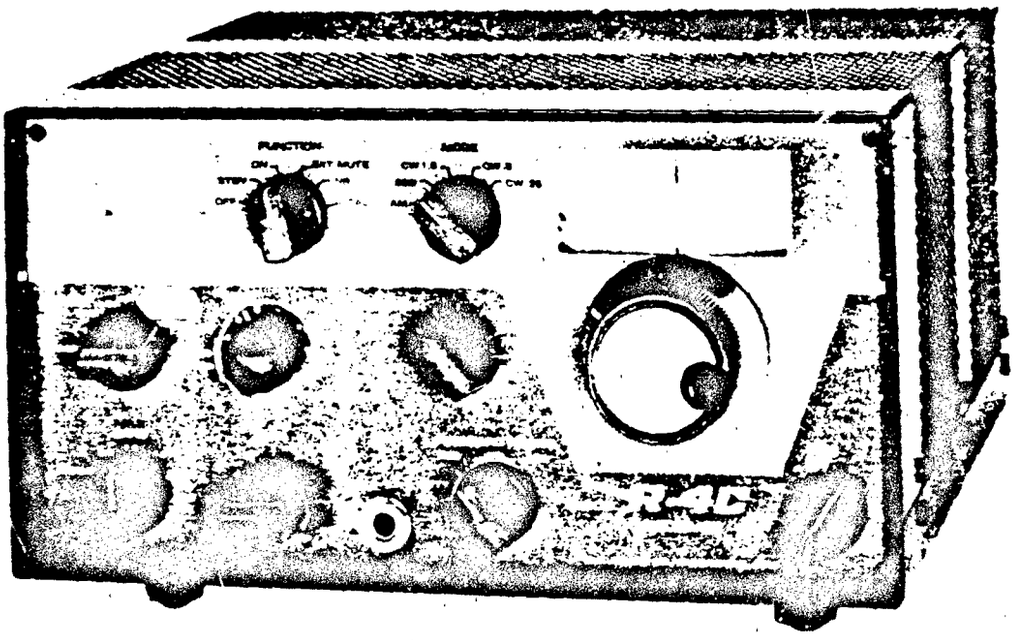
SPECIFICATIONS

Frequency Coverage:	
Crystals Supplied:	3.5 to 4.0 MHz 7.0 to 7.5 MHz 14.0 to 14.5 MHz 21.0 to 21.5 MHz 28.5 to 29.0 MHz
Accessory Crystals:	4 additional 500 kHz ranges (see table 2–1). Between 1.8 and 30 MHz Excluding: 2.3 to 3.0 MHz 5.0 to 6.0 MHz 10.5 to 12.0 MHz
Fixed Freq. Crystal:	Between 1.8 and 30 MHz Excluding: 2.3 to 3.0 MHz 5.0 to 6.0 MHz 10.5 to 12.0 MHz
Dial Calibration:	Zero to 500 kHz in 1 kHz increments.
Calibration Accuracy:	Better than 1 kHz when calibrated to the nearest 100 kHz point.

Frequency Stability:	Drift is less than 100 Hz after warmup and less than 100 Hz with 10% change in line voltage.
Modes of Operation:	
SSB:	Upper or lower sideband on all bands. VOX or push-to-talk.
CW:	Grid-block keying. VOX circuit is keyed for automatic transmit receive switching. Sidetone oscillator is keyed for monitoring. Shifted carrier system has no spurious output.
AM:	Controlled carrier AM modulation is built-in. This system is compatible with SSB linear amplifiers. VOX or push-to-talk.
RTTY:	Two methods of RTTY are available. 1. The VFO is easily adaptable to FSK. Signal frequency shifts same direction on all bands and same amount on any band with a given dial setting. 2. The RTTY signal may also be generated by applying undistorted audio tones at the mike input in the SSB mode. A jack is provided at the rear panel to shift the carrier oscillator such that the frequency response of the transmitter on LSB is altered so as to pass the tone frequencies without generating unwanted harmonics or sidebands.
Sideband Suppression:	60 dB or better.
Carrier Suppression:	60 dB or better.
Average Distortion Products:	In excess of 30 dB down.
Frequency Response:	SSB, 325 to 2725 Hz at 6 dB down.
Input Power:	SSB and AM–200 Watts PEP, CW–200 Watts.
Output Impedance:	Nominal 52 Ohms adjustable with pi-network. (SWR should be 2:1 or less.)
Microphone Input:	High impedance.
AGC:	Operates on SSB to prevent flat-topping due to overdrive.
Power Requirements:	650 Volts at 225 mA average and 400 mA maximum with 10% regulation from 50 mA to 330 mA and maximum ripple of less than 1%. 250 Volts at 120 mA with 10% regulation from 82 mA to 120 mA. This includes the effect of the 650 Volt supply change if both voltages are obtained from the same transformer. Maximum ripple must be less than 1/4%. –45 to –65 Volts DC adjustable filtered bias into 33 K Ohm load. 12.6 Volts AC or DC at 3 amps.
Dimensions:	5-1/2" high, 10-3/4" wide, cabinet depth 11-5/8", overall length 12-1/4".
Weight:	14 lbs. 10 oz.

DRAKE

INSTRUCTION MANUAL



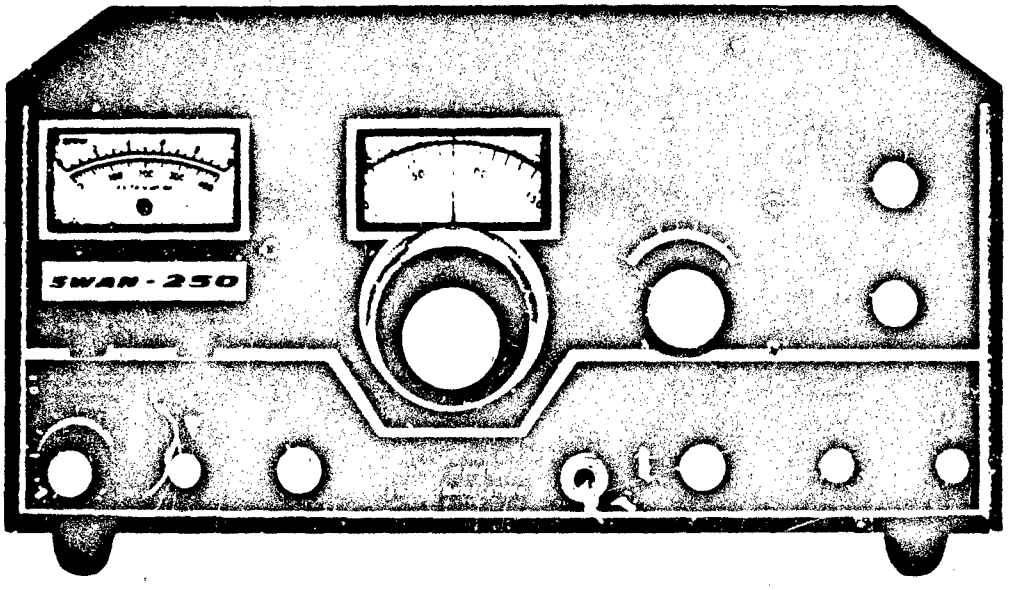
MODEL **R-4C**

RECEIVER

SPECIFICATIONS

Frequency Coverage:	Covers 3.5 to 4.0 MHz, 7.0 to 7.5 MHz, 14.0 to 14.5 MHz, 21.0 to 21.5 MHz, and 28.5 to 29.0 MHz.
Accessory Coverage:	15 accessory crystal sockets are provided. Coverage of any additional 500 kHz ranges between 1.5 and 30 MHz (except between 5.0 and 6.0 MHz) can be added by installing accessory crystals.
Modes of Operation:	SSB, CW, AM, RTTY.
Sensitivity:	SSB Mode: 10 dB signal-plus-noise to noise ratio obtained on 80 M-10 M amateur bands with less than a 0.25 microvolt signal on the antenna terminal, on other frequencies less than 0.5 microvolt signal.
Selectivity:	As supplied: SSB Mode: 2.4 kHz at 6 dB, 4.2 kHz at 60 dB. AM Mode: 8.0 kHz at 6 dB, 28 kHz at 60 dB. With accessory crystal filters: AM Mode, 2 filters available: 6.0 kHz at 6 dB, 10 kHz at 60 dB. 4.0 kHz at 6 dB, 7.5 kHz at 60 dB. CW 1.5, CW .5, CW .25 Modes, 3 filters available: 1.5 kHz at 6 dB, 3.0 kHz at 60 dB. 500 Hz at 6 dB, 1000 Hz at 60 dB. 250 Hz at 6 dB, 600 Hz at 60 dB.
Stability:	After warm up, frequency will not drift more than ± 100 Hz, including voltage variation of ± 10%.
Calibration:	Better than ± 1 kHz when calibrated at nearest 100 kHz calibration point.
Spurious Responses:	Internal spurious response less than the equivalent of a 1 microvolt antenna signal on all amateur bands.
Image Rejection:	(11.29 MHz above desired): Over 70 dB below 23 MHz, 60 dB above 23 MHz.
Input Impedance:	52 Ohms nominal.
Audio Output Impedance:	3.2 Ohms to speaker, or headphones, 3000 Ohms anti vox.
Audio Output:	0.7 Watt at AVC threshold, 2 Watts maximum at less than 5% T.H.D.
AGC:	Audio Output increases 3 dB maximum for a RF input increase of 100 dB above AGC threshold. AGC threshold typically 1 microvolt. Attack time: 1 millisecond Release times: Slow: 1 second Medium: 350 mSec Fast: 50 mSec
Power Consumption:	60 Watts, 120/240 Volts AC, 50/60 Hz.
Size:	5.5 inches high, 10.75 inches wide, 12.25 inches deep overall.
Weight:	17 pounds.

OPERATION and MAINTENANCE
MODEL 250 SERIES
Single Sideband Transceiver



INTRODUCTION

The Swan Model 250 Single Sideband Transceiver together with its accessories and optional equipment is designed to be used for SSB AM or CW communications in the 50-54 mc. amateur radio bands. MARS frequencies may also be covered by using the Model 405X oscillator accessory.

The Model 250 generates a single sideband signal by means of a crystal lattice filter, and the transceive operation automatically tunes the transmitter to the received frequency. When operating in single sideband mode, the normally used upper sideband (USB) is employed.

Basic circuitry of the single conversion design has been proven in several thousand of the popular Swan transceivers. Mechanical, electrical, and thermal stability is exceptionally high. All oscillators are temperature compensated and voltage regulated. Push-to-talk operation is standard, with provision for plugging in the Model VX-1 accessory Vox unit for automatic voice control.

With a suitable power supply, operation may be fixed, portable, or mobile. Power input is rated at 240 watts, PEP, on single sideband. 180 watts on CW, and 75 watts on AM. The basic transceiver includes automatic gain control (AGC), and grid block CW keying.

Recommended power supplies are the model 117-XC for ac operation and model 14-117 for 12-volt dc operation.

SWAN
ELECTRONICS
Oceanside California

SPECIFICATIONS:

FREQUENCY RANGE

50-54 mc. (except for a narrow segment at 53.5 mc)

POWER INPUT

Single Sideband, Suppressed Carrier:
240 watts, PEP, minimum.
CW:
180 watts, dc input.
AM (Single Sideband with Carrier):
75 watts dc input.

DISTORTION

Distortion products down approx. 30 db.

UNWANTED SIDEBAND SUPPRESSION

Unwanted sideband down more than 40 db.

CARRIER SUPPRESSION

Carrier suppression greater than 50 db.

RECEIVER SENSITIVITY

Less than 0.5 microvolt at 50 ohms impedance for signal-plus-noise to noise ratio of 10 db. Noise figure better than 3 db.

AUDIO OUTPUT AND RESPONSE

Audio output, 4 watts to 3.2 ohm load. Response essentially flat from 300 to 3000 cps in both receive and transmit.

TRANSMITTER OUTPUT

Wide-range Pi-network output matches antennas essentially resistive from 15 to 500 ohms impedance.

METERING

Power amplifier cathode current 0-400 ma. and 0-10 relative output indicator.

FRONT PANEL CONTROLS

Rec Tune-CW, AF Gain, R.F. Gain, Mic. Gain, Carrier Balance, PA Plate Tune, PA Grid Tune, PA Load, KC Tuning Dial, MC Tuning Dial, Meter Switch.

REAR PANEL CONTROLS AND CONNECTORS

Bias potentiometer, CW key jack, Jones plug power connector, Vox connector, Antenna jack, Auxiliary relay switching.

VACUUM TUBE COMPLEMENT

V1 6EW6 VFO Amplifier
V2 12BE6 Transmitter Mixer
V3 6GK6 Driver
V4 6146B Power Amplifier
V5 6146B Power Amplifier
V6 6HA5 Receiver RF Amplifier
V7 6HA5 Receiver Mixer
V8 6EW6 First IF Amplifier
V9 12BA6 Second IF Amplifier
V10 12AX7 Product Detector/Receive Audio
V11 6BN8 AGC Amplifier/Rectifier
V12 6GK6 Audio Amplifier
V13 7360 Balanced Modulator
V14 12BA6 Carrier Oscillator
V15 12AX7 Mic. Amplifier/Transmit Audio
V16 OA2 Voltage Regulator

DIODE AND TRANSISTOR COMPLEMENT

Q1	2N706 Oscillator
Q2	2N706 Emitter Follower
Q3	2N706 Buffer Amp.
D1001	Noise Limiter Diode
D1002	Noise Limiter Diode
D1601	1N2974A Zener voltage regulator
D1602	TS-2 Relay Silencing Diode

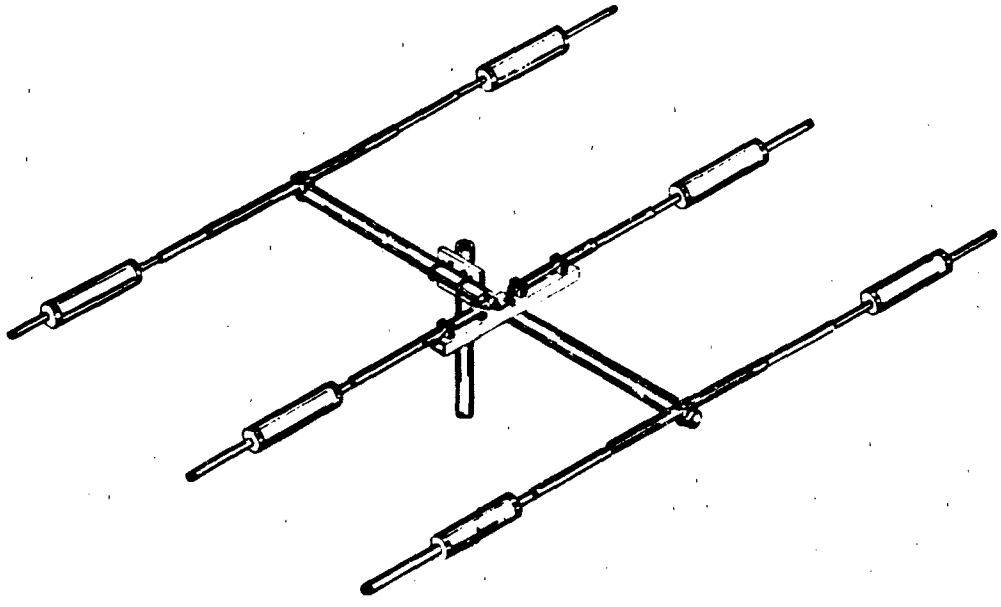
POWER REQUIREMENTS

Filaments	12.6 volts, 4.5 amps, ac or dc
Relay	12 volts dc, 250 ma.
Bias	-110 volts dc, 100 ma.
Medium voltage	275 volts dc, 150 ma.
High voltage	800 volts dc, 300 ma. Peak Trans.

DIMENSIONS AND WEIGHT

Height	5-1/2 in.	Depth	11 in.
Width	13 in.	Weight	17-1/4 lb.

ASSEMBLY INSTRUCTIONS
FOR
MOSLEY THREE ELEMENT
TRAP MASTER ANTENNA
MODEL TA-33 JR.



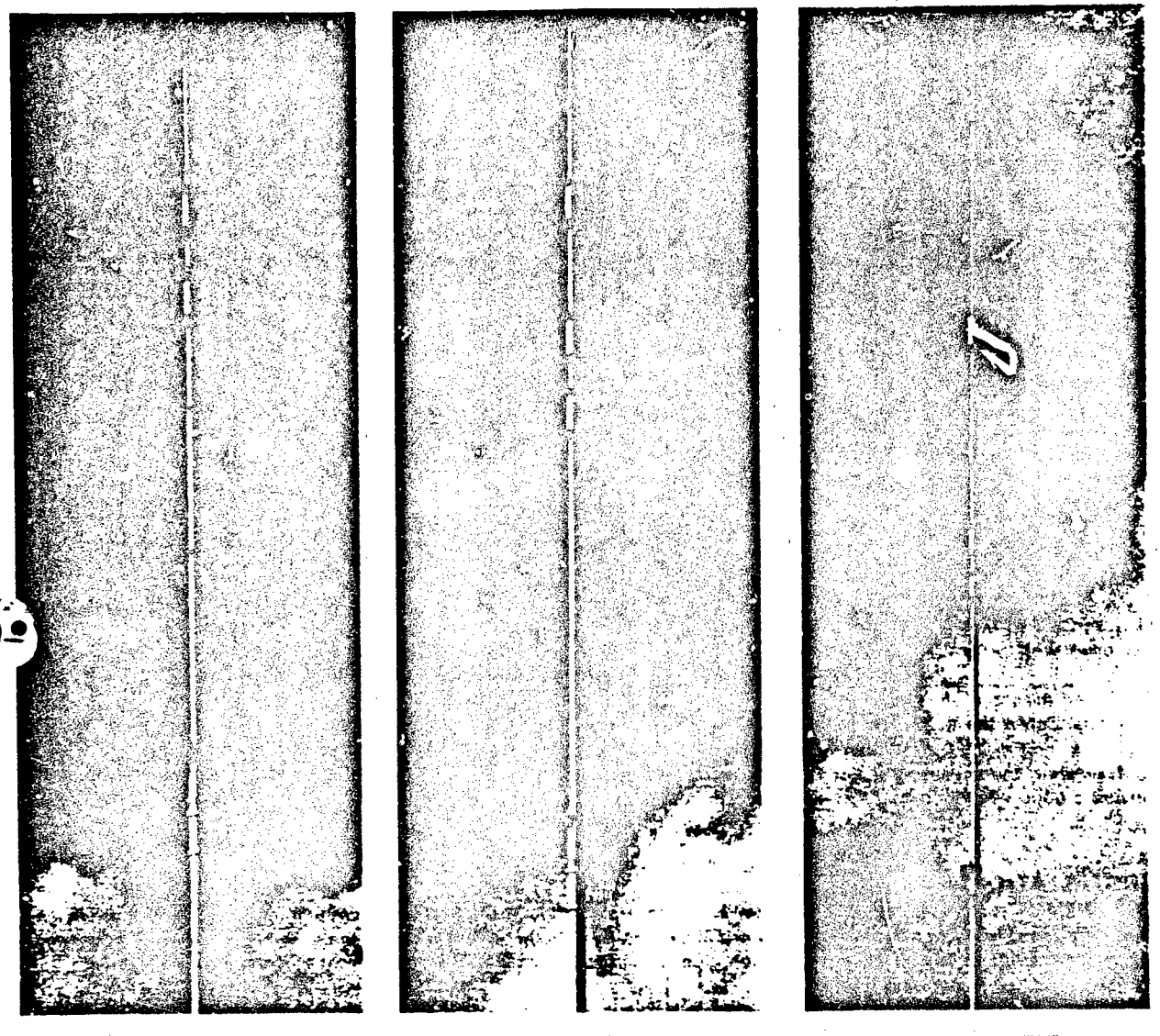
FREQUENCY CHART				
ELEMENT	COLOR	BAND	CODE 1*	11**
RADIATOR	RED	10 Meters	28.5	29.00
REFLECTOR	YELLOW	15 Meters	21.150	21.350
DIRECTOR	GREEN	20 Meters	14.150	14.250
*Best for CW			**Best for Phone	

NOTE: To order replacement parts from instruction sheet, refer to Form No. and Part No.

M·E·I

MOSLEY ELECTRONICS, INCORPORATED
4610 North Lindbergh Boulevard
Bridgeton, Missouri 63042

ASSEMBLY AND INSTALLATION INSTRUCTIONS



AV-3 AV-4 AV-5 ANTENNAS

Aircraft CORPORATION

AV3482

SPECIFICATIONS

	AV-3	AV-4	AV-5
Overall Height - CW - Phone	13 ft. 1½" (3.98m) 12 ft. 8½" (3.94m)	18 ft. (5.58m) 17 ft. 1¼" (5.33m)	27 ft ¾" (8.37m) 24 ft. 1¾" (7.44m)
Wind Surface Area - CW	1.02 sq. ft. (.10 sqm)	.46 sq. ft. (.14 sqm)	1.89 sq. ft.(.1859 sqm)
Assembled Weight	5.21 lbs (2.33kg)	7.15 lbs (3.22kg)	8.41 lbs (3.78kg)
Maximum Mast Diameter	1¾" (4.5cm)	1¾" (4.5cm)	1¾" (4.5cm)
Frequency Coverage (MHz)	28.0 - 29.2 21.0 - 21.5 14.0 - 14.4	28.0 - 29.2 21.0 -21.5 14.0 - 14.4 7.0 - 7.3	28.0 - 29.2 21.0 - 21.5 14.0 - 14.4 7.0 - 7.3 3.5 - 4.0
Nominal Input Impedence	50 ohms (Takes PL-259 Connector)		
Standing - Wave Ratio	1.5:1 or less at Resonance		
Power Handling Capability	2000 Watts P.E.P.		
Element Material	6063 - T832 Hard-Drawn, Bright Finish Aluminum Tubing		
Trap Material	⅛" (3.1cm) Wall Fiberglass Tubing, with Copper or Aluminum Wire		

LIMITED WARRANTY

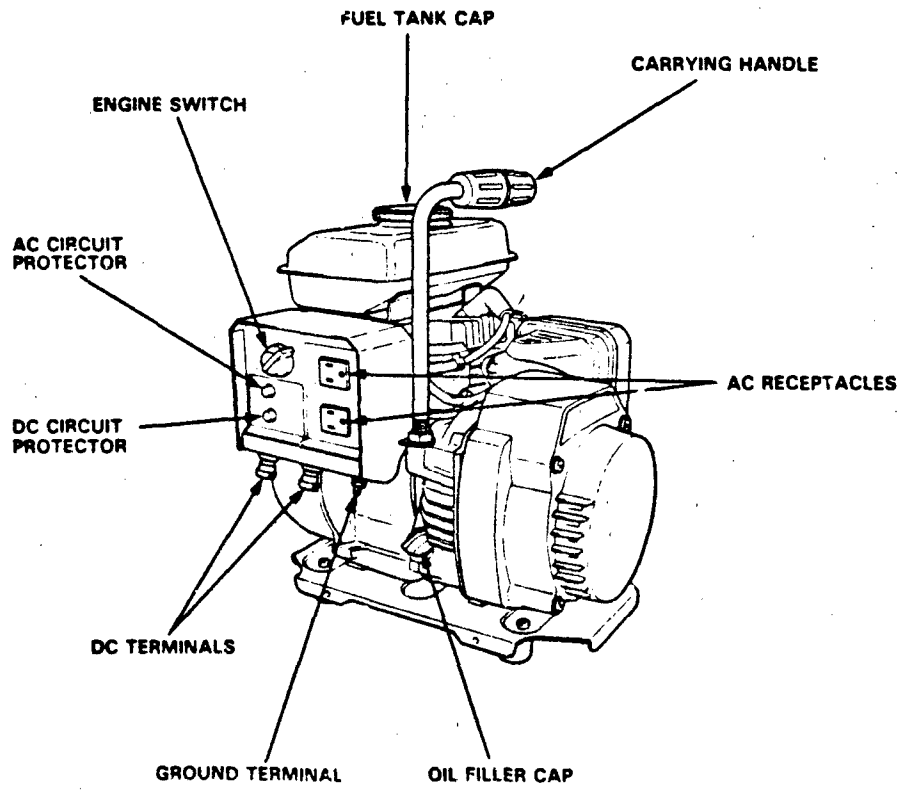
CUSHCRAFT CORPORATION P O BOX 4680 MANCHESTER, NEW HAMPSHIRE 03108 WARRANTS TO THE ORIGINAL CONSUMER PURCHASER FOR ONE YEAR FROM DATE OF PURCHASE THAT EACH CUSHCRAFT ANTENNA IS FREE OF DEFECTS IN MATERIAL OR WORKMANSHIP. IF, IN THE JUDGEMENT OF CUSHCRAFT, ANY SUCH ANTENNA IS DEFECTIVE, THEN CUSHCRAFT CORPORATION WILL, AT ITS OPTION, REPAIR OR REPLACE THE ANTENNA AT ITS EXPENSE WITHIN THIRTY DAYS OF THE DATE THE ANTENNA IS RETURNED (AT PURCHASER'S EXPENSE) TO CUSHCRAFT OR ONE OF ITS AUTHORIZED REPRESENTATIVES. THIS WARRANTY IS IN LIEU OF ALL OTHER EXPRESSED WARRANTIES, ANY IMPLIED WARRANTY IS LIMITED IN DURATION TO ONE YEAR. CUSHCRAFT CORPORATION SHALL NOT BE LIABLE FOR ANY INCIDENTAL OR CONSEQUENTIAL DAMAGES WHICH MAY RESULT FROM A DEFECT. SOME STATES DO NOT ALLOW LIMITATIONS ON HOW LONG AN IMPLIED WARRANTY LASTS OR EXCLUSIONS OR LIMITATIONS OF INCIDENTAL OR CONSEQUENTIAL DAMAGES, SO THE ABOVE LIMITATION AND EXCLUSION MAY NOT APPLY TO YOU. THIS WARRANTY GIVES YOU SPECIFIC LEGAL RIGHTS, AND YOU MAY ALSO HAVE OTHER RIGHTS WHICH VARY FROM STATE TO STATE. THIS WARRANTY DOES NOT EXTEND TO ANY PRODUCTS WHICH HAVE BEEN SUBJECT TO MISUSE, NEGLECT, ACCIDENT OR IMPROPER INSTALLATION. ANY REPAIRS OR ALTERATIONS OUTSIDE OF THE CUSHCRAFT FACTORY WILL NULIFY THIS WARRANTY.

cushcraft
CORPORATION
P O BOX 4680 MANCHESTER, N H 03108

SPECIFICATIONS SUBJECT TO CHANGE WITHOUT NOTICE

HONDA
EG650

COMPONENT IDENTIFICATION



SPECIFICATIONS

Dimensions

Length x Width x Height	350 x 300 x 360 mm (13.8 x 11.8 x 14.2 in)
Dry Weight	19.0 kg (41.9 lb)

Engine

Model	HONDA G100K1
Engine Type	4 stroke, side valve 1 cylinder
Displacement (Bore x Stroke)	83 cm³ (5.1cu.in) 48 x 46 mm (1.9 x 1.8 in)
Compression Ratio	6.5 : 1
Engine Speed	3600 rpm
Cooling System	Forced air cooled
Ignition System	Transistor Magneto Ignition
Oil Capacity	0.45ℓ (0.48 USqt)
Fuel Tank Capacity	1.3ℓ (0.34 USgal)
Spark Plug	BMR-4A (NGK), W14 MR-U (ND)

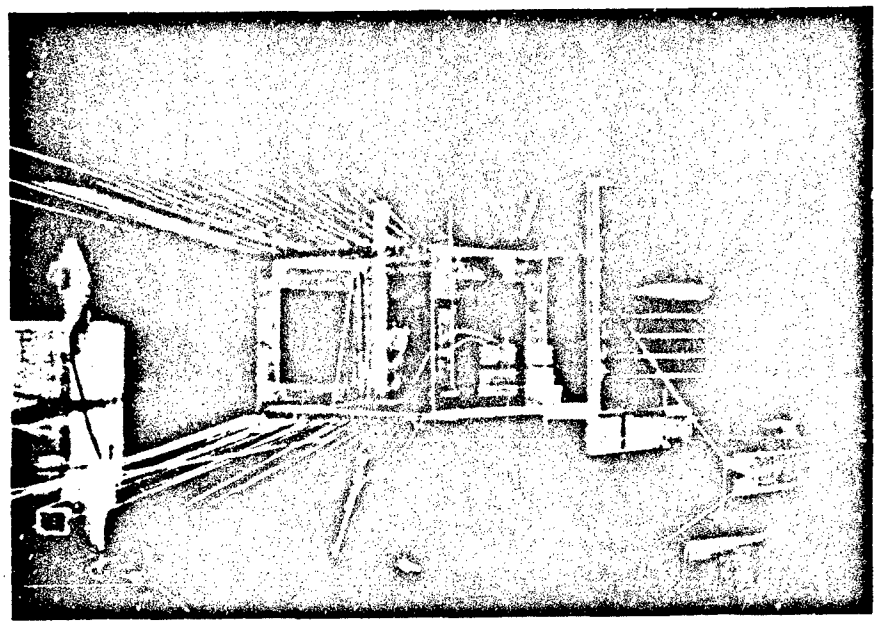
Generator

AC output	Rated voltage Rated frequency	120V 60Hz
	Rated ampere	4.6A
	Rated output	550 VA
	Maximum output	650 VA
DC output		Only for charging 12 V automotive batteries Maximum charging output = 8.3A

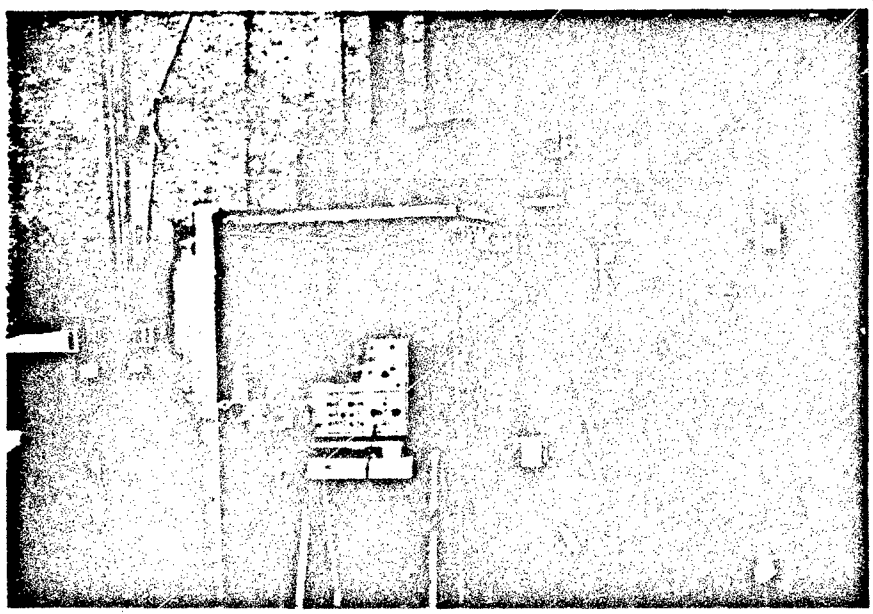
Section 8

Equipment Test Photographs

TEST PHOTOGRAPHS
EQUIPMENT TESTS

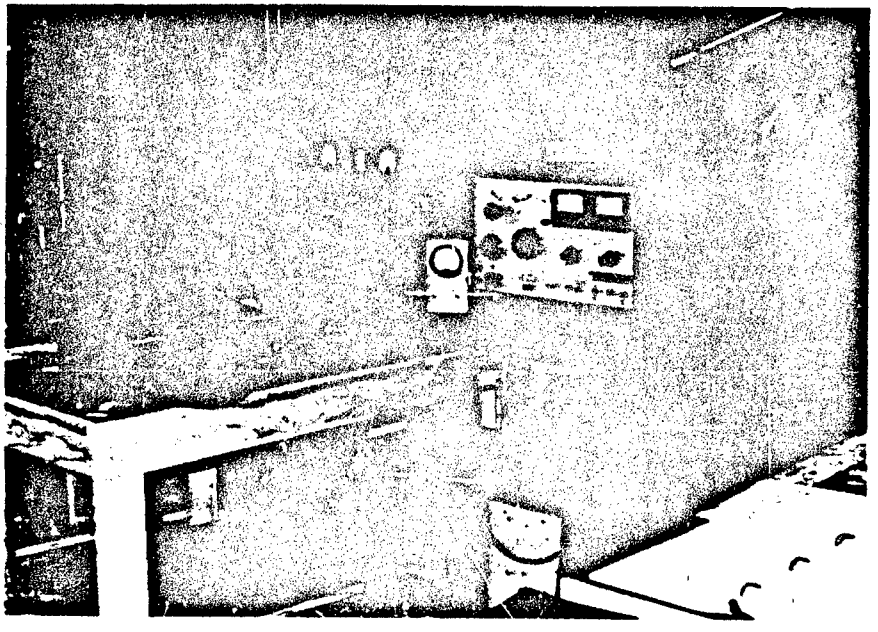


MARX GENERATOR

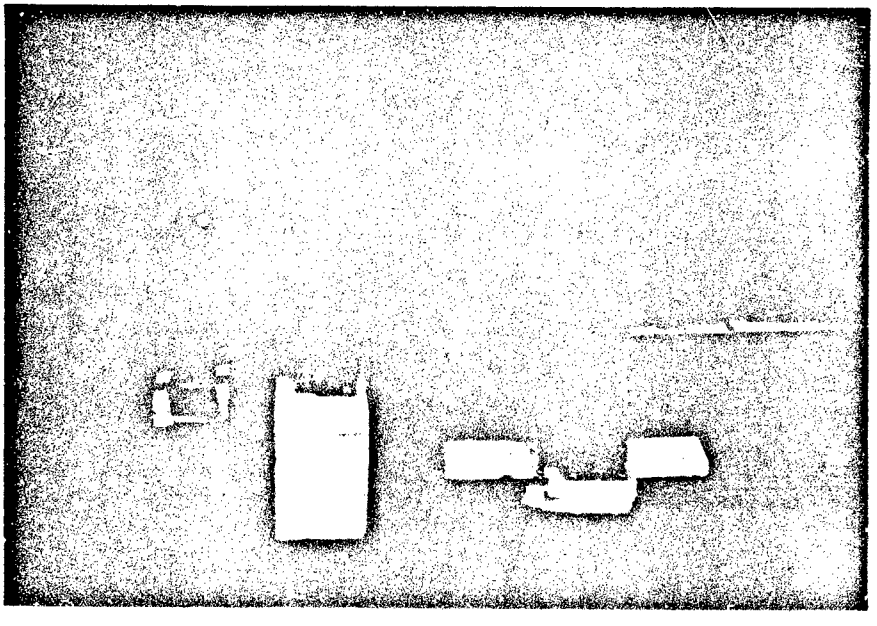


HIGH VOLTAGE DC POWER SUPPLY, OSCILLOSCOPE AND SCREEN ENCLOSURE, AND MARX GENERATOR

TEST PHOTOGRAPHS
EQUIPMENT TESTS



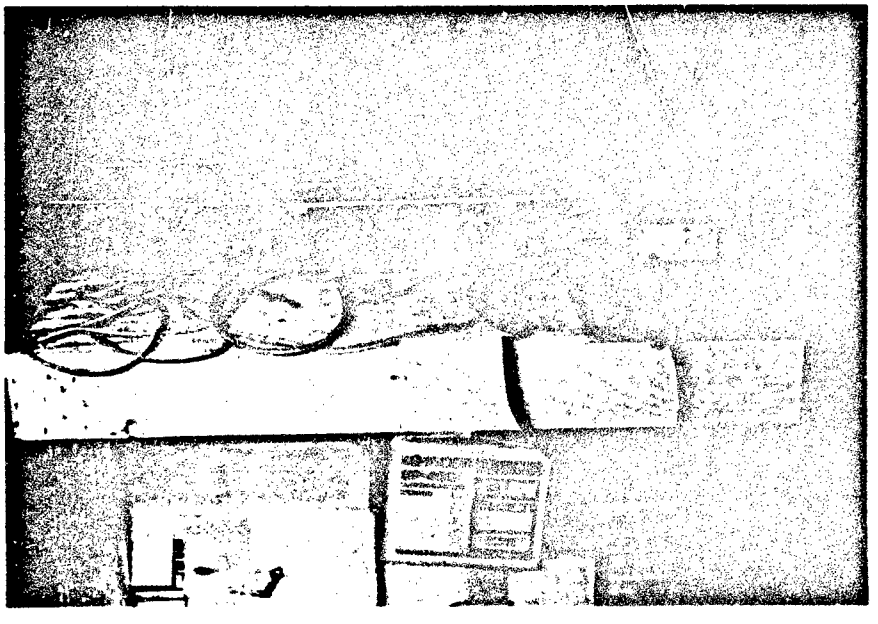
BENCH-CHECK EQUIPMENT



H FIELD SENSORS WITH METAL COAXIAL PROBE ON ROUND SENSOR AND FIBER OPTIC TRANSMITTER AND CABLE ON RECTANGULAR SENSOR.

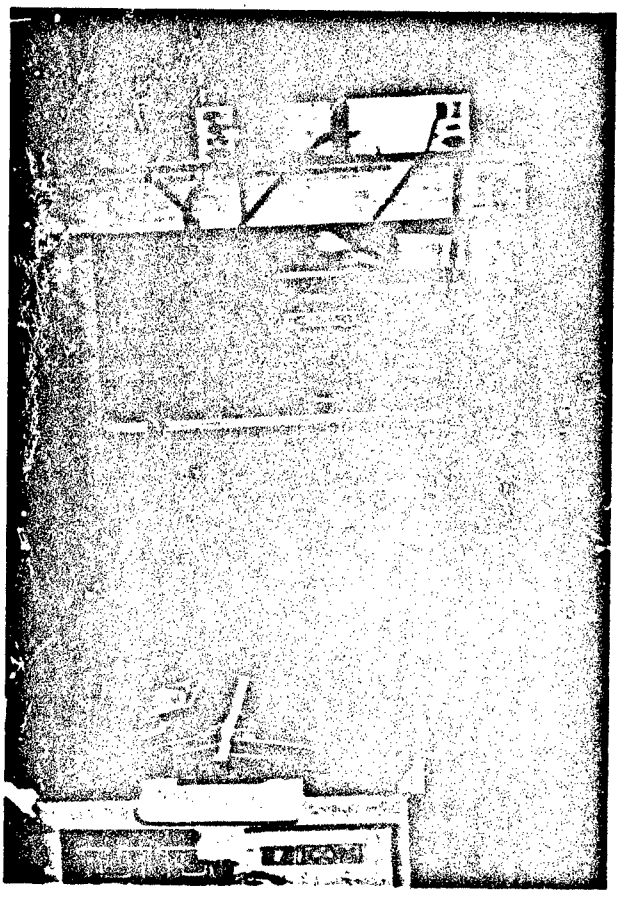
TEST PHOTOGRAPHS
EQUIPMENT TESTS

TYPICAL SERIES A TEST CONFIGURATION

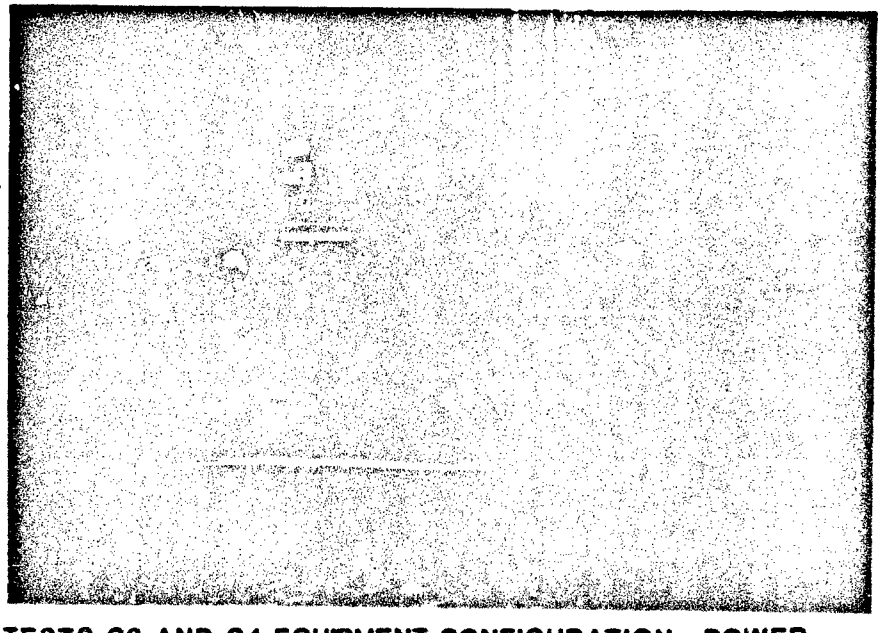


TYPICAL SERIES B1 TEST CONFIGURATION

TEST PHOTOGRAPHS
EQUIPMENT TESTS

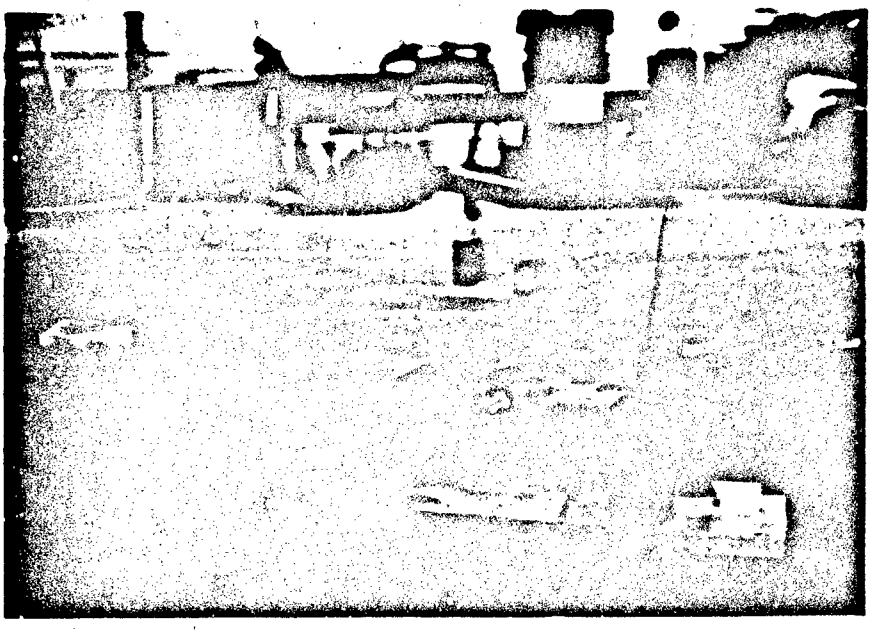


TYPICAL SERIES B2 TEST CONFIGURATION



- TESTS C3 AND C4 EQUIPMENT CONFIGURATION. POWER GENERATOR (IN BACKGROUND) AND ISOLATION TRANSFORMER (NOT SHOWN) WERE CONNECTED

TEST PHOTOGRAPHS
EQUIPMENT TESTS



TYPICAL CONFIGURATION FOR AC POWER INJECTION

TYPICAL DC POWER CONFIGURATION. A 12 VOLT
AUTOMOBILE BATTERY IN THE METAL BOX.
RF PROTECTION DEVICE IS INSTALLED IN COAXIAL LINE.