IR IED 76

INDEPENDENT RESEARCH AND INDEPENDENT EXPLORATORY DEVELOPMENT

ANNUAL REPORT FY76 AND FYTQ

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Foreword

This marks the ninth IR/IED report for the Naval Electronics Laboratory Center. In the last few years there has been strong emphasis toward developing both (1) new capabilities which will help us fulfill our role in providing the technological base for new performance demands of the future and (2) improved ability to achieve significant gains in equipment, reliability, and efficiency together with reduction in equipment size, weight, and life-cycle cost in the present. Examples of the first category include fiber optics, optical communications, charge-coupled devices, new materials for field-effect transistors, and millimetre wave devices to 60 GHz. Examples of the second category include digital techniques, modular approach to equipments, application of medium-scale integration (MSI) and large-scale integration (LSI), microprocessors, and increased reliability through understanding of device fabrication and failure.

A main thrust has been toward electro-optics technology: laser research and development, optical signal processing, fiber and integrated optics, and optical communications. As a result, there have been many advances that have present and potential value to the Navy. The Submarine-to-Aircraft Optical Communications System (SAOCS) is planned for advanced development in FY77 to enter the Fleet about 1985. The real-time programmable electro-optical signal processor will be used in a bioacoustic communication study to be made jointly with the Naval Undersea Center. A fiber optics system installed among the NORAD computer complexes at Cheyenne Mountain, Colorado, has operated successfully and paid for itself in 15 months.

Many fleet capabilities have their origins in IR/IED projects, as do many significant current development programs. Current NELC block programs also can be traced back to earlier IR or IED projects.

Block Programs	IR/IED Origins
Command Control	Natural Language Processing; Network Study
	Small Ship C^2 System
	Display Studies
Communication	HF—Propagation
	Signal Processing Theory
	EO—Laser Physics and Development
	Optical Communications
Solid-State and Microwave Technology	Millimetre Wave Integrated and Solid State Circuits
	III - V Semiconductor MIS Research
Fiber Optics	Optical Data Multiplexing
	Fiber Optics Communications
SEM (Standard Electronic Modules) R&D	BAMS

For FYTQ and FY77 half the IED funds are applied to command control technology projects in the Information Systems and Computer Sciences Departments for design of a tactical data distribution system and a distributed real-time data processing system. Their successful completion will enhance nodal command control survivability and reconfigurability.

A regrettable trend has been the decrease in discretionary funds starting with the Congressional cut in the IED funds for FY76 and the withdrawal of some IR funds by the Chief of Naval Research in FY77. It is hoped that the funds will be restored to earlier levels to give each Technical Director the capability to continue to support good ideas, to exploit new ideas before a sponsor is available, and to develop expertise in new fields of promise to the Navy.

This report is limited to unclassified information to allow broader distribution and ease of handling. Classified applications should be discussed with the appropriate principal investigator. The Center coordinator for this report is Dr Ellen E Kuhns, IR/IED Program Manager, Code 0220 (714) 225-2786.

C E BERGMAN
Technical Director

Contents

Optical Covert Communications Using Laser Transceivers (OCCULT)

Independent Exploratory Development ZF61 212 (NELC Z275)

GC Mooradian and LT RJ Giannaris

OCCULT is an infrared heterodyne system conceived to meet the Navy's need for a covert communication system that is highly immune to jam and intercept. In a recent sea test OCCULT demonstrated automatic tracking and acquisition while transmitting one video channel, four 20-kHz analog channels, plus one 20-kbit/s digital channel both ways simultaneously.

There is no operational communication system which is not significantly susceptible to jamming, intercept, spoofing, and direction finding. Current communication systems significantly increase vulnerability to the threat of ARM (antiradiation missiles). Existing systems also suffer from limited data rates, spectrum crowding, high cost, and large size, weight, power requirements, etc.

Solutions to these problems are looked for in both the rf and the optical spectra.

OCCULT was conceived to meet the Navy's need for a covert, low-probability-of-intercept, antijam, wideband communication system for service ship-to-ship and ship-to-shore (ref 1). The project was started in FY71 (ZFXX 212 NELC Z227). In FY72, 73, and part of 74 it was sponsored by Naval Sea (then Ship) Systems Command (62720NSF14 222 002 NELC B807). During that time ship-shore communication (voice and data) was demonstrated, including pointing, tracking, and acquisition capability from ships. Equipment needed for ship-to-ship tests was designed, the optical package was contracted, the receiver processing electronics and the pointing system were constructed, and testing was begun at NELC. In March 1974 the Director of Naval Laboratories provided IED funds to complete the development of advanced model. This was done in FY75 and 76 (ref 2). In FY76 the OCCULT equipment was used to perform experiments to determine the propagation effects of a sea-based environment upon the 10.6-μm optical heterodyne communication link (ref 3). The performance of the link was monitored on an 18.2-km over-the-water path across the entrance to the San Diego, California, harbor. Data were taken to permit a limited correlation to be drawn between meteorological conditions (clear air, rain, haze, and fog) and link operation. Reciprocal pointing and tracking between the two coherent optical transceivers was demonstrated and it was shown to be important in improving signal levels for propagation through the marine boundary layer for fog and haze as well as clear paths.

In FYTQ sea tests of OCCULT in Fleet Exercise 117 demonstrated automatic tracking and acquisition while transmitting one video channel, four 20-kHz analog channels, plus one 20-kbit/s digital channel both ways simultaneously. Additionally, high-precision station-keeping was accomplished with ±0.05° accuracy in relative bearing and ±2 metres in ship separation.

THE OCCULT SYSTEM

The initial motivation for OCCULT was the critical Navy need for an *ultracovert* means of tactical data exchange between ships at sea. The clear superiority of optics over rf with respect to covertness alone would entitle the optical link to strong consideration as the means for meeting this need—even if the advantages of optics in such considerations as cost, availability, reliability, size, weight, jamming resistance, and power requirements were disregarded.

The significance of the degree to which an optical system such as OCCULT is covert, as well as resistant to jamming and spoofing, can best be seen in quantitative examples. To detect the transmitted beam, a potential interceptor has to loiter in a beam which is 40 metres in diameter at a range of 40 km (25 miles). He then has to point his receiver field to view toward the transmitter with accuracy much more precise than 1°, because out-of-beam energy is 150 dB down 1° off axis. Furthermore, he has to locate a 5-MHz signal in a 50-GHz tuning range, assuming he knows a priori that a CO_2 laser system is being employed. To jam an OCCULT transmission is even more difficult. The jammer must be capable of covering a 50-GHz band of frequencies, or else face the interception problems just described.

If the exact frequency were known, so that the IF passband of the receiver could be entered, it would still be necessary to know the exact doppler shift introduced by the relative velocity of the transmitting and receiving vessels. For incoherent optical jamming to be effective, 150 watts of jammer power directed *on axis* to the receiver is required at a range of 16 km to degrade the carrier-to-noise ratio by 3 dB. If the jammer is 1° off axis, 100 GW of cw power is required. This would melt a steel hull.

The advantages of optics over rf for the covert ship-to-ship tactical role are evident in the following comparison of the characteristics of a projected production version of OCCULT with those of current shipboard hf to ehf rf systems of equivalent capabilities:

	OCCULT	hf—ehf
Size (antenna)	0.056 m^3 (2 ft^3)	3—10 m^3
Weight (antenna)	23 kg (50 lb)	100—300 kg
Prime power	150 watts	200—1000 watts
Information bandwidth	>5 MHz	0.1—1000 MHz
Max link acquisition time	<5 s	<1 s
SNR (light fog)	40 dB at 40 km	0—25 dB
MTBF (est)	>2000 h	1000 h

In addition, optical communications systems generate no rf interference and are insensitive to it.

A coherent (laser) system was required to obtain most of the benefits of an optical communication system. An infrared system choice was motivated by atmospheric propagation, covertness considerations, and source availability, which made ultraviolet and visible wavelengths less attractive. 10.6 μm was chosen over the near IR as the operating wavelength because of better atmospheric penetration, enhanced detection sensitivity, and less stringent pointing, tracking, and acquisition requirements. A heterodyne system was decided upon, as opposed to direct detection, because of the capability of obtaining quantum-noise-limited operation without large amounts of radiated power.

OCCULT is a system for communication between the highly unstable platforms represented by two ships at sea. Because it employs narrow beamwidths to enhance covertness, a means for keeping the transmitted beam within the field of view of the receiver is required. This requires a pointing and tracking system. OCCULT employs high-rate reciprocal pointing and tracking—a system in which, ideally, the beams transmitted over a link travel the same path in both directions. This is accomplished by having each receiver sense the motion of the received beam and alter its (receiver and transmitter) pointing so as to compensate. The reciprocal pointing and tracking system also has the important advantage of permitting near-optimum free space, diffraction limited transfer of power over a turbulent propagation path. It is important to note that reciprocal pointing and tracking serves not only to compensate for wavefront tilt and platform motion, but also to correct the alignment of the two optical systems with respect to each other.

For maximum communication efficiency and covertness the narrowest beamwidth compatible with reasonable pointing and tracking requirements is desired. However, during acquisition a broader beam minimizes acquisition time. To provide for both of these cases a computer-controlled zoom lens was included in the OCCULT design.

OCCULT was designed as a duplex system which permits simultaneous two-way communication (fig 1a). Because the above-determined requirements for pointing and tracking and control of beamwidth and field of view apply equally to the transmitter and receiver at a terminal, it is logical to employ common optics for these two functions at each terminal. This is indicated by the dotted boxes in figure 1a. There are two advantages to common optics. First, the number of optical components in the most expensive portion of the optical path—the pointing and tracking and collimating optics—is halved. This significantly reduces both cost and complexity. Second, true *reciprocal* pointing and tracking requires common optics if the transmitted beam is to follow precisely the inverse path of the received beam. In order to employ common optics, the transmitter and receiver are optically diplexed through polarization as shown in figure 1b.

Optical diplexing minimizes losses due to beamsplitters, which would result in at least 6-dB additional loss over the link, and also permits arbitrary pointing of the beam, because of the circular polarization. This makes the system insensitive to the "periscope" effect (in which the horizon as seen through a periscope rotates upside-down as one mirror is rotated about the periscope axis), which would severely complicate the pointing and tracking if linear polarization were employed.

In summary, the following list gives the major system engineering features which determined the design of OCCULT:

1. It is an optical communications system.
2. Wavelength is 10.6 μm.
3. Optical heterodyne detection is employed.
4. A pointing and tracking system is used.
5. It uses high-rate reciprocal pointing and tracking.
6. A variable beamwidth/field of view is employed.
7. The collimating and pointing and tracking optics are common to the receiving and transmitting sections.
8. The receiving and transmitting sections are optically diplexed—polarization is used to separate the transmitter beam from the local oscillator beam.

OCCULT consists of three packages—the coarse and fine pointing and tracking systems and the transceiver opto mechanical package (developed by Hughes Aircraft). The mechanical arrangement is shown in figure 2. The coarse pointing system is a two-axis, gimbal mounted mirror which is controlled by the system computer, a Data General Nova minicomputer. The fine angle system, also a two-axis device, uses a set of two galvanometer driven mirrors in a feedback loop with the nutation system to provide small angle tracking motion of the beam. The optical transceiver, with its associated rack of electronics, includes the collimating optics, the transmitter and modulator, and the heterodyne receiver optics and electronics.

The characteristics of the system are summarized in table 1.

Figure 3 is a photograph of the transceiver box with its top removed and the optical paths shown. The transceiver mechanical package is a built-up channel structure forming a rigid optical bench capable of maintaining optical alignment in a shipboard environment.

OCCULT OPTICAL SYSTEM

Figure 4 shows the optical system of the OCCULT transceiver plus the tracking systems The system is optically diplexed; that is, the collimating and pointing and tracking optics are shared by the transmitted and received beams.

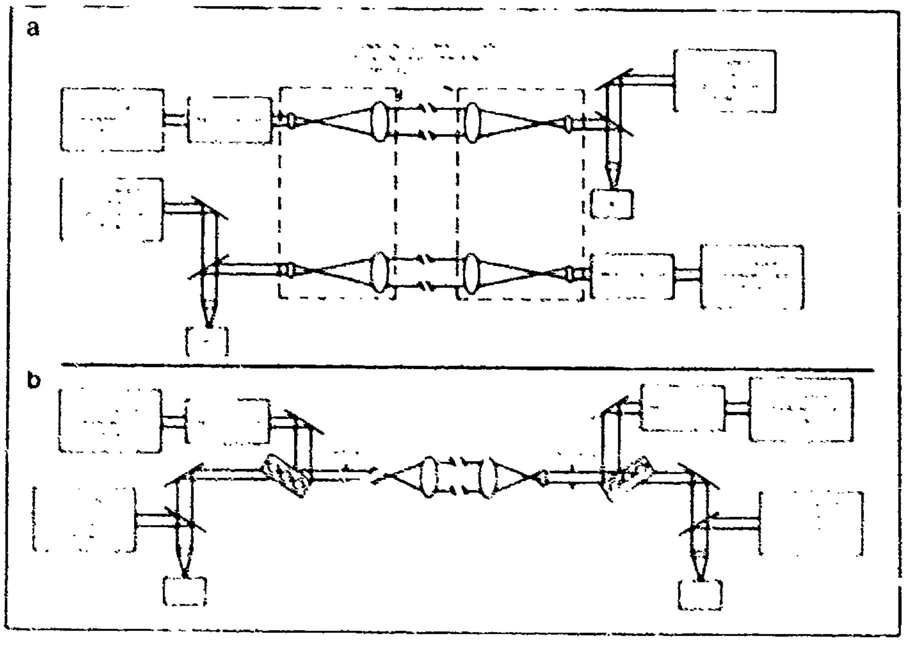

Figure 1 (a) A duplex optical heterodyne communications system (b) The system shown in (a) optically diplexed

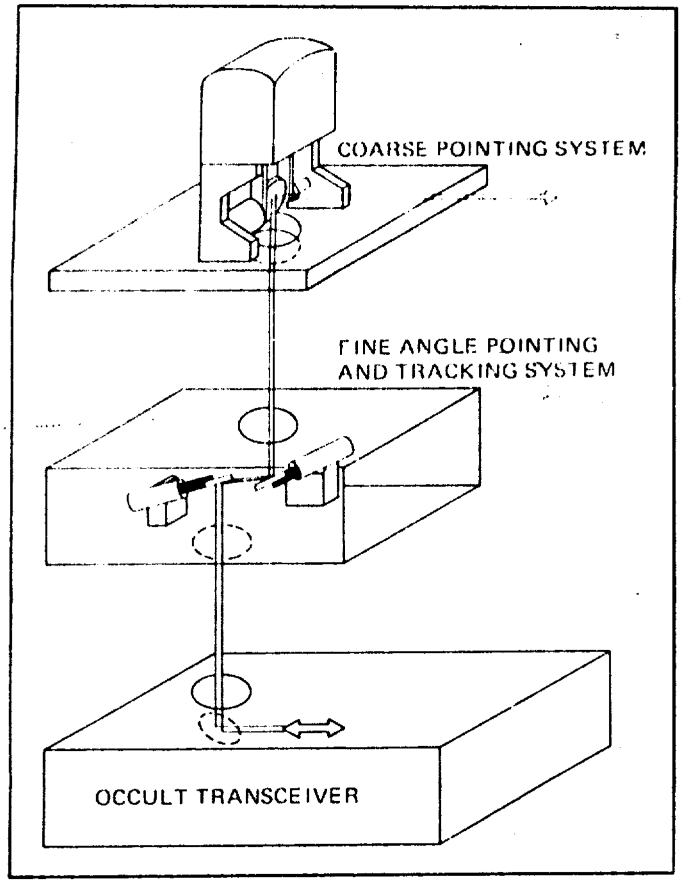

Figure 2. Outline drawing of OCCULT packages.

Table 1. OCCULT performance characteristics.

Information bandwidth	>5 MHz
Beamwidth	0.05° (1 mrad)
Radiated power	0.5 W
Radiated power density	<100 mW/cm^2
Tracking accuracy	0.005° (100 μrad)
Tracking rate	360°/s
Tracking acceleration	3600°/s^2
Full (blind) acquisition time	~1 s
Automatic station keeping capabilities (accuracy at 32 km (20 mi))	±15 m (±50 ft) range ±0.1° relative bearing ±0.51 m/s (±1 kt) relative velocity
Sidelobe suppression	<-150 dB 1° off axis
Sidescatter (clear air)	-100 dB 90° off axis 1 m from beam
Sidescatter (marine haze)	<-150 dB 10° off axis 1 km from beam
SNR (light fog)	~40 dB at 40 km (25 mi)
Rfi	emits none and is insensitive to rfi
Weight (antenna)	23 kg (50 lb)
Size (antenna)	0.056 m^3 (2 ft^3)
Prime power	150 W
Cost per terminal	$50 000
MTBF	>2000 h

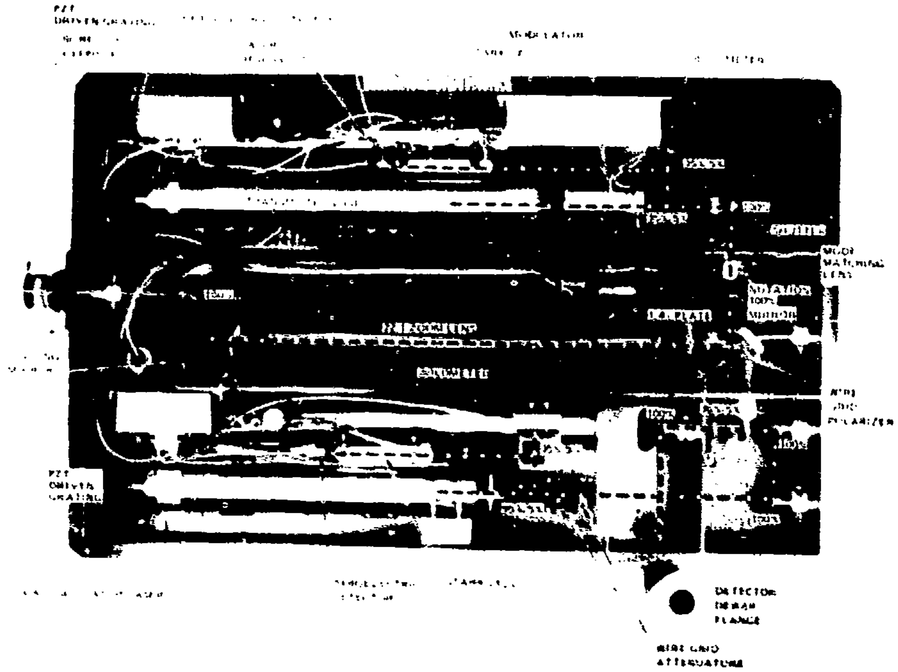

Figure 3. The optical paths and components of the transceiver.

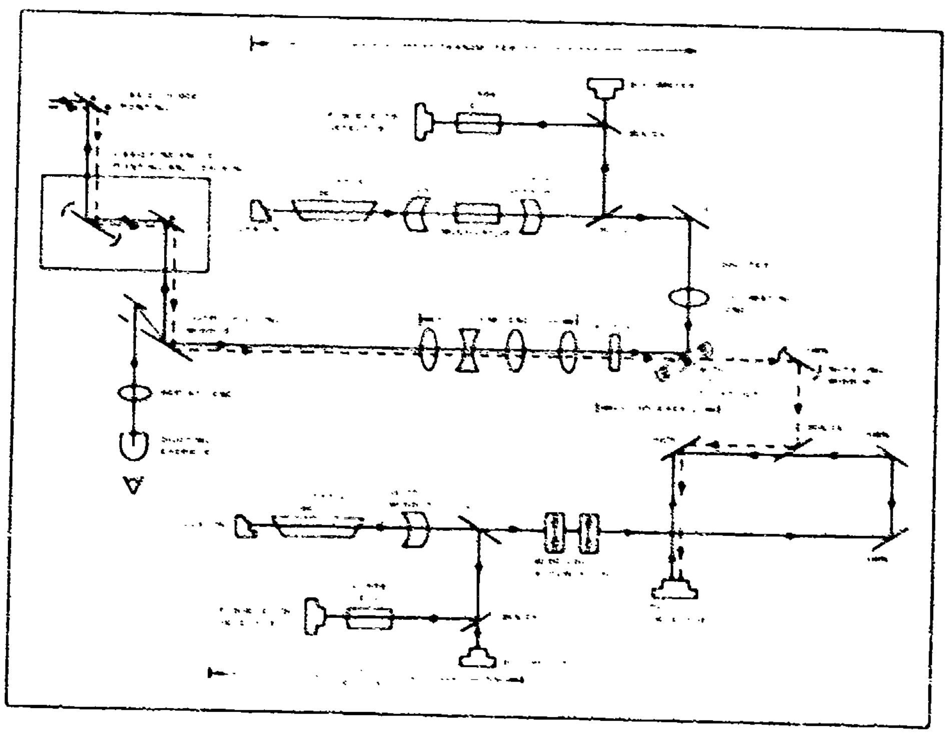

Figure 4. Schematic diagram of the optical paths of the OCCULT system

This is accomplished by using different polarizations for the two. Let the transmitter be vertically polarized and the local oscillator horizontally. The vertically polarized beam from the transmitter is reflected from a wire grid polarizer which passes only horizontally polarized light. It then passes through a quarter-wave plate, producing a right-hand circularly polarized beam. This exits through the zoom lens and pointing and tracking optics. The received beam appears as left-hand circularly polarized light at the receiver looking back at the transmitter. It then passes through the quarter-wave plate, resulting in horizontally polarized light. This is passed *through* the wire grid polarizer and mixes with the horizontally polarized local oscillator at the detector.

The following paragraphs discuss the operation of the various optical components shown in figure 4. The components are discussed in the order in which they are encountered by the received beam, and a discussion of the components in the transmitting section follows.

FINE ANGLE POINTING AND TRACKING SYSTEM

The fine angle pointing and tracking system consists of two optomechanical components—a nutator and a set of two axis tracking galvanometer driven mirrors. The nutator consists of a mirror on the back of which has been mounted a ceramic bimorph with two orthogonal axes. When the bimorph is driven by sine and cosine signals of the proper phase, the received beam nutates, or travels a circular path, over the surface of the detector. If the transceiver is pointed exactly at the other station, the circular path will be symmetric around the center of the detector (as it mixes with the local oscillator signal which is optically aligned with the detector). If a pointing error exists, a larger output will be obtained over one part of the circular path than over the rest. This will cause a change in amplitude of the signal out of the IF strip. Note that the received modulation is FM, so that, ideally, even when there is a pointing error, there is no detected FM output. The fine angle tracker compares the demodulated AM output (filtered at the 2-kHz nutation frequency) with the two signals used to drive the axes of the bimorph. This permits x and y position error voltages to be derived, and these are used to drive mirrors mounted on galvanometers which form the fine angle tracking mechanism.

The optical pointing and tracking operation is accomplished by two self-centering galvanometers with mirrors attached to their rotating shafts. The mirrors are elliptical, with major and minor axes of 8.26 and 5.72 cm. The mirrors are mounted on the galvanometers with their major axes mutually orthogonal, thus providing a constant aperture while permitting two-axis pointing over ±5°. In order to obtain the 100-Hz (min) tracking rate required by the frequency spectrum of the angle of arrival fluctuations, it was necessary to design compensating circuits which would enable driving the galvanometers faster than their natural mechanical resonances.

ZOOM LENS. The recollimating telescope is a four-lens, mechanically compensated, electrically operated zoom system with a maximum 22:1 zoom range. The input pupil is 6 mm, the exit pupil variable from 2 to 50 mm. A visible sighting telescope is boresighted to the optic axis for visual acquisition. A gear motor drives the zoom through a chain, and a three-turn potentiometer furnishes a feedback signal for determining the zoom position. The zoom housing and drive assembly is located in the center section of the transceiver box (see fig 3).

DETECTOR. The detector and Dewar are mounted on a flange to the side of the transceiver box. The Dewar is metal and holds the liquid nitrogen used to cool the detector for 1—2 hours. OCCULT uses a lead-tin-telluride photodiode detector 0.2 mm in diameter. The detector is held in a vacuum of about 10^{-7} mm Hg. A thin antireflection coated germanium window allows the 10.6-μm energy to enter the diode chamber.

BOLOMETERS. A small portion (~5%) of the outputs of the local oscillator and transmitter lasers is sampled by a beamsplitter and directed to a balanced thermistor bolometer. This permits monitoring of the laser outputs and also triggers the Stark cell laser frequency stabilization control. The sensitivity of these devices is ~5 mW/V, with a rise time of less than 1 ms.

LASERS. The laser subassemblies are based on channeled baseplates that mount in two of the transceiver box channels. The OCCULT lasers are metal-ceramic waveguide units. Their operating frequency is determined by the resonant length of the laser cavity. This permits both adjustment and stabilization of the operating frequency, and frequency modulation, by altering the cavity length via the bimorph-mounted gratings which are supported with a toggle arrangement to allow selection of either of two transitions, the P(14) (λ = 10.5326 μm) or the P(20) (λ = 10.5912 μm). In the OCCULT system, the local oscillator of one terminal and the transmitting laser of the other terminal are tuned to the P(20) transition. The other two lasers are tuned to the P(14) transition. The laser operating frequency stability is one part in 6×10^7.

SUMMARY

OCCULT has demonstrated the validity and practicality of several important system attributes:

The large improvement in SNR for coherent propagation through both turbulent and scattering media due to high-rate reciprocal pointing and tracking

The preservation of coherence in propagation through scattering media

The ability to derive fine angle pointing information from a nutated received beam

Computer-controlled, closed-loop, high-rate, integrated coarse and fine angle pointing and tracking

The high degree of covertness attainable with infrared optical communications

The high-accuracy frequency stabilization of tuned cavity lasers using Stark cells

The acquisition scheme developed for narrow optical beam systems

In summary, the OCCULT system has made feasible a whole new spectrum of covert naval tactical communications. It has also proved to be a uniquely valuable experimental tool for optical propagation, pointing and tracking, and communication systems research.

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III-V Semiconductor MIS Device Technology

Independent Research
ZR021 02 (NELC Z102)

DL Lile and LJ Messick

Silicon circuits and devices have reached the stage of refinement where further development is becoming increasingly difficult and costly. III-V semiconductors—compounds of one element from the third column of the periodic table with one from the fifth, such as gallium arsenide, indium phosphide, gallium phosphide, indium arsenide, and indium antimonide—are attractive alternates to silicon. Marked system advantages may accrue using these materials with even a modest device and circuit technology, as recent work in both industry and government laboratories has demonstrated.

Progress is recorded in III-V compound semiconductor growth, compatible dielectric development, and device and circuit fabrication. Application is foreseen in microwave communication systems, high-data-rate logic systems, and complementary metal-insulator-semiconductor switching.

Successful developments include the GaAs Gunn device with its extremely high frequency of operation and the Schottky gate field effect transistor (FET) with its extremely low noise properties. Such devices find application in highly sensitive low-noise microwave communication systems and high-data-rate logic.

Many functions accessible via these new materials, such as the transferred electron effect, are not possible at all via silicon because of fundamental differences in material properties.

Although the principles are the same, the technology which has been developed for silicon IC manufacture is not applicable in toto to this new class of semiconductors. It is the object of this project to develop a baseline IC technology for the III-V compounds. Specifically, NELC is addressing the problems of epitaxial semiconductor growth, compatible dielectric development, and device and circuit fabrication.

EPITAXIAL SEMICONDUCTOR GROWTH

During FY76 and TQ thin epitaxial layers of device grade GaAs were grown by use of liquid phase epitaxial procedures. A materials machining technique relying upon a self-limiting anodic stripping of the semiconductor was developed for the postgrowth treatment of layers. This technique (fig 1) permits an essentially automatic leveling and thinning of the semiconductor to a thickness suitable for FET applications.

COMPATIBLE DIELECTRIC DEVELOPMENT

Both wet chemical anodization and chemical vapor deposition were examined for suitability in forming dielectrics compatible with the III-V compounds. High-quality insulator layers were grown by both techniques on a variety of materials. In particular, MIS diodes were fabricated on InP which exhibit effective surface trap densities approaching those of the Si/SiO_2 system.

DEVICE AND CIRCUIT FABRICATION

The techniques described above were combined and applied to the fabrication of MIS FETs on epitaxial layers of GaAs. The FETs exhibit good saturation, extremely low hysteresis, and effective mobilities in excess of 2000 cm^2/V-s. They offer promise in applications requiring the extremely high input impedance and bipolar flexibility of a MIS gate device; complementary MIS (CMIS) circuitry, for example.

Surveillance and Countermeasures Division (NELC Code 2300) assisted in the high-frequency evaluation of these devices.

FY77 PLANS

Work in FY75 under Z102 and Z195 laid a foundation for this year's program by providing information on possible dielectrics for use with III-V compounds, the development of techniques for the assessment and characterization of bulk dielectric and interfacial properties, and the growth and characterization of high-quality epitaxial layers. FY77 plans include the further refinement of the geometry of the devices fabricated in FY76 and

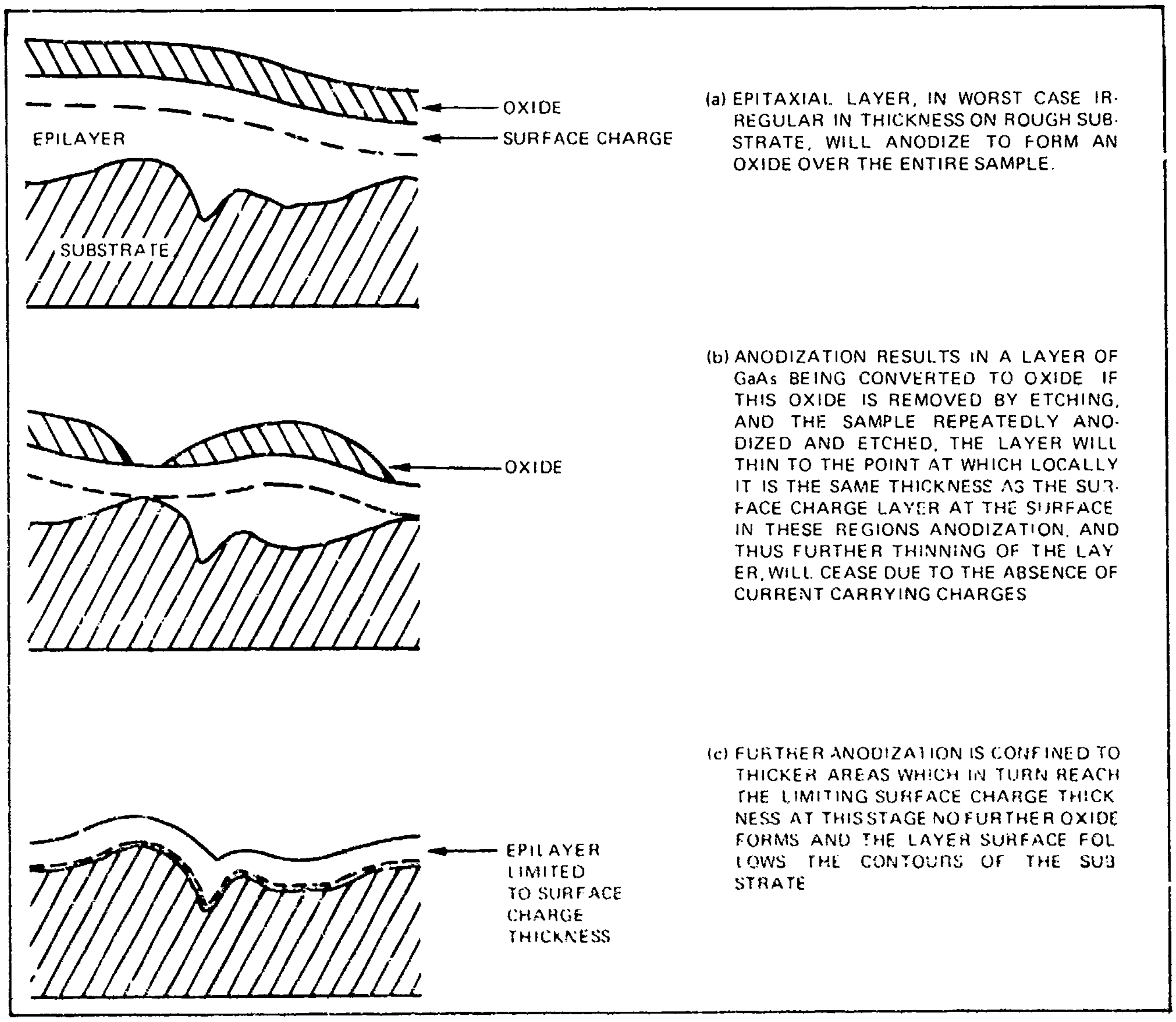

Figure 1. Automatic thinning and self-leveling of epitaxial layers by anodization.

their combination with passive devices—resistors and capacitors—in prototype monolithic IC structures.

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Continuous Blood Pressure Monitoring

Independent Research
ZR041 01 (NELC Z107)

FR Borkat

A transducer (pressure capsule tonometer) for the continuous noninvasive monitoring of blood pressure has been designed and built. At the UCSD School of Medicine it was tested against an intraarterial catheter on an anesthetized dog. For changes about normal blood pressure the two measurements agreed. A spin-off was a microprocessor cardiotachometer now in daily use at the Heart Station of NRMC, San Diego.

This project was initiated 2 years ago to identify a technique for the continuous and noninvasive monitoring of blood pressure. During FY75 the technique of pressure capsule tonometry was identified and briefly studied, and it was determined that this technique might be suitable for meeting project objectives.

During FY76 the major areas known to require further study were as follows: (1) The tonometer capsule would drift over even a short period of time. (2) The method used to hold and restrain the tonometer on the wrist was found to restrict blood flow to and from the hand, causing discomfort and congestion. (3) The analysis and output of the paired systolic and diastolic values were provided by a cumbersome PDP-8 minicomputer and slow teletype. (4) The striking similarities between the tonometer output and the expected arterial waveform could not be calibrated except with the standard auscultation method.

During FY76, the capsule and wrist restraint mechanisms were redesigned. The bladder and pressure transducer tube were replaced by a diaphragm-covered hard plastic chamber. Excessive drift, mentioned in the FY75 article, was thought to be due to thermal effects. In actuality the drift was due to relaxation of the rubber capsule material when under continuous pressure. Polyethylene does not appear to undergo stress relaxation in use as the tonometer diaphragm. The diaphragm material now used is polyethylene.

Positioning of the tonometer is provided by placing the arm in a fixture which flexes the wrist to bring out the radial artery. An adjustable holder locates the tonometer on the artery. With a cooperative subject the tonometer positioner and design provide for stable readings.

A microprocessor with LED display replaced the PDP-8 and teletype. The new data processing scheme also calls for measuring the electrocardiogram (EKG) as a cue to indicate the start of a heartbeat. The pressure wave is searched for 500 milliseconds after the peak value (R wave) of the EKG. The relative minimum is that period is the diastolic pressure. The relative maximum between any two R waves is the systolic pressure. Both these values are stored for display and manipulation. In addition, since the heart beat interval is available from the EKG, heart rate is also computed and displayed. The display of these values is on a beat-to-beat basis or on the average of a preselected number of beats. For trend recording, the systolic and diastolic values are presented as output from two D/A converters. The entire microprocessor with A/D and D/A converters occupies approximately 45 square inches of circuit card space and provides more information than had been provided by the PDP-8 and teletype.

The tonometer was tested in place beside an in-dwelling catheter during experiments performed on animals at the University of California, San Diego, School of Medicine. Standard catheterization methods were used to place a Statnam-type pressure transducer in the femoral artery of an anesthetized dog. The tonometer was placed over the opposite artery with the adjustable hold. Recordings of both devices were made for greater than one hour. A sample waveform from this period is shown in figure 1. During the first part of the recording session, four different cardiovascular drugs were administered to induce a change in pressure. The effect of one of these drugs on waveform can be seen in figure 2. In all these trials the tonometer followed the direction of change as shown by the in-dwelling catheter. Amplitude at the extremes of pressure change differed, however. During the second part of the recording, no drugs were given. The tonometer output drifted only slightly over a 30-minute period.

With some further development the pressure capsule tonometer technique can be made to be linear over the useful range of arterial pressure

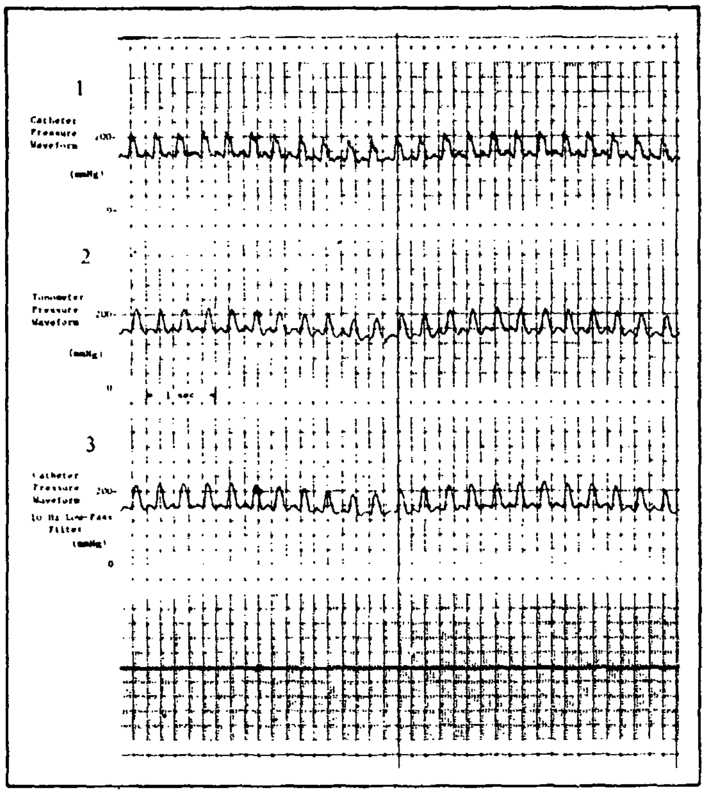

Figure 1. Sample tonometer waveforms. Panel (1) interarterial catheter waveform. (2) tonometer waveform. (3) waveform of panel (1) after 10-Hz low-pass filtering.

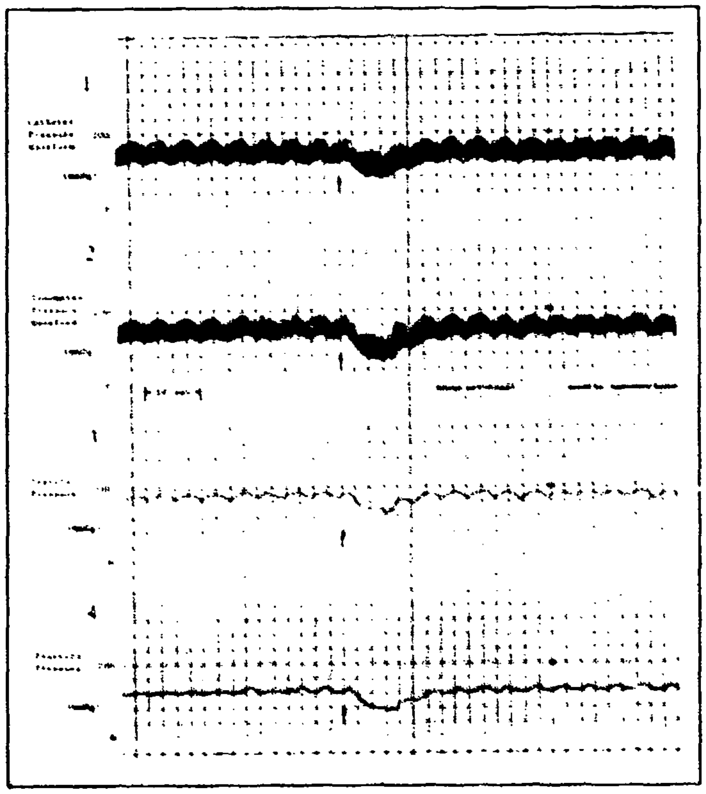

Figure 2. Panel (1) interarterial catheter waveform showing effect of drug injected at time indicated by arrow. (2) tonometer waveform for same time period. (3) systolic pressure taken by tonometer. (4) diastolic pressure taken by tonometer. Record covers approximately 100 seconds.

changes. Stability and calibration can also be improved to the point where the technique can be used clinically. It still will require, however, complete immobility of the measuring site.

Heart rate information is also used by the cardiologist in the diagnosis of a wide range of abnormal cardiac functions. If the decision functions can be adequately described for programming, it is within the range of capabilities of the microprocessor to duplicate some of the cardiac arrhythmia diagnoses. The presence of an automatic diagnostic instrument alongside the EKG monitor already present in the coronary care unit would contribute considerably to the high level of care already present.

FOLLOW-ON

The extension of this work to cover refinements and application to a clinical environment has been funded for FY77 ($45k) as a result of a proposal to the Naval Medical Research and Development Command. The heart rate programming of the microprocessor circuit has been isolated and packaged separately as a cardiotachometer. This device is in daily use at the Heart Station of the Naval Regional Medical Center, San Diego, where it provides the critically needed information of instantaneous heart rate during exercise EKGs. Technicians who formerly took rate measurements during stress tests manually, using a calibrated rule and an EKG strip chart tracing, have come to trust the improved accuracy of the cardiotachometer display and now rely solely on it for rate presentation during exercise.

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Period:
1 July 1975—30 June 1976

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Applications Resulting from Past IR/IED Projects

MINIATURIZED SUBMARINE TERMINAL AND INTERFACE CONTROLLER (MISTIC)

In FY74 work was started on Advanced Digital Communication Modules (ADCOM) with IED funding (ZF61 212 NELC Z272). The objective was to determine whether microprocessors could be used for direct functional implementation of communications requirements. Based on the results of this project, the Submarine Satellite Information Exchange System (SSIXS) subscriber system was chosen for implementation because the function was well understood and test procedures and facilities existed that could be used to evaluate the degree of success achieved.

The demonstration equipment was developed as one facet of the Center's Direct Laboratory Funded program (62762N ZF54 545 NELC Z401) in FY75. This equipment successfully performed the required functions and had several features that made it significantly more attractive as the SSIXS submarine equipment than equipments then planned for use.

As a result PME 106 funded the MISTIC project in FY76 (33109N XCC46 NELC J427; $620k) to develop a production package to retrofit ON-143 (V)5/USQ units. Prototypes were built and completed technical evaluation. Some of the comments sent to this Center after the TECHEVAL included that the "ON-143(V)5 subscriber system was particularly impressive" and "flawless in TECHEVAL." It is the "only device in recent memory to use state-of-the-art electronics to reduce system complexity vice to expand the scope of the task being attempted."

Some of the advantages of the MISTIC system over the original submarine terminal are:

1. Reduced complexity and improved operability, reliability, and maintainability.

   105 printed circuit (PC) cards of 25 types were reduced to 14 PC cards of 10 types.

2. | | |
   |---|---|
   | Reduction in weight | 5 to 1 |
   | Reduction in space | 4 to 1 |
   | Reduction in power consumption | 9 to 1 |
   | Reduction in cost | 3 to 1 |

3. Reduction in training time from 16 weeks to 10 weeks.

The equipment is undergoing operational evaluation on two submarines. Present plans are to procure over 60 units for fleet installation in FY77.

SUBMARINE-TO-AIRCRAFT OPTICAL COMMUNICATIONS SYSTEM (SAOCS)

Concept studies were made on IED project Optical Communication Technique for Information Transfer (62766N ZFXX-512) during FY71. Light sources have been studied on several IR projects. Since FY72 the Naval Sea Systems Command and the Naval Electronic Systems Command have sponsored SAOCS to a total of $5.2M. Feasibility tests on the experimental development model were completed in February 1976.

During FY77 two parallel $300k contracts will be awarded for system definition of the advanced development model which should be completed and evaluated in FY80. The equipment should be introduced into the Fleet about 1985.

NAVY Science Assistance Program (NSAP)

A joint task between NELC and NWC provided a new, successful approach to surface swimmer and small-craft detection. NSAP project PHP-1-75, High Resolution Radar, combined a modified SPS-53 radar with NELC's Time Compression Display (TICODS). COMNAVSURFLANT and the Inshore Underseas Warfare Group (IUWG) were extremely impressed with the system's performance. IUWG ONE has recommended that the short-pulse adaptation by China Lake be applied to I-band radars and that TICODS be made available to IUWGs and other mobile tactical units. The concept demonstrated a marked improvement in harbor defense. TICODS was initially developed on IED funding (FY66—FY70).

Marine Corps Support

Beginning in FY74 a portion of the IED funding has been dedicated to the solution of problems in support of, and usually peculiar to, the USMC. Several of these have led to additional developments.

Fiber Optics Tactical Data Link for Marine Corps Tactical Command Control System (FY74) resulted in USMC FY77-79 effort called TPS-32 Fiber Optic Data Link (62721N XF21 241 180 NELC F248). The purpose is to develop and fabricate a fiber optic link in order to remote the TPS-32 radar from the TAOC complex for antiradiation missile (ARM) security.

USMC Tactical HF Modems (FY75) resulted in completion of two time diversity units. The tests were sufficiently impressive that a USMC 6.2 project was established to demonstrate the feasibility of and gains from the use of time diversity modems in the tactical environment. The USMC is currently evaluating the results and the modems for possible procurement action.

A surface acoustic wave signal processor and coding scheme designed on the USMC LWBSR Modulation and Coding (FY75) project was fabricated and feasibility was established on the Lightweight Battlefield Surveillance Radar Study (62712N XF12 151 001 NELC D217).

Shipboard Maneuvering Calculator

Previously designated as the Tactical Shipboard Calculator, the Shipboard Maneuvering Calculator (SMC) is a small, dedicated, microprocessor-based computing system which provides solutions to all the usual maneuvering problems encountered by ships. It is designed to completely replace the Maneuvering Board presently in use on Navy ships and will perform, directly, the following functions:

Closest Point of Approach (CPA). Provides CPA solution, plus true course and speed for up to eight contact ships. These solutions are automatically updated.

Collision Avoidance. Provides required-maneuver solutions to avoid collision with a given contact by a given range.

Stationing Maneuver. Provides course and time-to-station solutions for maneuver to a predetermined station relative to a guide ship.

True and Relative Wind. Provides solutions for true wind given the relative wind conditions and for required maneuver to obtain a desired relative wind.

The SMC is an updated expanded version of the CPA calculator which was designed on IED funding in FY72 and FY73. It has been tested at sea on USS TICONDEROGA and USS PEGASUS (PHM 1).

In FY76 the Naval Sea Systems Command funded this Center to make design and functional modifications in order to provide production design for a device suitable for installation in fleet units. Prototypes have been completed and are being tested. The units should go through TECHEVAL and OPEVAL in late FY77.

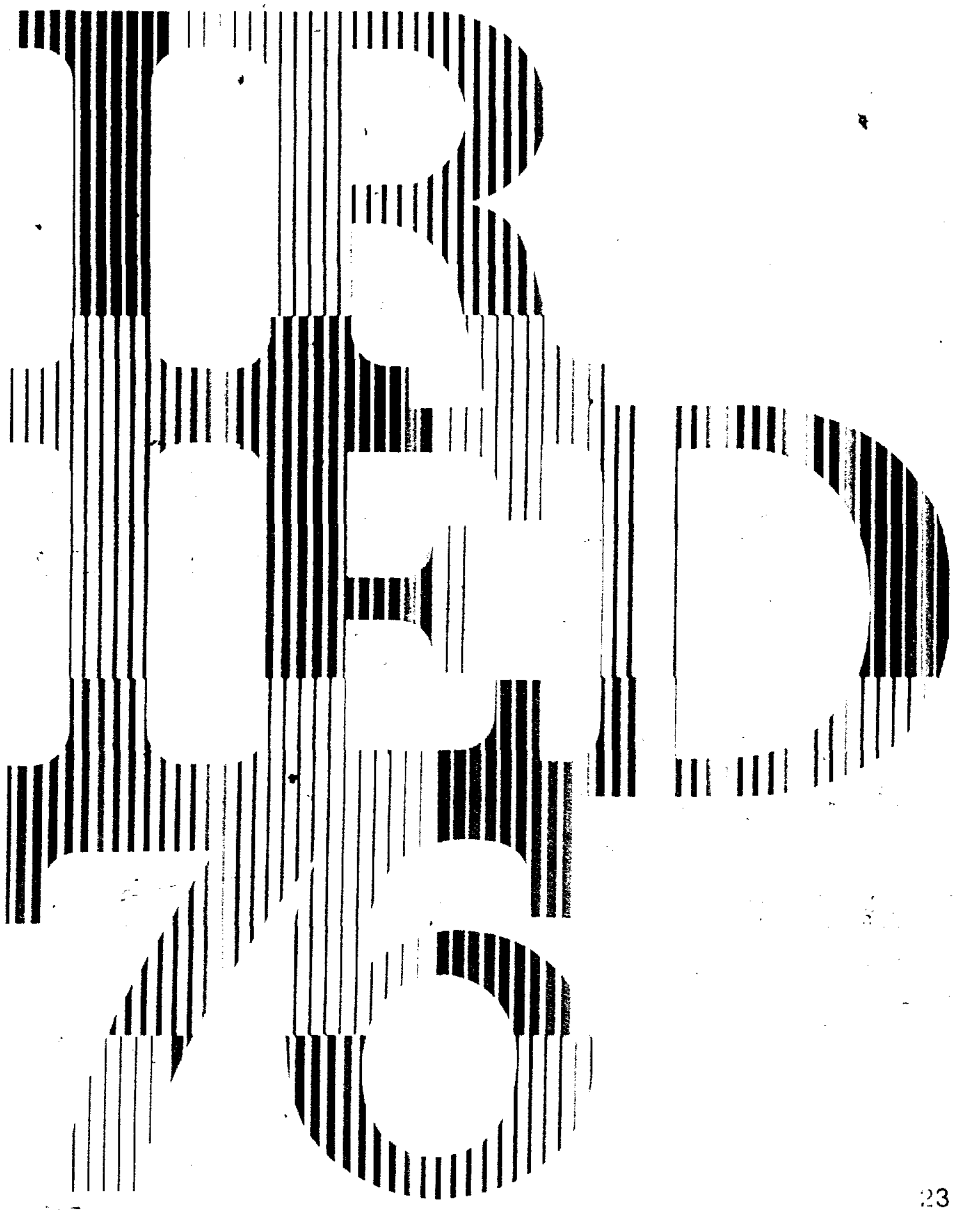
Sponsored Projects Based on IR/IED–Initiated Work

(Only projects not listed in earlier reports: NELC TD 141, 1 Sep 1971; TD 194 1 Sep 1972; TD 267, 1 Sep 1973; TD 348, 1 Sep 1974; and TD 448, 1 Sep 1975.) FY77 funds are those received by 3 November 1976.

Funding	$k FY76-TQ-77	Title	NELC No	Based on
Electro-Optics				
61101E (DARPA)	228	Optical Fiber Evaluation, Reliability of Strength Improvement	F244	62766N ZF61 212 (NELC Z267)
62633N SF33 341 423	30	Fiber Optic Undersea Cable SEA	F243	62766N ZF61 212 (NELC Z242)
62711N WF11 121 703	180	Fiber Optic Undersea Cable AIR	F241	62766N ZF61 212 (NELC Z242)
62721N XF21 222 037	398	Electro Optical Techniques for Communications	B195	62766N ZF61 212 (NELC Z274) 62766N ZF61 212 (NELC Z275)
62721N XF21 222 702	213	Blue Green Communications Systems Techniques	B237B	61152N ZR011 07 (NELC Z198)
62721N XF21 241 180	50	TPS 32 Fiber Optic Data Link for USMC	F248	62766N ZF61 212 (NELC Z271)
63705N S0398	60	Operational Manning Reduction Devices (Optical Communications)	B102	62766N ZF61 212 (NELC Z275)
25670N W0031	152	Fiber Optic Development for Naval Electronic System Command (PME 107)	B818	62766N ZF61 212 (NELC Z236)
OMN CINCPAC	35	Fiber Optics for CINCPAC Communications Systems	F601	62766N ZF61 212 (NELC Z246)
APN NAVAIR	150	Manufacturing Technology Development of Fiber Optic Cables for Aircraft	T306	62766N ZF61 212 (NELC Z246)
NSWC NIF	25	Nitinol Fiber Optic Connector	F247	62766N ZF61 212 (NELC Z267)
63000F AF K NM	15	Automatic Pointing and Tracking (APT) Fiber Optic Video System	F245	62766N ZF61 212 (NELC Z246)
AF K NM	20	Fiber Optic Cabling for APT	F246	62766N ZF61 212 (NELC Z246)
RDT&E DCA	50	Fiber Optics for DCS Applications	B903	62766N ZF61 212 (NELC Z246)
PDA NSA	979	Long Run Fiber Optic Data Link	F239	62766N ZF61 212 (NELC Z246)
Propagation				
61153N RR 032 08 62543N RF 43 411 804	35 25	Submarine to Air Radio Communications (ELF)	M228	61152N ZR021 01 (NELC Z135)
62759N ZF52 551 001	93	EO Propagation in the Marine Boundary Layer	M117	61152N ZR011 07 (NELC Z117)
62712N SF 12 152 401	60	Propagation Effects on Shipboard Electro-optic Systems	M115	61152N ZR011 07 (NELC Z117)
NASA HA	18	Solar Modeling	M229	61152N ZR021 01 (NELC Z110)

Funding	$k FY76-TQ-77	Title	NELC No	Based on
Command Control				
61101E (DARPA) 62721N XF21 211 005	309 530	Advanced Command Control Architectural Test Bed Program (ACCAT)	J732	61152N ZR014 10 (NELC Z166)
62721N SF21 241 402	431	Command Control System Architecture	Q239	62766N ZF61 212 (NELC Z270)
62721N XF21 121 002	175	Multiplatform Command Control Engineering	J731B	62766N ZF61 212 (NELC Z259 and Z270)
OMN NAVSEC	50	Submarine Data Processing Analysis	Q240	62766N ZF61 212 (NELC Z270)
Electronic Devices and Components				
62766N XF54 584 001	1842	SEM Research and Development	R228 B	62766N ZF61 512 (NELC Z240 and Z248)
62766N XF54 587 005	373	Microprocessor LSI Technology	R229 B	62766N ZF61 512 (NELC Z283)
64363N BSB21 & B0003	353	Microelectronic Technology Support to SSPO	R230*	62766N ZF61 512 (NELC Z241 and Z262)
33109N XCC46	620	Miniaturized Submarine Terminal and Interface Controller (MISTIC)	J427	62766N ZF61 212 (NELC Z272)
OMN, NAVSEC and NAVSEA	125	Shipboard Maneuvering Calculator	A119	62766N ZF61 212 (NELC Z253)
Bioelectronics				
NMRDC	45	Continuous Monitoring of Blood Pressure	S111	61152N ZR041 01 (NELC Z107)

Independent Research



Solid-State Device Reliability and Vulnerability

Independent Research
ZR011 02 (NELC Z195)

CR Zeisse

Characterization of the insulator-semiconductor interface of silicon and III-V compound devices reveals usable information on the properties of materials and the effects of processing methods. Anodic oxide on GaAs is shown to have a bleak future as far as application in devices is concerned. Silicon dioxide grown on InP by chemical vapor deposition, on the other hand, is very promising.

The cost, performance, and reliability of semiconductor devices are directly related to the properties of the materials from which they are made. There are many examples of this relationship.

The ability to control and measure the material characteristics of a semiconductor over progressively larger and larger areas has enabled the cost per device to fall progressively lower and lower. Methods of analysis such as X-ray topography have shown that high densities of dislocations near the edge of large silicon wafers are the primary cause for low device yield in those regions of the wafer.

Low surface state densities right at the semiconductor-insulator interface are required for low transistor turn-on voltages; furthermore, the surface states must be stable with time in order to produce devices free from drift. The prime mechanism of radiation damage, as a matter of fact, is a large increase in surface state and insulator trap density which drives the switching voltage outside any attainable range.

The purpose of this continuing program has been to develop and apply methods for the characterization of the insulator-semiconductor interface of silicon and III-V compound semiconductors. The measured characteristics have been related to the performance and reliability of devices made and investigated under a companion independent research program (NELC Z102).

The project registered progress in FY76 along three parallel paths:

Existing equipment was modified.

Photoluminescence and doping profile capabilities were developed.

Auger, electrical, and electrochemical methods established the quality of various III-V compounds and their compatible oxides.

EQUIPMENT MODIFICATION

The X-ray topograph is normally used to examine dislocations by transmitting X rays through a thin wafer of silicon. Most III-V compounds, however, are much more opaque to X rays than silicon. The topograph was therefore modified to examine X rays reflected from III-V compounds.

Interface behavior and doping profiles can be deduced from test structures by measuring the small-signal capacitance and conductance as a function of bias voltage. The lock-in amplifier used in FY75 for these measurements has been connected to a computer. The data are now taken automatically and converted immediately into equivalent surface state capacitance and conductance (when the Nicollian-Goetzberger model is being applied to a metal-insulator-semiconductor test structure) or doping profile (when the Schottky model is being applied to a Schottky barrier test structure).

CAPABILITY DEVELOPMENT

The capacitance-voltage method for deriving substrate doping profiles was implemented in FY76.

When thin films of GaAs are grown by the method of liquid phase epitaxy, the substrates must be heated to 800°C, whereupon their surface often "converts" to a conducting state which unfortunately shorts out any device ultimately made from the film. Photoluminescence has been developed as a nondestructive tool for examining this interface. Photoluminescent peaks have been discovered which appear after (but not before) the GaAs substrate is heated. These peaks have been tentatively associated with impurities of carbon or silicon (or both) which form complexes with arsenic vacancies at the interface and apparently act as acceptors, creating a p-type layer at the surface

MEASUREMENT RESULTS

There is a large lattice mismatch between InAs and GaAs. Therefore, poor properties would be expected from thin films of InAs grown by vapor phase epitaxy on GaAs. However, the properties are actually quite good, approaching (and, for the mobility, even exceeding) those of bulk InAs. An Auger study of this system has now explained the reason why: a thin (~150 nm) region of graded composition occurs during growth of the highest mobility films, relieving the strain and minimizing dislocations that would degrade the InAs film properties.

A standard galvanostatic procedure was used to study the initial phase of anodic oxidation of n-GaAs in a 3% by weight aqueous solution of tartaric acid mixed with propylene glycol. The initial phase is controlled by a two-dimensional growth of oxide from nuclei generated at a rate of about 10^7 $cm^{-2}s^{-1}$. After this phase, the oxide growth appears to be controlled by the transport of OH^- ions through the growing film. The jump distance for the principal charge carrier is estimated to be approximately 1.12 nm, indicating a "highly defective" film. The change in the preexponential factor with the change in solution composition and film thickness suggests a participation of more than one charge carrier. The oxide growth is believed to be a complex process with the parasitic reactions depending not only on solution composition but also on film thickness and rate of oxidation.

Furthermore, it has been shown that the growth of anodic oxides on GaAs affects the growth mechanism. This conclusion has been reached by observing the electrode approach its rest potential and by examining the oxide structure. It is therefore suggested that the dependence of the process efficiency on the growth rate is related to, and probably governed by, transport phenomena within the growing layer modified by the oxide structure.

The oxide mentioned in the preceding two paragraphs has also been annealed and then examined electrically. Major results are

A surface state density of $(1-5) \times 10^{12}$ states/cm^2-eV

A breakdown field greater than 10^6 V/cm *if the sample is kept dry*

A 10 000-fold increase in leakage current upon exposure to an atmosphere of 100% humidity

Altogether, this oxide has a bleak future for device applications.

On the other hand, silicon dioxide grown on InP by the method of chemical vapor deposition has been shown to be a very promising system for device applications. Capacitance-voltage measurements reveal an apparent surface state density of 2×10^{11} per cm^2 per eV, which is very low for InP. There is very little electron trapping in the insulator. The current-voltage characteristic implies conduction by a Schottky or Poole-Frenkel emission mechanism, which is characteristic of a high-quality insulator.

FY77 PLANS

Generally speaking the program will continue along the same lines. Measurement techniques which have already been developed will still be applied to the pyrolytic and anodic oxides of GaAs. Measurements on the oxide-$InAs_xP_{1-x}$ interface will be started, and an ellipsometer will be set up for the measurement of film thickness and dielectric content.

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Capacitor Dielectric Breakdown Investigation

ZR022 06 (NELC Z120)

NK Wagner

This investigation is a new research project based upon the catastrophic failure of large oil-filled capacitors in Navy vlf transmitters during 1975. The purpose is to aid in the development of both short- and long-term solutions by developing methods to warn of impending capacitor failure and by studying the physics of the dielectric materials.

Field experience indicates that partial discharge activity (corona) precedes dielectric breakdown. A corona detection system therefore could warn of impending failure.

Accomplishments during FYTQ included the design, construction, and successful testing of a prototype corona detector which senses high-frequency current impulses due to corona in entrapped gases within a test capacitor cell.

Plans for FY77 include field testing of the corona detection concept and study of the physics of failure of the dielectric materials.

Period:
1 July—30 September 1976

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High-Speed Electro-Optic Devices

ZR011 12 (NELC Z104)

HF Taylor

Optical technology offers significant advantages over electronics in bandwidth, processing rate, and immunity to interference and intercept. A considerable R&D effort must be accomplished before these advantages can be realized in operational Navy systems. This project explored the development of a modulator and a detector in FY76 and is aiming at the development in FY77 of a device using integrated optics for the addition of binary numbers.

Target of this project for FY76 was the development of two key components for use with optical fibers in Navy optical communication and signal processing systems—a photoemissive detector and a traveling wave modulator.

The waveguide detector developed consists of a silica substrate upon which a glass optical waveguide, aluminum electrodes, and a Cs_3Sb photoemissive film have been deposited under vacuum. The vacuum is maintained by a glass envelope. The aluminum electrodes provide electrical contact to the film, which is the cathode of the device. The anode is a wire which extends into the tube from a side arm. Light coupled into the waveguide from a laser is absorbed in the film. This stimulates the emission of electrons, which are accelerated by the applied voltage and collected at the anode (fig 1).

Two tubes with good photoemissive characteristics were fabricated. Spectral response curves for these tubes were similar to those reported for conventional Cs_3Sb photocathodes, with a sharp fall-off in quantum efficiency for wavelengths above 500 nm. To investigate waveguide coupling, 632.8-nm light from a HeNe laser was focused to a small spot by a 50× microscope objective and passed in its focal plane across the waveguide aperture. A sharp increase in photocurrent indicated the occurrence of efficient coupling into the waveguide and photoemissive film. An enhancement of the photoemission from the film by a factor of three was observed under waveguide excitation over the conventional method of illuminating the film from the back or front side. When losses in coupling from the laser to the waveguide and losses in the waveguide are taken into account, it is found that the internal quantum efficiency is enhanced by a factor of 30 due to waveguide excitation.

The traveling wave modulator consists of an optical waveguide coupled into a coplanar

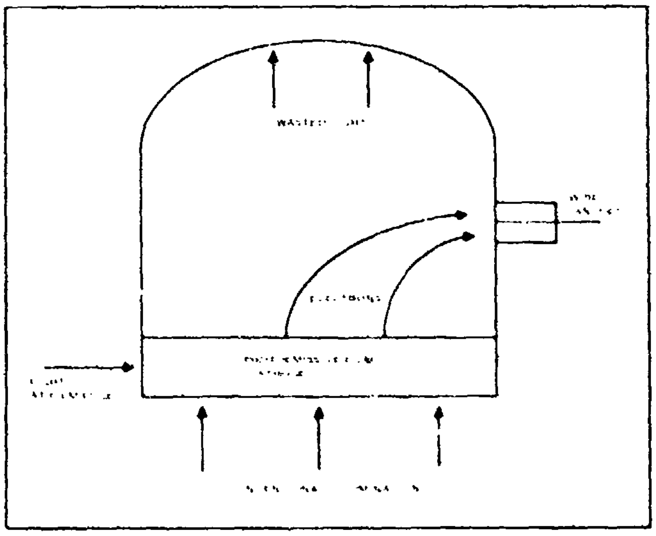

Figure 1. Illumination of photoemissive film at the edge increases path length with resultant increased absorption of light. Emission of electrons is increased threefold over older method.

transmission line on a $LiNbO_3$ substrate. An rf signal produces phase or intensity modulation of the optical wave. The optical waveguide is fabricated by masked diffusion of Ti into the $LiNbO_3$ substrate. A silver film for the electrodes is then deposited on the $LiNbO_3$ and etched to form the coplanar line pattern.

Critical factors considered in the design of the modulator were obtaining constant impedance in the coplanar line to avoid reflections; obtaining a strong interaction between optical and rf modulating fields; and obtaining phase match between rf and optical waves.

The electrode pattern contains a 75-μm-wide electrode gap region, an expanding constant ratio taper, and two right-angle turns leading to rf terminations. The lithium niobate is oriented with the C-axis normal to the optical waveguide axis to maximize the electro-optic interaction.

Several patterns were etched into a silver layer on lithium niobate to determine the proper aspect ratio for matching the impedance of the coplanar transmission line to a 50-ohm load. The best result, measured by time domain reflectometry, was an impedance of (46 $\pm$2) ohms with a center-conductor-to-waveguide width ratio of 0.28. No significant mismatch was observed at the rf connector-substrate interface.

Diffused optical waveguides ranging in width from 5 to 50 μm were fabricated. The optical output power of 30-mm-long waveguides was measured to be 25-50 μW with a HeNe laser as the optical source.

The electrode pattern was successfully aligned to place the optical guide in the high field region of the transmission line, and phase modulation of the optical field was observed with a 5-volt signal applied to the electrode pattern through the rf connector. Both phase and amplitude modulation were observed. Phase matching of the rf and optical fields has not been observed because of damaged center conductors on the completed devices, which prevented proper electrical termination.

Planned for FY77 are traveling wave modulators and photoemissive detectors improved with respect to bandwidth and efficiency, and a device using integrated optics for addition of binary numbers.

Tasks on fiber optics delay lines and optical A/D converters (see p 29) which were originally conceived under this project will be continued under the NAVELEX Special Electronic Devices Block Program (62762N XF 54 583 007 NELC F215) during FY77.

PUBLICATIONS

Taylor, HF, "Electro-Optic Technique for Adding Binary Numbers," Electronics Letters, vol 11, p 313, 314, 24 July 1975

Period:
1 July 1975—30 June 1976

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Optical A/D Converter

ZR011 12 (NELC Z115)

HF Taylor

The objective of this 6-month program was to design and fabricate an integrated optics analog-to-digital (A/D) converter with potential application in Navy radar and electronic warfare systems.

Confidence in the feasibility of the converter is based on the fact that the output of an optical intensity modulator is a periodic function of the applied voltage, just as each bit in the binary representation of an analog quantity is a periodic function of the value of that quantity.

The device, which was conceived under another Independent Research Project (NELC Z104) during FY75, consists of an array of optical modulators fabricated on an electro-optic substrate. Each modulator corresponds to one bit in the conversion. A time-varying voltage, the analog quantity to be converted to digital form, is applied to the signal electrode of each modulator. Light from a helium neon laser is coupled into each of the modulators, and the intensity-modulated output is detected by an avalanche photodiode. The amplified photodiode output drives an electronic comparator. The comparator voltage outputs (one for each modulator) give the binary representation of the signal voltage.

During FY76 and FYTQ, a design for a device with up to eight bits of precision and a potential conversion rate of 1 gigaword (10^9 samples) per second was formulated. Lithium niobate was selected as the substrate material because of its large electro-optic coefficient and low cost, and the modulators incorporate a traveling wave configuration first demonstrated here during FY75. Computer programs for an interactive display terminal were developed and used in the design of complex mask structures needed for the device.

Lithium niobate substrates were processed and techniques for fabricating waveguides by titanium diffusion were investigated. Patterns for the waveguides were produced by photolithography. Excellent waveguide definition was obtained for patterns as narrow as 5 μm. To date, due to unexplained high losses in waveguides produced by diffusion of titanium into the substrates, it has not been possible to successfully demonstrate the electro-optic A/D converter.

This project was completed at the end of FYTQ. Further work on the electro-optic A/D converter will be supported during FY77 under the NAVELEX Special Electronic Devices Block Program (62762N XF54 583 007 NELC F215).

PUBLICATIONS

Taylor, HF, "An Electro-optic Analog-to-Digital Converter," Proceedings of the IEEE, vol 63, p 1524, 1525, October 1975

Period:
1 April—30 September 1976

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Molecular Vapor Dissociation Laser

ZR011 07 (NELC Z116)

EJ Schimitschek

Blue-green lasers, operating in the transmission window of ocean water (450-510 nm), offer a unique potential for Navy electro-optical system applications such as optical communication, submarine detection, bottom mapping, underwater imaging and illumination, and countermeasures. Ongoing developmental system programs such as submarine-to-air optical communication (SAOCS) and optical ranging and detection (ORADS) could greatly benefit from improved blue-green laser sources.

The ongoing NAVELEX exploratory development program Blue-Green Laser Development (program element 62762N) supports promising laser technologies with proved feasibility to a performance level compatible with system applications (power, reliability, size). Mainly three classes of lasers are being funded—dye lasers, copper lasers, and excimer lasers. Although each of these lasers has unique features and will satisfy certain application demands, the growing "market" for compact and efficient blue-green lasers in the Navy seems to justify research into new classes of blue-green lasers.

The aim of this research project is to investigate the feasibility of obtaining lasing action in molecular vapors by dissociative excitation. In particular, it will be the goal to achieve population inversion in radicals HgX (X = Cl, Br, or I) by dissociating the parent molecule HgX_2 or RHgX (R = organic radical). The emission of the excited HgX radicals is known to occur in the blue-green spectral region (ref 1—3). This effort could therefore lead to the demonstration of vapor phase lasers in that spectral region which is of great interest to the Navy's underwater communication and surveillance systems.

In discussions with Dr N Djeu of NRL it became apparent that NRL has also been working on mercuric halides as possible blue-green laser materials. So far, their approach has been directed toward e-beam excitation. A cooperative program between NRL and NELC is being formulated to avoid duplication.

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Period:
15 April—30 September 1976

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Intercept and Identification of Spread-Spectrum Signals

ZR021 05 (NELC Z105)

RA Dillard and DH Marx

Recent advancements in spread-spectrum technology are leading to greatly increased military uses of spread-spectrum systems by a number of governments. In order to exploit spread-spectrum signals to locate and track enemy forces, the Navy must develop techniques for detecting and recognizing a great variety of waveforms under low signal-to-noise ratio conditions. The objective of this project is to develop techniques for detecting and identifying spread-spectrum signals and to formulate the concept of a total intercept system that employs these and other suitable, proved techniques. Although not a specified objective, a natural result will be design criteria for developing Navy antijam and low-probability-of-intercept systems resistant to signal intercept.

In FY75, the first year of this project, an initial concept formulation was made of an ideal system, and an experimental prototype system was evolved and outlined in block diagram form. Literature surveys were conducted to obtain information on spread-spectrum signals employed by possible adversaries, current US capability against them, and work elsewhere related to this project.

The initial designs of two new major techniques for detecting and recognizing spread-spectrum signals were completed in FY76. One is a pattern-recognition technique for automatically determining the presence of a signal that has the features of a signal category. The set of signal categories can be changed or expanded to correspond, at any time, with the signals of current interest. This pattern-recognition process was designed to operate on data obtained by adaptively quantizing the detected outputs from a bank of narrowband filters. The corresponding digital implementation logic was developed for a hardware processor operating real-time on binary data. An adaptive thresholder employing two first-order recursive filters was designed for the receiver-processor interface. The second new technique employs spectrum folding and cross correlation as a means of exploiting symmetric spectrum properties of direct sequence pseudonoise signals. For operation in the hf band, a channel-activity excision stage adapts the energy sampling process to the noise floor and user levels.

In order to exploit spread-spectrum signals to locate and track enemy forces, techniques are being developed for detecting and identifying spread-spectrum signals and a total intercept system will be planned. During FY76 the initial designs of two major techniques were completed. One is a pattern-recognition technique for automatically determining the presence of a signal category, the various categories corresponding to signals of interest and amenable to change. The second employs spectrum folding and cross correlation as a means of exploiting symmetric spectrum properties of direct sequence pseudonoise signals.

Preliminary analyses of performance were made for the pattern-recognition processor, the adaptive thresholder, and the pseudonoise symmetry detector. The original plan to implement a prototype system in FY77 for a full evaluation of the techniques was dropped because of the cost of the proposed hardware. Instead, the techniques are being evaluated by computer simulation, using pseudorandom sequence and transformation methods of generating data with appropriate signal and noise probability distributions. If suitable tapes of digitized data from actual receivers are obtained, the necessary filtering transforms will be programmed and the new techniques will be fully evaluated.

PUBLICATION

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Period:
1 July 1975—30 September 1976

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Lawrence Source Encoding

ZR014 08 (NELC Z119)

DW Gage

Lawrence Source Encoding is an information-preserving data compression scheme developed at NELC as a modification of Schalkwijk encoding under earlier IR and IED projects (ref 1, 2). The current project evaluated the applicability of this technique, which is a generalization of run-length encoding, to digitized voice, to narrative, and to facsimile data to provide a useful degree of data compression with an acceptable loss of information (zero loss for narrative data).

Previous work at NELC in this area had provided:

- An assessment of the effectiveness of Schalkwijk encoding in the compression of high-quality facsimile data
- An implementation for the facsimile application of the Schalkwijk and suitable preprocessing algorithms in hardware
- A qualitative assessment of the applicability of the Lawrence technique to digitized voice data to provide an improved secure voice capability

Because of the scope of the previous work on facsimile data, the FYTQ effort focused on the narrative and the voice applications. Computer programs were written to perform several types of preprocessing (such as differential and bit plane encoding) on the data and to model the performance of the Lawrence encoding algorithm for various input parameters. Also, programs were written to calculate the single-character and character digram entropies of narrative text and to automatically compile dictionaries with either character-sequence or whole-word entries. In addition to this modeling effort, an analysis was made of the actual information content (entropy) of narrative text, working from the classic analysis of Shannon, complemented by data derived from naval narrative messages.

The single-word entropy of English literary text is approximately 2.5 bits per character (on the basis of a 26-character alphabet). Lawrence encoding would yield about three bits per character or a 1.67:1 compression from a baudot character representation. The inclusion of punctuation, the Navy penchant for acronyms, and the "technical" nature of much naval message traffic would all tend to increase the information content of the text, degrading the performance of the Lawrence encoder still further.

Both the analysis and the modeling work indicated that nothing like the desired 2.5:1 compression of narrative data could be achieved without highly sophisticated preprocessing. Similarly, the best compressions achieved with preprocessed speech data fell far short of the 6:1 hoped for.

The reason for these failures is the "subtle" nature of the redundancy of these kinds of data. Simple forms of preprocessing such as differential encoding and bit plane encoding suffice to "extract" the redundancy from high-quality facsimile data so that good compression can be achieved. The analogous preprocessing for voice data would be a linear predictive coder; for narrative text, state-of-the-art techniques in syntactic and semantic information processing would be required. In either case, the preprocessing would be far more complex than the Lawrence encoder itself.

On the basis of these unpromising prospects, the decision was made in September to "gracefully" terminate this project. The findings will be documented in a technical note which will be issued in November.

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PUBLICATION

TN to be issued in November 1976.

Period:
1 July—30 September 1976

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CCD Analog and Digital Correlator

ZR021 03 (NELC Z194)

I Lagnado and S Steigerwalt

Analog signal processors using charge-coupled-device technology offer inherent high speed of operation with low control overhead requirements. A CCD cross correlator with numerous potential Navy system applications is nearing completion.

The primary objective of this project is to develop a fully integrated, high-speed, highly parallel, "digital" cross correlator by means of charge-coupled-device (CCD) technology. A CCD signal processor with a code storage capability of 32 samples would meet a wide range of systems requirements. The ability to cascade processors of this type would greatly extend their range of usefulness. Recent work has shown that whenever analog accuracy is acceptable, the analog CCD transversal filter or correlator can be used as a modular building block for the implementation of filtering, cross convolution, Fourier analysis, and beamforming with high intrinsic speed, a high degree of parallelism, and minimal control overhead. Significant achievements were registered at NELC during FY76 and FYTQ under this project.

Preliminary evaluation included the study of candidate discrete Fourier transform approaches including radix arithmetic, residue arithmetic, radix quarter square, and residue quarter square. A design implementing the mathematical identity $s(n) \times r(n) = \frac{1}{4} \{ |s(n) + r(n)|^2 - |s(n) - r(n)|^2 \}$ was selected to maximize the inherent simplicity of the CCD approach. A photomicrograph of this device is shown in figure 1.

The preliminary design and layout of the correlator were accomplished via a modular approach making use of two 32-sample CCDs, one of which is bidirectional to allow both correlation and convolution. The detailed design modules for charge injection and transfer and nondestructive charge sensing by the floating gate, a "multiplier" module for injecting charge into a charge adder, a floating gate amplifier for squaring charge, and a signal output amplifier were completed.

A fabrication process for implementing the design was developed which used double-level n^+-doped polysilicon and aluminum conductors over a silicon dioxide on 1—3-Ω-cm p-substrate silicon. A preliminary design was fabricated incorporating several components of the design including adders and a complete multiplier module.

Equipment and computer models to support the program were developed, including a four-phase clocking circuit and wafer testing programs for the Sentry LSI automatic tester for screening of chips before bonding to detect conductor-to-substrate shorts, open contacts, leaky gates or protective devices, and interphase shorts.

Extensive experimental and theoretical work was conducted in order to develop the theory of operation of the various components of the system. Computer simulation models were developed to evaluate the response of the floating gate to stored charge and to the potential on the bias electrode; to simulate the response of the floating gate amplifier and the output diode amplifier as a function of the implanted interface charges in the depletion-mode load transistors; and to simulate the charge injection mechanism. Experiments on the response of the floating gate and output diode amplifiers and on the charge injection mechanism indicated that the theory and parameters of the models were essentially correct. Experiments were also performed which verified the squaring response of the floating gate amplifier to small-signal variations and dc signals, as shown in figure 2. In addition, some tests on the addition module were performed, and the results indicate that addition of charge occurs The output current is proportional to the sum of the input signals over the appropriate range of signal voltages.

The experimental and theoretical work on charge injection will be used to establish the relationship between the output signal and the input signal. The information will also be used to set input diode and input gate voltage parameters to minimize injection noise.

During the year the corporate adder portion of the correlator was redesigned to minimize the difference in the size of the potential wells and to reduce the charge transfer distance. At the same time numerous test devices were added to allow more complete evaluation of the components.

Remaining to be tested are the responsivity of the floating gate to stored charge, the four-phase clocking of the CCD, and the operation of the full multiplier. The complete convolver/correlator is expected to be available for testing in early January. With substantially all the modules performing as predicted, operation of the correlator can be achieved with minimal delay.

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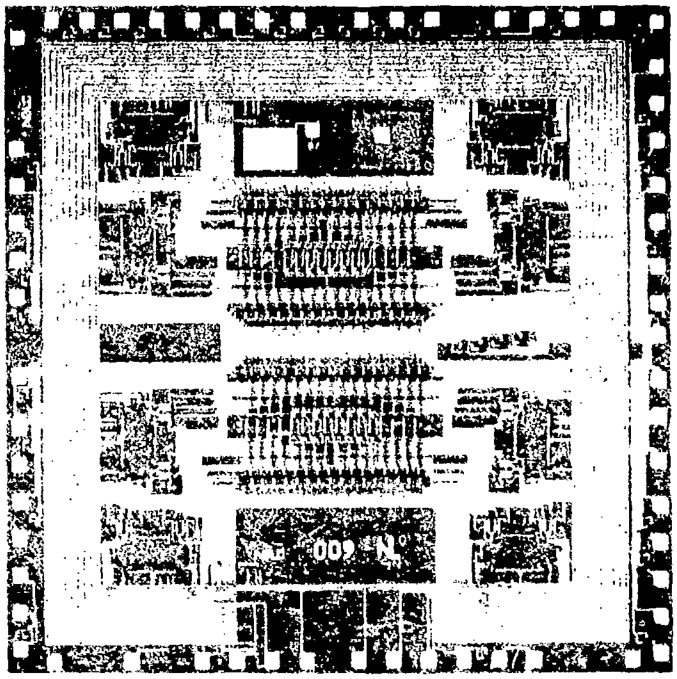

Figure 1. Photomicrograph of optimized charge-coupled device implementing a complex mathematical identity.

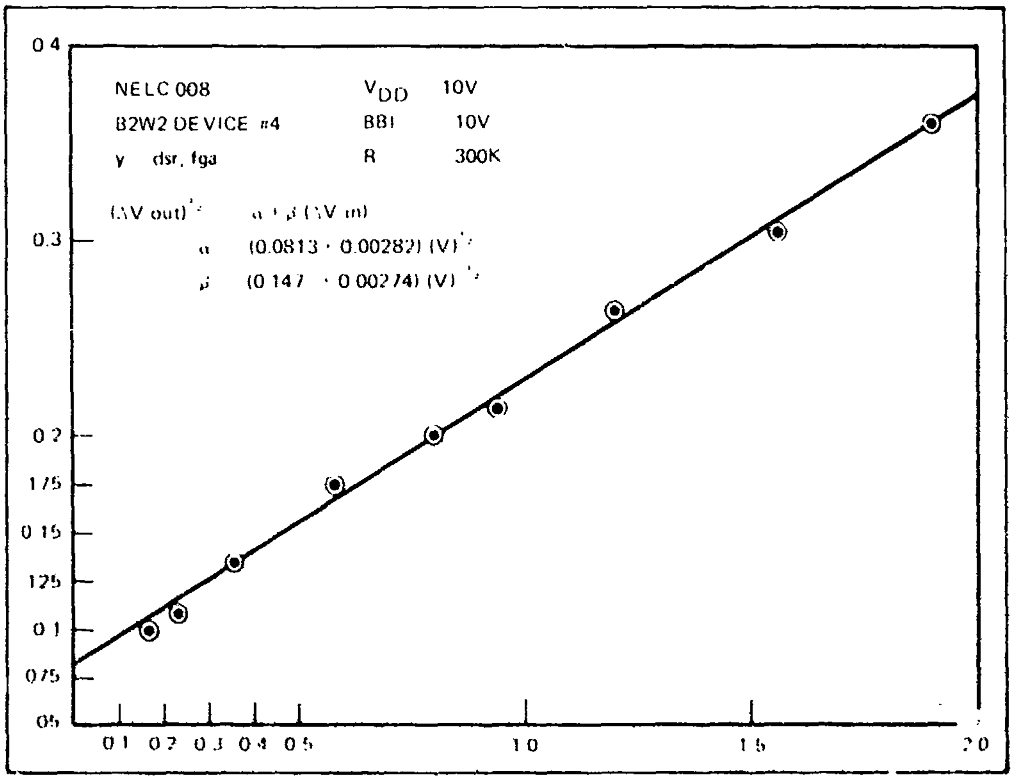

Figure 2. Small-signal response of the floating gate amplifier

Advanced Concepts of the Cordic Algorithm

ZR021 03 (NELC Z114)

GL Haviland

The objective of this project is to design via custom LSI (large-scale integration) a dedicated processor for coordinate conversion (resolver) employing state-of-the-art microelectronic technology and having wide application in Navy electronic systems.

With the advent of high-density integrated circuits, hardware implementation of special algorithms on a single silicon chip is a common occurrence. These circuits are often special-purpose processors solving a single, but frequently occurring, problem. When they are used in real systems, the rewards have been remarkable. The algorithms are more powerful since the implementation is not compromised by other constraints, the particular function is less demanding upon the central computer, reliability is increased, and cost is reduced. This project deals specifically with two frequently occurring "operations," to be designed and built via LSI solid-state technology, for application in real-time digital control systems.

In dealing with antenna, weapon, navigation, and guidance systems, serial chaining of resolver or resolver-like operations is used in solving a large class of problems. The problems relate to vector transformation, angular position, velocity, acceleration, force, torque, etc. A typical example is that of a fire-control director utilizing true bearing and evaluation orders and a knowledge of ship's attitude as given by the Eulerian angles heading, pitch, and roll to direct train and elevation gimbals for line-of-sight control. A chain of seven resolver operations provides the solution.

The proliferation of microwave antennas, guns, and missile launchers on a ship alone justifies development of new hardware techniques for real-time solution of control problems. Guidance and navigation problems are equal candidates in examining the utility of special hardware algorithms for size and cost reduction in associated equipment. The further application to submarine, aircraft, and missile, as well as ship platforms, will result in wide application of an LSI implementation of the two predominate resolver operations. Applications include its use as special hardware internal to general-purpose computer architecture, as a processing device external to such computers, or as part of special control devices for communications, weapon systems, and navigation.

With the LSI mechanizations, new system design concepts will probably be developed utilizing multiple arrays of coordinate converters.

The design of the processor involved the application of commercially available hardware plus the development of two custom LSI devices. Final packaging will consist of a hybrid assembly.

The first of the LSI devices was the CORDIC Arithmetic Processor (CAP), which performs all the computational requirements of the processor. The final size of the circuit, which required in excess of 3000 transistors, is 205 × 230 mils^2. The second circuit functions as storage registers, eight words deep, and instruction decoder (SID). This circuit is still in the design phase. All the circuits under development, plus the commercially available hardware, are fabricated as CMOS (complementary metal oxide semiconductor).

In addition to the normal circular coordinate systems, the resolver may also be used in the hyperbolic and linear coordinate system. Therefore, calculation of a broad class of elementary functions such as multiplication, division, trigonometric, hyperbolic, exponential, and square root is part of the repertoire.

Speed and accuracy of the processor depend upon the function programmed. In general, computation is 24 bits in length; however, 12 bits is programmable. In a typical mode—ie, coordinate conversion with 24-bit computation—the rms error is 2^{-19} with a computation time of less than 35 μs plus 5 μs each for load and unload. The inherent growth factor of the CORDIC algorithm is eliminated, or scaled to unity, during the computation cycle. In cases in which this is unimportant, such as a division of two preceding operations, the computation time is reduced to 24 μs.

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Electronic Determination of Speech Intelligibility

ZR021 03 (NELC Z112)

Elaine Schiller

A method for reliable evaluation of speech communication systems electronically (without human subjects) is not yet in hand. A family of devices based on principles investigated here is foreseen when problems such as variation among talkers and listening groups have been solved.

There is no accepted technique for determining the intelligibility of a speech communication system without the use of human subjects, and direct measurement of intelligibility using word lists and listener panels is difficult and expensive. For these reasons it has been customary to specify easily-measured objective tests such as frequency response and sensitivity. Use of such tests to infer level of intelligibility, however, gives erratic and unreliable results. As a consequence, systems with poor intelligibility could be rated good while those with good intelligibility could be rated poor, thereby leading to faulty procurement decisions.

Recent research in the Netherlands with a device called STIDAS (Speech Transmission Index Device using Artificial Signals—ref 1) indicates the possibility of determining intelligibility without the use of human subjects. STIDAS is a relatively simple device which can be readily simulated by standard laboratory test equipment. The transmitter subunit generates a complex test signal which the analyzer subunit receives and evaluates for signal degradation across the system. The output of the analyzer is the speech transmission index, which is used with a graph to predict the system articulation score for phonetically balanced (PB) word lists.

Although STIDAS appears to have validity for a limited set of conditions, several factors that affect intelligiblity have had little or no investigation. These include the effects of acoustic transducers (microphone, loudspeaker, earphones); sharp peaks and dips in frequency response; various noise spectra; and heavy peak clipping. Under this project NELC will investigate and expand upon the STIDAS principles, particularly as they apply to Navy voice circuits and terminals

Many different devices of various levels of sophistication could be based on the principles investigated here, such as a very precise device with 20 frequency bands to be used for specification testing of systems and components; a general-purpose piece of test equipment with five frequency bands for shipboard use; and a special-purpose, very simple device in two or three frequency bands to evaluate sound-powered telephones aboard ship.

In FY76 we showed that electronic means to determine speech intelligibility can be used when there is degradation in only one or two variables and when only a single device such as a microphone is under test.

The work in FYTQ was intended to fill in some of the gaps in the data obtained in FY76 and to test STIDAS on a system simulating shipboard-announcing systems.

Tape recordings of the real voice (PB word lists) and the STIDAS signal were projected by a shipboard loudspeaker in our noise shelter at increasing noise levels. The noise and signals were recorded 5 feet from the loudspeaker so that the full reverberation of the noise shelter was involved. The tape recordings were analyzed through intelligibility tests and the STIDAS analyzer, respectively, which is the method used to obtain all previous data.

Originally, the signal-to-noise levels were recorded in 6-dB steps and did not supply sufficient data for the determination of smooth curves. Additional tapes with different SNRs were made up as before and intelligibility testing was performed by a contractor (instead of NELC, because of lack of time and funds to adequately train new subjects or to retrain original subjects if available). As a check on the reliability of the new intelligibility tests, some of the original tape recordings were included with the new ones.

The recordings made with the STIDAS signal and analyzed on the STIDAS analyzer agree very closely with the data obtained in the Netherlands by the designers of STIDAS. However, the intelligibility test data obtained at NELC do not agree with the data obtained in the Netherlands, and the contractor test data do not agree with the data from either NELC *or* the Netherlands. So the contractor data cannot be used to fill in the gaps within NELC's data, NELC's intelligibility data do not confirm the Netherlands' intelligibility data, and the effectiveness of STIDAS in predicting intelligibility cannot be determined because of the wide variation in the intelligibility test scores.

Intelligibility testing must be improved to minimize variation among talkers and listening groups. A method to minimize these variations has been devised and will be the subject of a new proposal that will probably involve the Bureau of Standards. The new method will assure use of typical talkers and listeners to minimize variation among testing groups.

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Period:
1 July 1975—30 September 1976

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Millimetre Wave Solid-State Devices

ZR021 03 (NELC Z111)

D Rubin

This project included two tasks. First, millimetre wave microstrip circuits using solid-state devices were designed and fabricated. The circuits included oscillators, mixer down-converters, and the passive components (couplers, filters, etc) necessary for integration into millimetre wave receiver front ends. Second, a particular form of millimetre wave detector was fabricated and tested in which rf localized heating affects the majority carrier concentration in semiconductors. "Warm carrier" thermoelectric diodes were fabricated of both GaAs and InAs materials under contract for NELC, and were contacted and tested at NELC at dc, 10 GHz, and 35 GHz.

MILLIMETRE WAVE MICROSTRIP CIRCUITS

Varactor-tuned Gunn oscillators were fabricated on substrates of low dielectric constant (2.2) at center frequencies of 35 and 38 GHz with tuning ranges in excess of 1.2 GHz. Packaged Gunn diodes were mounted perpendicular to the microstrip line and chip varactors with ribbon leads were connected to the diodes through quarter-wave impedance inverting microstrip lines.

In response to the need for a reliable down-converter for the SURVSATCOM phase locking system, several microstrip balanced mixers were fabricated from low-cost Schottky beam lead diodes. The mixers operated over 34—38 GHz with conversion losses as low as 8.5 dB (34 GHz), using less than 2 milliwatts of local oscillator power.

Microwave IC devices developed at NELC combine the advantages of new materials and improved processing.

In conjunction with the REWSON millimetre wave surveillance program, a full-band 40—60-Ghz balanced mixer was developed. The mixer utilized the best GaAs beam lead diodes commercially available, in conjunction with a miniature reverse-phase twist hybrid coupler developed at NELC. Conversion losses were similar (9.5 dB) to those of full-band waveguide mixers in this frequency range.

WARM CARRIER THERMOELECTRIC DIODES

The warm carrier diode withstands the shock of large pulses better than conventional diodes, and its potential value in rf detection and mixing was recognized a decade ago. The limitations of germanium/silicon technology retarded applicational development for a number of years, but interest was revived with the recognition of the unique properties of InAs and GaAs and the advent of improved processing techniques (fig 1). The new materials have the advantage of higher mobility, and the improved processing techniques permit lower carrier concentrations. Along with small contact diameters, high mobility and low carrier concentration are essential for sensitivity in warm carrier devices.

Previous experiments with thermoelectric diodes utilized small metal points which contacted semiconductor surfaces directly to form small regions which would be heated through rf current conduction. The conditions of the surface and the point often made the results difficult to interpret, particularly since the contact radius of the point had to be known for analysis.

The polarity of the detected output indicates whether the diode is rectifying (undesired) or truly indicating the warm carrier thermoelectric effect. As expected, all the InAs diodes exhibited the thermoelectric effect whereas some GaAs diodes rectified. The output voltage for a given input power was within an order of magnitude of that calculated, whereas the ohmic resistance was higher than expected for the configuration used. The carrier concentrations associated with the bulk semiconductor materials used made these diodes inefficient for microwave/millimetre wave use. Lower doped epitaxial material would be needed for a useful device.

FY77 PLANS

In FYTQ this Independent Research project transitioned into Exploratory Development project Millimetre Wave Integrated Circuits and Devices (ZF615 12 NELC Z287). A successful mixer developed for SURVSATCOM in FY76 (fig 2) has led to a request to NELC to build mixers at higher frequencies in FY77.

PUBLICATIONS

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1 July 1975—30 June 1976

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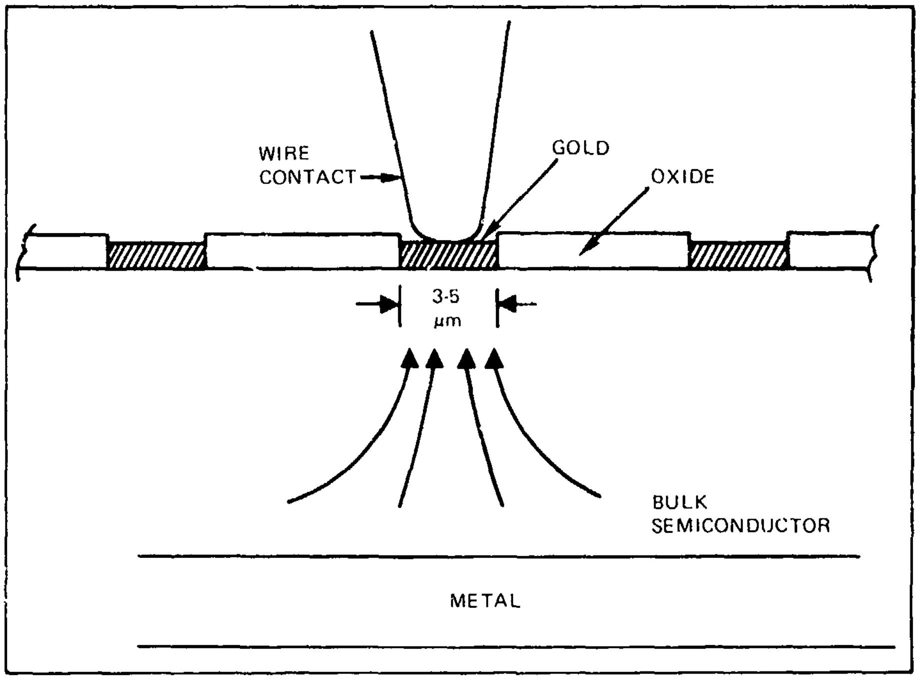

Figure 1. In the "honeycomb" technique, normally used in Schottky barrier detectors, windows are photographically defined in an oxide layer over a bulk semiconductor. Gold is evaporated through the windows to form very small contacts of known dimensions. A fine wire is brought into contact with one of the windows. The essential contact of the device is the gold-semiconductor interface — the warm carrier effect is not determined by the dimensions of the wire contact. Higher sensitivities may be achieved by the substitution of a lower-concentration epitaxial material for the relatively high-concentration bulk semiconductor.

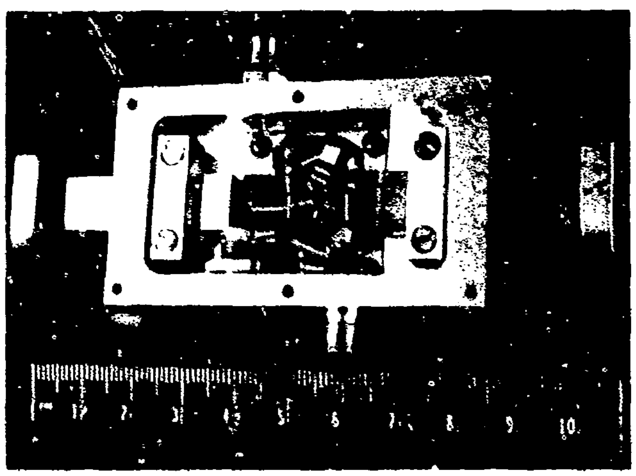

Figure 2. 34—38-GHz mixer, one of the millimetre wave circuits developed on low dielectric substrates. Silicon Schottky beam lead diodes are used in two ports of a 180° hybrid ring coupler. The beam lead bonding provides higher reliability by eliminating spring-loaded contacts and the associated momentarily open circuits in waveguide mixers.

Ion Implantation

ZR021 02 (NELC Z113)

ME Aklufi and I Lagnado

A technological base was developed at NELC during the reporting period in the application of ion implantation to the design and fabrication of a wide variety of solid-state devices.

Ion implantation provides more uniform and reproducible dopant distributions than present deposition/diffusion techniques—implanted resistors, for example may be 10 times more uniform with respect to the mean value than deposited/diffused ones. This accuracy increases yield. It makes tighter device specification possible. It enhances reliability by narrowing the range of variation of device electrical characteristics. It will permit complex Navy electronic functions to be implemented more precisely and at lowered cost.

A versatile 300-keV ion implanter was acquired and installed in a specially prepared room with rigid safety precautions instituted for both high voltage and radiation hazards. The system is shown in figure 1. The machine consists of six basic parts: ion source (1), accelerator (2), analyzer (3), beam line (4), target chamber (5), and control console (6).

The major area of investigation in FY76 and FYTQ was the implantation of boron (B^{11}) in silicon, with specific emphasis on the conversion of an existing CMOS p^-deposition process to an ion implantation process. This area of investigation proved fruitful in providing for the initial calibration of the system. Further, advances in CMOS processing have been obtained by providing improvements in p^-well uniformity by a factor of two across the wafer and by a factor of five from wafer to wafer. Working graphs for resistivity and NMOS (p^- well) threshold voltages versus implanted dose were generated.

The implanter is capable of accurately measuring the number of ions being implanted. Four-point probe resistivity measurements, typically used in deposition/diffusion processes, did not monotonically follow light dose implants. By utilizing van der Pauw resistivity measurement techniques, it was found that implanted resistors, depending on their value, were 10 times more uniform (to the mean value) than deposited/diffused ones, while the four-point probe technique indicated an improvement of only 5 times. A plot relating the more accurate van der Pauw values to those of the four-point probe was made.

The physical properties that control MOS transistor threshold voltages and the inherent accuracy of ion implantation can uniquely be coupled. Techniques and design rules for fabricating phosphorous (P^{31}) ion implanted NMOS depletion load transistors were developed. Working curves relating turn-on voltages to implanted doses were plotted. This information can be extended to provide information for obtaining a wide range of matched thresholds for both depletion and enhancement NMOS and PMOS transistors.

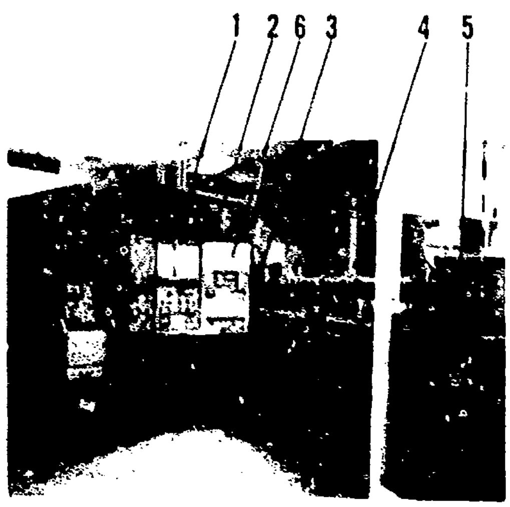

Figure 1. 300-keV ion implanter.

The results of this investigation in ion implantation have shown the usefulness of the technique. Uniform and reproducible dopant distributions provide for tighter device specifications, higher yields, and lower costs. In addition, the inherent low-temperature feature provides the only alternative for the design and fabrication of compound semiconductor such as GaAs whose constituents have high vapor pressures at relatively low temperatures (500—600°C). The acquisition, installation, and operation of the 300-keV ion implanter have markedly expanded NELC's technological base in solid-state device physics and fabrication.

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1 December 1975—30 September 1976

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Electrochromics and Liquid Crystals

ZR011 07 (NELC Z118)

P Soltan

Electrochromics are basically organic or inorganic solid materials that change color under an applied electrical field. Generally the image goes from colorless to dark blue. Tungsten oxide and strontium titanate are doped with molybdenum and iron to make electrochromics materials.

Liquid crystals are amorphous liquids that exhibit crystalline properties in certain temperature ranges. There are three basic types, nematic, cholesteric, and smectic, of which the last two have exhibited storage properties. These materials exhibit a variety of electro-optical effects which, upon application of dc or ac signals, allow transmission, reflection, refraction, scattering, phase modulation, and color generation.

Electrochromic displays closely resemble liquid crystal displays, and the two are superficially nearly identical. There are significant differences between them, however, and they tend to favor electrochromics. Electrochromics have superior and more stable storage properties, higher absorption capabilities, and freedom from angular dependence or visual distortion. They also have a wider range of working temperature (-50°C to 100°C vs -15°C to 75°C).

Practical application of liquid crystal and electrochromic materials to electro-optical processing and display requires an understanding of the factors that influence the speed, efficiency, and, particularly, lifetime of displays. The NELC approach is to determine experimentally how these factors are influenced when the components incorporated into displays are systematically varied. The components include the electrodes, active material, electrolytes, package, and associated electronics. The associated electronics have an important effect on the speed and life of mechanical displays because these depend on whether constant-voltage or constant-current drive is used.

NELC initially, in cooperation with industry, will fabricate and test a vacuum-deposited thin-film transistor (TFT) network within a transmissive liquid crystal as a display panel which can be matrix addressed. Characterization of this first liquid crystal/fiber optics (LC/FO) experimental device and that of an electrochromics device will determine the material properties needed for improvement of these two technologies.

An early application of the LC/FO technology will be to use the matrix-addressed transmissive liquid crystal to selectively modulate incoherent lights into light piping fibers. The fibers will illuminate an alphanumeric flat display panel which will be useful in the cockpits of advanced naval aircraft (1980 time frame). This portion of the work is sponsored by the Naval Air Systems Command through the Naval Air Development Center.

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Communication Disturbance Prediction—Solar Flares

ZR021 01 (NELC Z110)

MP Bleiweiss

This task is part of an ongoing effort to create and develop an environmental disturbance forecasting capability to minimize the effects upon Navy communications of solar flares, ionospheric storms, and similar phenomena. The central task is the PME-106-3 sponsored SOLRAD HI Environmental Disturbance Prediction System. Supporting efforts are NAVAIR sponsored SOLRAD Satellite Applications; Air Force sponsored Solar Radio Maps; and NASA sponsored Solar Modeling. Each of these contributes with data acquisition, equipment support, or analysis to support the solution of problems created by environmental disturbances.

NELC La Posta Astrogeophysical Observatory finds correlation between temperature of solar active regions and the occurrence of solar X-ray flares which disrupt Navy communications. Effort is underway to determine what additional information is required in order to make prediction more definitive.

Solar flares which emanate from "active regions" on the sun emit large amounts of excess X-ray radiation which disturbs the earth's ionosphere, resulting in absorption of hf radio waves and disruptions of communication. At the same time, changes occur in received phase at vlf which could cause positional errors in navigation systems such as Omega. The same flares emit particles (primarily protons) which can cause ionospheric storms and disrupt worldwide hf propagation for days. The objective of this task is to determine solar flare precursors and develop forewarning criteria to improve Navy communications by minimizing the effects of communication blackouts and disturbances caused by solar flares.

The approach has been to analyze the 8.6- and 19.5-mm solar radio maps obtained at NELC La Posta Astrogeophysical Observatory to determine their potential for meeting the objective. There have been hints in the literature that the brightness temperature of active regions at radio wavelengths can yield a forewarning of an impending large solar flare. NELC efforts have been to test these concepts to determine their validity.

Basically, the temperatures of the active regions (acquired daily) have been obtained and compared with the occurrence of solar X-ray flares. Also, the ratio of 19.5- to 8.6-mm emission has been used. The results are promising in that thresholds have been defined which signal the onset of a significant flare within the following 24 hours or more. These are

8.6-mm temperature $>0.08T\hat{C}$ above background
19.5-mm temperature $>0.15T\hat{C}$ above background
19.5- to 8.6-mm ratio between ~ 2 and ~ 5

For the time under study (August 1972 through December 1974), there were no flares during periods when these criteria were not met. There are times, however, when the criteria *are* met and a flare does not occur within 24 hours. Undetermined additional information is necessary to provide more definitive disturbance prediction.

The objective of this study, however, has partially been met—the ability has been acquired to identify those solar active regions capable of producing an X-ray flare of enough intensity to disrupt communications.

This Independent Research project is part of a total effort at La Posta to develop a Navy disturbance forecasting capability. For the reason that no one sponsor could fund the total project, there are several sponsors, as indicated in the first paragraph.

Z110 reduced and analyzed the data for communication outage prediction schemes; M225 provides the operational test and justification for the Z work; M403 sponsored the data collection and some of the analysis (the proton event prediction); M229 and M207 assist in the data analysis; and several past projects have assisted in the data analysis and development of the capability (M408, M406, M214, for example).

With more analysis to work out the details and present results to others for confirmation, it is expected that the Space Environment Services

Center of the National Oceanic and Atmospheric Administration and the Air Force Global Weather Central will utilize the forecasting technique developed under this project. They have already informally expressed interest.

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1 July 1975—30 June 1976

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Blue-Green Propagation Through Clouds

ZR011 07 (NELC Z117)

HG Hughes

Accurate electro-optical propagation codes are required for precise calculation of transmission loss through a wide variety of cloud conditions for assessment of Navy electro-optical systems. Single-particle scattering effects on optical frequencies propagating through clouds are reasonably well understood; however, the effects of multiple scattering need to be evaluated for the marine environment. The work described here will determine the effects of multiple scattering and pulse stretching on blue-green optical frequencies propagating through dense marine fogs.

An experimental test plan was developed in FYTQ under Z117 for (1) measuring the time history of the radiant power of a light pulse after propagating through various clouds or marine aerosols, and (2) quantifying the various loss mechanisms inherent to the aerosols. Of primary interest is the blue-green portion of the spectrum which, after propagating through a cloud, can penetrate seawater and be of use in a submarine-to-aircraft/satellite communications system.

It is generally assumed that such a system would be effectual only in cloud-free environments, a limitation which greatly impairs overall system capability. Yet the fact that sunlight gets through optically dense clouds on overcast days suggests that a sufficient amount of pulsed laser radiation might be available for demodulation/decoding after transversing the cloud if the field of view of the receiver were made wide enough to collect the scattered irradiance. The effects of multiple scattering by dense atmospheric/marine clouds on pulsed radiation translate into a pulse stretching and spatial broadening of the initial signal. Thus, the performance of any gated and continuous image viewing systems and communications systems using pulse-coding techniques will be degraded in terms of limited message data rates and reduced signal-to-noise ratios.

The test plan developed (ref 1) describes the pulse stretching measurements to be conducted at a site on Point Loma, San Diego, which encounters considerable marine fog.

Generally, two types of fog prevail at Point Loma—stratus cloud and Santa Ana fog. The mechanisms producing each fog type appear to be distinctly different. Stratus cloud related fog is a mid-calendar-year phenomenon and is produced when the base of the stratus clouds descends to the ground, usually at night. Evidence indicates that a sequence of events initiated by radiation cooling at the cloud top causes the cloud base to descend slowly. The visibility in this type of fog seldom reduces below 0.5 km, which is typical when marine aerosols are involved.

Fog related to wintertime Santa Ana conditions appears to have two formation mechanisms. However, both types of fog appear to be transported into the San Diego region by the movement of mesoscale troughs at different orientation. One type usually moves into San Diego as a diffuse or sharp fog bank. The other, and less common, moves as a low, thin deck (about 30-50 metres thick) northward from the coast of Baja, California into the San Diego region. Because of the smaller-size continental aerosols involved, this type of fog is much more dense than the stratus cloud type and provides the best opportunity for observation of the pulse stretching effects. Also, since the Santa Ana fogs approach the propagation path from the west and south, various conditions exist which allow the laser source and receiver to be both or separately immersed in the fog.

The two terminals of the propagation link are separated by 2.4 km. The elevations above MSL are 110 and 32 metres. The laser source and receiver will be synchronized via a uhf radio link. The source is a frequency-doubled Nd:YAG laser emitting 200-kW, 20-ns pulses at 0.53 μm with pulse rates to 10 per second. The received pulses will be recorded by a fully automated digital data acquisition system. In addition to the propagation measurements, the meteorological parameters (aerosol size distributions and visibilities) describing the propagation path will be measured and used as inputs to computer codes to assess the measured results and to serve propagation prediction purposes.

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PUBLICATION

See reference 1.

Period:
1 July—30 September 1976

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Independent Exploratory Development

IED 76

Introduction

When Congressional action resulted in a cut in this Center's IED funds in November 1975 from $1170k to $532k, all the unexpended funds were assigned to the OCCULT project (NELC Z275), which is one of the highlights, and some IR funds were added to the Real-Time Mask for Electro-Optical Processor project (Z274) to assure its completion. Both those projects have now been completed. The other three FY76 IED projects described were the only ones which had reportable accomplishments. The remaining three projects (see p 81) which supported the Marine Corps, had used very few resources ($23k) and are not separately described in this report. The most promising work, Signal Processing for the USMC Lightweight Battlefield Surveillance Radar, was continued with sponsor funding.

Brief descriptions of the IED projects which were started in FYTQ are given.

Low Cost Electronics/TELCAM

ZF61 512 (NELC Z269)

JH Townsend

The TELCAM (Telecommunications Equipment Low-Cost Acquisition Method) program was originated in FY74, the Low Cost Electronics program in FY75. Both programs were administered by the same NELC research team in FY75 and the two were consolidated for FY76. This report covers the continuance of the program from 1 July 1975 through 5 November 1975, when funding was terminated because of IED budget cuts. The primary purpose of the FY76 effort was to validate the feasibility of the recommendations made by TELCAM, TELCAM II, and Low Cost Electronics in the NELC Project Manager's Guide.

The validation program was conducted jointly between NELC and COMNAVSURFPAC (CNSP). CNSP supplied a shopping list of requirements, a variety of ships, and equipment usage data. NELC supplied all equipments and engineering and test services, made the ship installations, provided for operational support, and performed data analysis. Two requirements were selected which satisfied the necessary validation criteria: WWV receiver and medium-frequency (mf) homing beacon. The WWV receiver was selected to validate the TELCAM screening criteria and to demonstrate the feasibility of the TELCAM recommendations. The mf homing beacon was selected to validate the Low Cost Electronics development criteria and the TELCAM II recommendations concerning parts selection and screening. Both projects were conducted in strict accordance with the draft Project Manager's Guide. All equipment procurements, development, and installations were completed; however, the laboratory tests and analysis necessary to complete the equipment performance predictions essential to the validation effort were not performed because of the funding termination. Because Fleet data are now being generated on the basis of the work which was accomplished, it will be possible to complete the validation project when funds become available for the laboratory testing and analysis

A preliminary edition of the Project Manager's Guide was published and circulated to selected project managers at NELC for review and comment, to Navy Postgraduate School for use in a program management course, and to contacts in the systems commands, NAVMAT, Assistant Secretary of the Navy (R&D), ASN (I&L), and Office of the Secretary of Defense (OSD). Comments were solicited for use in revising the Guide.

A planned task to measure and correlate shock parameters and to develop a test standard for repetitive shock environments (from gunfire, catapult launches, etc) was postponed when funding was terminated. A planned task to assist NAVAIR in implementing the Commercial Airlines Acquisition Method (CAAM) was postponed because the Microwave Landing System (MLS) program, to which CAAM was to be applied, is subject to international agreements which have not yet been reached. However, the CAAM criteria are being successfully applied by the Air Force on its Inertial Navigation System (INS) acquisition. The CAAM is documented by ARINC publication 1313-01-1-1447, which is the product of FY75 Low Cost Electronics contractual efforts.

Project personnel have actively supported activities in the systems commands which contribute to the goals of Low Cost Electronics, including the pending revision of MIL-STD-781. NELC's contributions have been noted in such periodicals as Aviation Week & Space Technology (19 April 1976). The project has also supported the Commercial Commodity Acquisition Program being conducted by ASD (I&L); deeper involvement in the OSD program is awaiting funding. It is probable that project personnel will be tasked to support the Navy's Acquisition R&D program in FY77.

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Period:
1 July—5 November 1975

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Microprocessor Support System

ZF61 512 (NELC Z286)

MJ Perrin

In the generation of software for a microcomputer by a minicomputer, cost is largely a function of interactiveness between computers. The conventional paper tape link was eliminated by interfacing the microcomputer directly to the minicomputer I/O bus. Software is generated at a high level of interactiveness, with the corresponding cost saving, and throughput of microcomputer-based systems is increased.

Microcomputer software development systems offer various levels of sophistication. Software costs are directly related to the level of interactiveness the method provides. In each case, the interactiveness is diluted (and the programming costs are increased) by the paper tape link between the host computer and the microcomputer system. A minicomputer-based Interactive Microcomputer Development System (IMDS) was designed in FY75 by the Advanced Mechanization Applications Division of NELC, where it is now operational.

The basic hardware and software for IMDS consist of a PDP-11/40 minicomputer and associated peripherals. The minicomputer system software is disk-based and can be used as a single user or a foreground/background operating system. The system software is invoked from the DEC writer control terminal and includes a text editor, Fortran compiler, assembler, linking loader, and utilities package The RSX-11/M operating system allows multiple users of IMDS.

In order to program and test microcomputers interactively, the microcomputer system is interfaced directly to the minicomputer I/O bus. The minicomputer is used to generate source programs for the microcomputer system. Cross-assemblers, written in Fortran, are converted to run on the minicomputer and are used to produce object code on disk files. The object code is transferred from the disk files to the microprocessor RAMs via the PDP-11/40 I/O bus and parallel interface. Object code can also be simulated on the minicomputer with a simulator program written in Fortran.

Specific interface designs and corresponding programs have been implemented for an Intel 8080 and an RCA COSMAC. Current microprocessor software on IMDS includes cross-assemblers for the Intel 4040 and 8080, Motorola M6800, Fairchild F8, Signetics 2650, and RCA 1802 and ATMAC. An 8080 simulator also runs on IMDS.

In general, IMDS takes advantage of minicomputer state-of-the-art software and hardware to handle the microcomputer software requirements. In the long run, this provides a considerable cost savings. Use of the system requires a minimum effort in purchasing cross-assembler and simulator source programs from vendors or software houses and converting them to run on the minicomputer. The interface between mini and microcomputer is simple and can be designed to perform more sophisticated functions The system improves the software generation process and increases the throughput of microprocessor-based projects.

IMDS is currently supporting the following projects at NELC.

MMPS (Minimum Essential Emergency Communications Network Message Processing System)

ACES (Army Communications Encryptions System)

SMC (Shipboard Maneuvering Calculator)

GPS Algorithm/ATMAC Support

IMDS is being time-shared among these projects. Follow-on work since June 1976 has included the development of an LSI-11 microcomputer system which can operate in parallel with IMDS. An additional effort will provide interactive PROM generation via the PDP-11/8080 linked system.

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Period:
1 July—6 November 1975

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Millimetre Wave Solid-State Devices

ZF61 512 (NELC Z287)

D Rubin

This development project transitioned from Independent Research (ZR021 03 NELC Z111) at the beginning of FYTQ. Its purpose is to investigate and develop new ehf technology in the areas of integrated circuits and solid-state devices for application in surveillance and communication.

Two forms of network analyzer were constructed for use between 26 and 40 GHz in FYTQ. The objective was to be able to view on a scope the full-band input impedance (or reflection coefficient) of millimetre wave devices connected to an input port. Commercial network analyzers for this frequency range require a separate full-band backward wave oscillator ($7.5k) and mixing apparatus ($10k) and allow viewing of only a small part of the band at one time. For the NELC analyzers it was necessary to measure insertion phase and compensate each part of the apparatus with waveguide spacers.

Figure 1 shows two analyzers, one of them (panel A) a moderate success. This analyzer was usable over a 6-GHz bandwidth. The other could not be compensated for isolator and dual directional coupler dispersion.

Several experiments were started in FYTQ with a new form of device based on a 3-dB coupler using triplate between 8 and 12 GHz (ref 1). NELC scaled the X band coupler to Ka band and scaled the dimensions for microstrip use.

Coupler performance is shown in figure 2.

This is the only 3-dB broadband millimetre wave coupler reported to date that is truly planar—special handling and bonding wires are not necessary. Major difficulties encountered have been with large insertion loss and somewhat unequal coupling. No theory is yet available. Development is proceeding on an empirical basis.

FY77 PLANS

Effort will be directed toward the development of passive and active millimetre wave MIC (microwave integrated circuit) devices and warm carrier thermoelectric detectors in the 30—60-GHz range. Microstrip fixed tuned oscillators will be constructed from gallium arsenide and indium phosphide diodes (Gunn effect), filters and diplexers will be improved, subharmonically

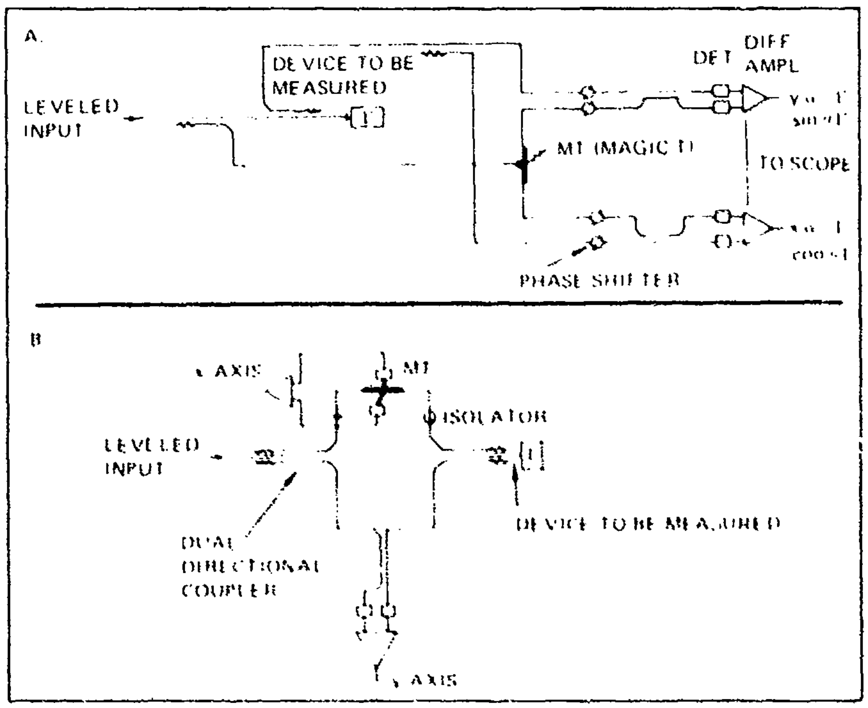

Figure 1 26.5—40-GHz network analyzers.

pumped mixers will be fabricated, and a three-channel diplexed receiver front end will be integrated on a single substrate. Other types of MIC circuits, including a low-noise InP amplifier, may be attempted. Warm carrier detectors will be fabricated of low-doped epitaxial material instead of the single-crystal material used previously. Honeycomb-type device chips will be contracted for, dc tested, and mounted in millimetre wave testing wafers. (Refer to Z111 under Independent Research.)

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Period:
1 July—30 September 1976

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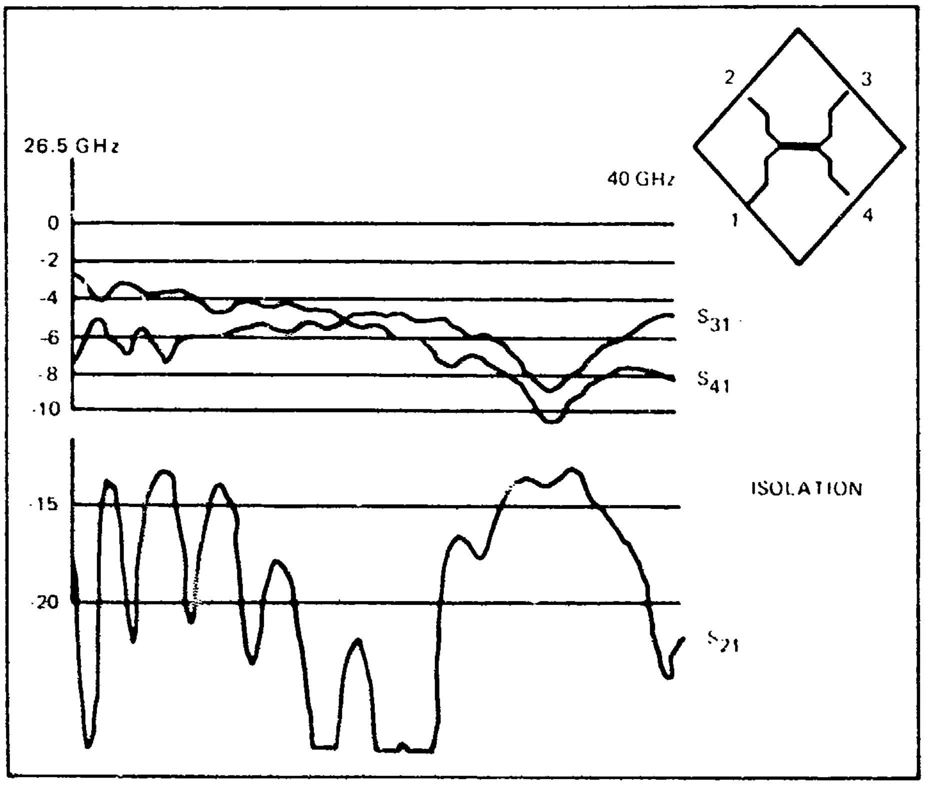

Figure 2. Performance of comb-line 3-dB coupler scaled to Ka band (26.5-40 GHz). Ideally, two outputs (top) would be equal and isolation would be high.

Real-Time Mask for Electro-Optical Processing

ZF61 212 and ZR01 112 (NELC Z274)

RP Bocker, AC Louie, and MA Monahan

Electro-optical (EO) processors inherently possess properties of fast multiply and parallel operation which represent the potential for a tremendous increase in processing performance over that available with conventional analog and digital devices. For this potential to be realized in full, EO devices must have the ability to modify their transfer characteristics (ie, program) in near real time. The incorporation of a high-speed EO programmable mask into the EO processing architecture offers a means by which this ability could be provided.

NAVELEX sees in the special capabilities of EO an answer to the demands of naval signal processing systems which must perform relatively complex linear and nonlinear transformations. The objective of this NELC project is to incorporate a programmable optical mask into the area array charge-coupled device (CCD) being assembled here under NAVELEX funding 62721N, XF21.222.025 (NELC B195) (fig 1).

The NELC FY75 effort had been concerned primarily with a search for the most promising recyclable EO materials and methods with which to update information on the mask. It had determined that the most desirable mode for addressing an active optical medium, from the standpoint of compactness in system size and weight, would be a solid-state electrode matrix approach and that the active optical medium best suited for this type of addressing would be the nematic liquid crystal.

During FY76 a matrix electrode addressed liquid crystal real-time mask was incorporated into the area array CCD processor, replacing the photographic film on which the transform kernel information had been encoded in the FY75 version. The real-time mask portion of the system consists of three essential components—liquid crystal matrix array cell, driver electronics, and electrical connector. The liquid crystal cell has a 1-by-1-inch active area containing 100 by 100 resolution elements, each of which can be individually controlled electrically. One such cell is shown in figure 2. A number of these cells have been fabricated by the Hughes Aircraft Company for the Air Force Avionics Laboratory (AFAL) to be used in flat panel display applications. NELC has acquired two of them from AFAL.

The cells consist of a thin layer of nematic liquid crystal material contained between a transparent conductive cover and a large semiconductor substrate incorporating a matrix array of electrically controlled reflective electrodes. The reflectivity of each resolution element in the cell depends upon the optical scattering characteristics of the liquid crystal material which in turn depend upon the magnitude of the applied potential at that resolution element site.

The array of individually controllable electrodes is formed simultaneously by use of large-scale-integration semiconductor circuit technology. The necessary external electronic circuitry for driving the liquid crystal cell was designed, fabricated, tested, and evaluated in house via digital medium-scale-integration technology. The information contained on the liquid crystal mask is capable of being changed and updated up to 30 frames per second when interfaced with a video camera, minicomputer, or microprocessor (60 frames with computer), and these performance rates have been demonstrated at NELC.

An electrical connector for the approximately 200 conductive paths that must be established between the liquid crystal cell and the driver electronics was also fabricated in house.

This project was initiated under IED funding in March 1974. When these funds were reduced in November 1975, IR funds were added so the project could be completed.

PUBLICATIONS

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Period:
1 July 1975—30 June 1976

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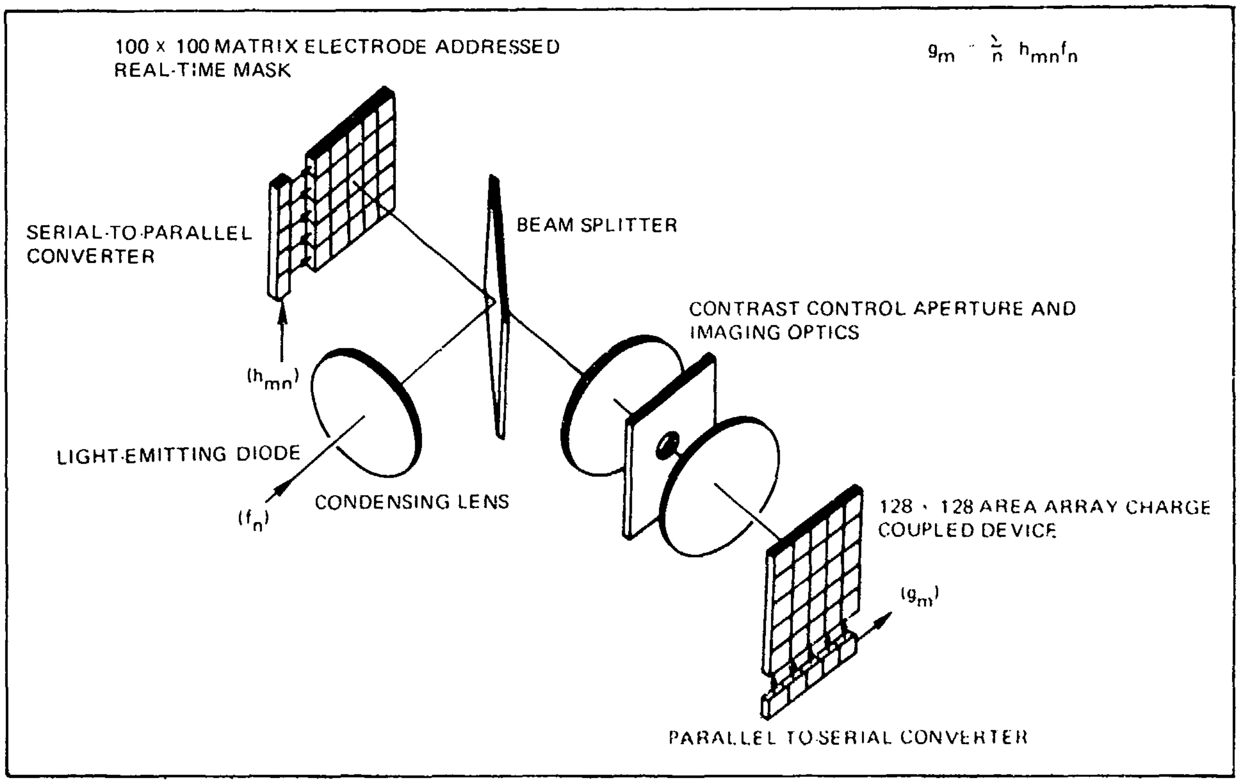

Figure 1. Area array electro-optical processor with real-time mask. Electrical input signal (f_n) temporarily modulates the radiance of a light-emitting diode. Condensing lens maximizes the light throughput in the system by imaging the light source into the entrance pupil of the imaging optics. Beam splitter directs the light from the condensing lens to the face of the matrix electrode addressed real-time mask. The transform kernel information (h_{mn}) is spatially encoded on the face of the real-time mask. An image of the real-time mask face is formed at the face of the area array CCD via the contrast control aperture and imaging optics. CCD completes the necessary self-scanning and integrating operations, thus yielding the desired transform (g_m). h_{mn} may be updated at a 60-frames-per-second rate.

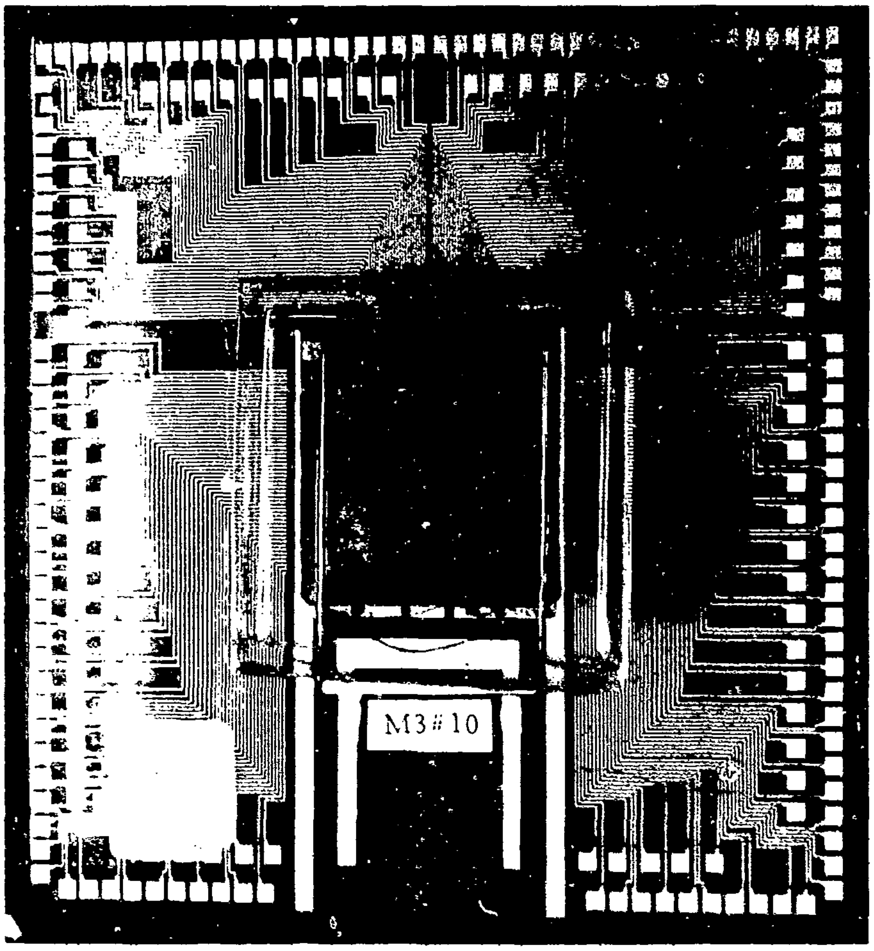

Figure 2. Solid-state matrix electrode addressed liquid crystal cell containing 100 · 100 resolution elements over a 1-by-1-inch area. Cell was fabricated by the Hughes Aircraft Company.

ECCM for Agile Radars

ZF61 112 (NELC Z289)

BF Summers and GM Dillard

Shipboard radar surveillance systems which allow computer control of parameter selection offer considerable performance improvement over conventional approaches to electronic counter-countermeasures (ECCM). Of interest in this project is the development of the rationale and algorithms for optimizing parameter selection, particularly as it affects performance in a hostile ECM environment.

An automated, integrated ESM and frequency-agile radar will be designed to automatically optimize radar performance in a hostile environment by optional selection of operating frequency.

Some preliminary measurements have been taken which show that considerable potential exists for those systems which are capable of pulse-to-pulse parameter changes. These areas will be investigated in detail during FY77.

Period:
1 July—30 September 1976

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Infrared Image Enhancement by Video Processing

ZP61 112 (NELC Z290)

PS Catano

The capability of simultaneous presentation on a tricolor display of image information from two or three spectrally distinct radiation bands is the objective of this effort. Effectively, spectral compression would be performed—information collected from the visible, the 3—5-μm, and/or the 8—14-μm regions of the electromagnetic spectrum would be displayed wholly in the visible band.

Video tapes have been acquired which contain imagery from the visible and 8—14-μm region. The two sensors had a common line of sight and were both TV compatible. A color superposition was attempted on a red-green-blue color television monitor. Imagery from the visible band was inserted into the red input and imagery from the 8—14-μm band into the green.

Lack of synchronization prevented thorough evaluation of the superposition, but it was apparent that each color image had information the other did not, as well as common information. A TV sync stripper was designed to slave one tape recorder to the other during playback. This plus a time base corrector will be used in an attempt to overcome the synchronization problem.

A bispectral display of visible and 8—14-μm imagery will be performed. The approach will be to photograph the display on a TV monitor from each of the video tapes. These photographs will then be spectrally distinct images of the same scene. A TV camera will then be used to stare at each photograph. In this way, the synchronization problem will be solved (along with the problem of limited available videotape). The two TV cameras will act as scan converters then, and will need to be synchronized with each other.

Period:
1 July—30 September 1976

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Command Control Distributed Design and Validation Process

ZF61 212 (NELC Z291)

DD Hall

As a result of accumulated bitter experience, the development of the data base management system, insofar as it leads to algorithms and procedures, is to be accompanied by facilities for their verification and validation. Testing, checking, and proving are now recognized as no less important than the original production of software and firmware. Work to date has been directed toward defining and delimiting the validation system that will ultimately evolve. The next step is to begin laying out the detailed specifications.

The results of this research should lead to the definition of verification and validation methods, or of a system, that will be especially adapted to present Navy tactical software as well as anticipated advances in which some of the functions currently performed by software are taken over by firmware.

Distributing a real-time data processing system requires that executive program functions be analyzed and guidelines developed for interfacing component processing elements to the system. Apart from the physical or logical interface of processing elements, definition of the interface of executive programs is required, as well as partitioning of executive functions between those performed locally and those performed globally. This is required in order that the system will operate efficiently and provisions can be made for system error recovery and initialization, distribution of common data bases, and system level task scheduling.

Work to date has consisted of analysis of existing tactical executives (SDEX-20 and ATES) and the Family of Operating Systems (FOS) work performed by Massachusetts Institute of Technology for the All Applications Digital Computer (AADC) program. This has led to the definition of functions and the data bases required by them. These functions will be applied to the distributed environment with additional functions defined as required and data bases partitioned between local and global. It is expected that a standard set of primitives will be defined from the FOS work and that additional primitives will be defined for distributed processing. Items required for a demonstration have been procured.

Period:
1 July—30 September 1976

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Adaptable Shipboard Tactical Data Distribution System

ZF61 212 (NELC Z292)

LCDR HC Schleicher

Future systems which will be installed in Navy complexes, both shipboard and shore based, will be impacted by the necessity to conduct serial interchange of data through a versatile switching system.

The interconnection of computer components using bulky, expensive parallel cabling and manual switches has been improved in shore-based complexes by use of parallel-to-serial converters, electronic matrix switches, and serial-to-parallel converters. The added versatility realized in the matrix switch is as desirable as the savings in material, weight, and installation costs. Virtually any channel of any equipment can be connected to any channel of any other equipment. Automatic fault detection and correction in distributed switching systems are feasible.

The objective of this NELC task is to determine the requirements of a shipboard combat computer/peripheral switching and distribution system and to demonstrate an expandable converter-switching system for shipboard use.

The two phases of this task are (1) to accumulate data on current converter-switching systems and shipboard computer complexes, and (2) to analyze the data accumulated in phase 1 to outline the baseline switching system which best satisfies present and future needs.

Three shore-based converter-switching systems have been studied: the AN/USQ-62 at Fleet Combat Direction Systems Support Activity Atlantic, Dam Neck, VA; the AN/USQ-67 at Combat Systems Maintenance Training Facility, Vallejo, CA; and the High Speed Data Switch (HSDS) at Fleet Combat Direction Systems Support Activity Pacific, San Diego, CA. The attributes of these systems have been tabulated. Documentation on the systems has been acquired for ready reference at one centralized location. Listings and configurations for shipboard computer complexes have been accumulated.

Period:
1 August—30 September 1976

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Tactical Data Network Programmable Data Terminal Set

ZF61 212 (NELC Z277)

RE Kelly

A flexible, pipelined architecture was developed for a programmable signal processor and controller which would have capability to implement a variety of modulation, netting, and error control techniques. The initial application was to be Link 11 modulation, net control, and error control. The modules were partitioned for general-purpose use wherever possible.

The following modules were fabricated:

8080 CPU

Random-Access Memory (2k × 8 bits)

Read-Only Memory (2k × 8 bits)

Display Interface (to interface between the 8080 and a Display/Monitor/Control box)

Radio Set Interface (A/D, D/A, sample and hold, filtering)

FFT (Dual-channel 64-point Fast Fourier Transform performed in 0.5 to 1.5 milliseconds, depending on application)

Additionally, programs were written for the 8080 to perform some of the net control and error control functions for Link 11, a Display/Monitor/Control box was fabricated, and programs were written to display and change the net control functions required for Link 11.

Tape Recordings of Link 11 signals were taken and processed on a chart recorder at reduced speed to assist in analysis of preamble anomalies.

Computer modeling of a digital Hilbert transform algorithm was completed for assessment of its effect on overall signal processing noise.

Potential applications of programmable signal processor and controller technology (not limited to an eight-bit microprocessor) include Tactical Data Intelligence Link TADIL-A (Link 11), TADIL-B, TADIL-C, Multitone FSK, Multiple Access Demand Assignment Netting, antijam/low probability of intercept, Radar Processing, and Sonar Processing.

Work was stopped in progress due to funding cutbacks.

Period:
1 July—6 November 1975

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Hf Radial Wire Ground Plane Analysis for Marine Corps

ZF61 212 (NELC Z288)

MJ Dick and JM Horn

The objective of this project is to develop guidance for selection of radial wire ground systems for selected USMC shore field antennas. The approach is to identify the antennas that use radial wire ground screens; implement the AMP2 (CDC) program on a selected computer; integrate the modified LLL Sommerfeld routines with the AMP2 program; obtain prediction results for the antenna/ground screen situations identified; and incorporate the prediction results in the form of a handbook.

For decades knowledgeable communicators have made use of radial wire ground planes to improve hf communications, but no known capability exists to allow accurate prediction of the improvement to be gained with a given ground plane scheme for a given antenna setup. There is currently a strong desire among senior communicators in the Marine Corps to establish procedures for the implementation of ground planes to maximize improvement and overall efficiency. NELC is preparing a handbook.

Two computer modeling codes, WFLL2B (ref 1) and AMP2 (ref 2), were considered. The WFLL2B is designed to solve general wire/finite earth problems. It includes subroutines for the Sommerfeld integrals. The subroutines are applicable to the general wire antenna above a radial wire screen. The program may not provide accurate answers when the center of the radial is within 0 03 wavelength of the interface, however, this may not impose a practical limitation on the results.

The WFLL2B code lacks rotational symmetry, which is essential in this study for economical computer utilization. The AMP2 code employs rotational symmetry but does not incorporate the Sommerfeld routines. The decision was made to add the Sommerfeld routines to the AMP2 program rather than to add rotational symmetry to the WFLL2B. Dr Chen of Purdue University is providing useful modifications of the Sommerfeld integral for the case in which the antenna wire is close to the earth (private communication).

The CDC 7600 computer was chosen for this project since AMP2, the WFLL2B Sommerfeld integral routines, and Dr Chen's modifications to the Sommerfeld routines were all written for the CDC 7600. Various CDC 7600 computers are available for use via ARPANET, including the machine located at the Lawrence Berkeley Laboratory, which has a reputation for good service and provides the facilities necessary to yield its output on the NELC high-speed printer. Presently, experience is being obtained with a remote terminal operating at NELC via ARPANET.

The investigators observed various wire antennas with radial ground systems at Camp Pendleton and interviewed several MC communicators. The communicators indicated that exotically shaped antennas such as disc-cone cages are not used in the field. The field antenna used is nearly always of the simple whip variety.

The AMP2 program is currently being installed on the CDC 7600 at Berkeley The program will be run with the Sommerfeld routines for antenna setups studied previously. Results will be obtained for MC antennas and a user handbook will be developed.

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Period

1 July—30 September 1976

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Taylor, HF, "Electro-Optic Technique for Adding Binary Numbers," Electronics Letters, vol 11, p 313, 314, 24 July 1975

Wagner, NK, "Compositional Profile of Heteroepitaxial InAs on GaAs Substrates," Thin Solid Films, accepted for publication

Wagner, NK, "Failure Analysis Using Auger Electron Spectroscopy," Proc 1976 Inter Microelectronics Conf, Anaheim, CA

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"Application of the Commercial Airline Acquisition Methodology to Department of the Navy Electronic Equipment Acquisitions," ARINC publication 1313-01-1-1447, 15 October 1976

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Johnson, RL, and Knobloch, EW, "The A-7 ALOFT Cost Model: A Study of High Technology Cost Estimating," thesis, Navy Postgraduate School, December 1975

Martinez, R, "A Look at Trends in Microprocessor/Microcomputer Software Systems," Computer Design, vol 14, no 6, p 51—57, June 1975

Monahan, MA, Bocker, RP, Bromley, K, Louie, AC, Martin, RD, and Shepard, RG, "The Use of Charge Coupled Devices in Electrooptical Processing," Proceedings of the 1975 International Conference on the Application of Charge-Coupled Devices, p 217—227, October 1975

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INDEPENDENT RESEARCH

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Dillard, GM, "Adaptive Thresholder for Stationary Binary Statistics," NELC Technical Note 3229, 29 September 1976

Mooradian, GC, Geller, M, Stotts, LB, and Hughes, HG, "Experimental Test Plan to Investigate the Propagation of Blue/Green Radiation Through Clouds," NELC Technical Note 3233, 1 October 1976

Rubin, D, and Saul, D, "Millimeter Wave Integrated Circuits Using Low Dielectric Substrates," NELC Technical Note 3203, August 1976

INDEPENDENT EXPLORATORY DEVELOPMENT

Bocker, RP, "Optical Matrix-Vector Multiplication and Two-Channel Processing with Photodichroic Crystals," NELC Technical Document 458, December 1975

Giannaris, RJ, Mooradian, GC, and Stone, WR, "CO_2 Coherent Propagation (with Reciprocal Tracking) Through the Marine Boundary Layer," NELC Technical Report 1994, 28 June 1976

Giannaris, RJ, Mooradian, GC, and Stone, WR, "OCCULT: Optical Covert Communications Using Laser Transceivers," NELC Technical Note 3232, 30 September 1976

Martinez, R, "Microprocessor/Microcomputer Software Systems: Present and Fugure," NELC Technical Document 439, 25 June 1975

Martinez, R, Perrin, M, Hendrickson, D, "Interactive Microcomputer Development System," NELC technical note (submitted for publication)

NELC Project Manager's Guide, preliminary edition, 1 January 1976

Presentations to Professional Meetings

INDEPENDENT RESEARCH

Invited Papers

DL Lile and NM Davis, "Optical Techniques for Semiconductor Material and Circuit Inspection," Advanced Techniques in Failure Analysis Symposium, Newport Beach, CA, February 1976

DL Lile, "The Applications and Properties of the III-V Compounds," Seminar, Department of Physics, California State University, San Diego CA, March 1976

HF Taylor and DJ Albares, "Integrated Optic Devices for Communications and Information Processing," Electro-Optics International Laser Conference, Anaheim, CA, November 1975

HF Taylor, WE Martin, and WM Caton, "Channel Waveguide Electrooptic Devices for Communications and Information Processing," IEEE/OSA Topical Meeting on Integrated Optics, Salt Lake City, UT, January 1976

Contributed Papers

MP Bleiweiss, FL Wefer, and MD Hurst, "Active Region Characteristics at Radio Wavelengths and their Relationships to Solar Flare Prediction" (Abstract), International Symposium of Solar-Terrestrial Physics, Boulder, CO, 7—18 June 1976

MP Bleiweiss and FL Wefer, "Observations of Coronal Hole Associated Features at Wavelengths of 2.0 cm and 8.6 mm," American Astronomical Society, Haverford, PA, 28 June—1 July 1976

GM Dillard, HF Taylor, and BR Hunt, "Fiber and Integrated Optics Techniques for Radar and Communications Signal Processing," National Telecommunications Conference, Dallas, TX, November 1976

I Lagnado and S Steigerwalt (NELC), JW Bond, JM Speiser, and HJ Whitehouse (NUC), "A Digital and Analog CCD Correlator," 1976 International Conference on the Technology and Application of Charge Coupled Devices, Edinburgh, Scotland, September 1976

D Lewis (ONR) and HF Taylor (NELC), "An Integrated Optical Analog-to-Digital Converter," NATO/AGARD meeting on Optical Fibers, Integrated Optics and their Military Application, London, England, 16—20 May 1977 (accepted)

DL Lile and DA Collins, "The Electrical Characteristics of the InP Surface," Third Annual Conference on the Physics of Compound Semiconductor Interfaces, San Diego, CA, 3—5 February 1976

E Schiller, "Research in Electronic Determination of Speech Intelligibility," Acoustical Society of America, San Diego, CA, 19 November 1976

S Szpak, "Formation of Anodic Oxides on GaAs," American Electrochemical Society Fall Meeting, Las Vegas, Nevada, 18—22 October 1976

NK Wagner, "Compositional Profile of Heteroepitaxial InAs on GaAs Substrates," Ninth Annual Symposium, Southern California Chapters of the American Vacuum Society, Hawthorne, CA, 8 June 1976

NK Wagner, "Failure Analysis Using Auger Electron Spectroscopy," International Microelectronic Conference, Anaheim, CA, 25 February 1976

INDEPENDENT EXPLORATORY DEVELOPMENT

Invited Papers

Townsend, JH, "TELCAM", Fourth Annual DoD Procurement Research Symposium, Colorado Springs, CO, 14—16 October 1975

Townsend, JH, "TELCAM and Low Cost Electronics," Steering Committee, OSD Commercial Commodity Acquisition Program, Washington, DC, 26 January 1976

Townsend, JH, "TELCAM and Low Cost Electronics Requirements Studies," Engineering Management Society, IEEE, San Diego Chapter, San Diego, CA, 23 June 1976

Contributed Paper

R Martinez, "Microprocessor Applications in Navy Systems," Ninth Asilomar Conference on Circuits, Computers, and Systems, Monterey, CA, November 1976

Honors and Awards

PATENT AWARD

Dr Carroll T White, NELC, and Dr M Russell Harter, Professor of Psychology, University of North Carolina, received a Navy patent award of $11 235 for their patent "Method and Apparatus for Determining the Effectiveness of Spatial Vision." The work for which this patent was granted was funded under the NELC Independent Research Program from FY68 through FY70. Part of that time Dr Harter worked with Dr White at this Center on a National Academy of Sciences-National Research Council postdoctoral fellowship.

While working on pattern recognition studies to improve information displays on Navy sensors, Dr White and Dr Harter discovered changes in electrical energy created by the brain in reacting to visual stimuli. Through this discovery, they were able to determine the exact amount of nearsightedness, farsightedness, or astigmatism in a subject's vision with the aid of a computer which records the brain's reaction to a flashing checkerboard pattern to determine how well individuals see the black and white patterns. When the image is most clear is defined by the characteristics of the evoked response measured by the computer. Evoked response is the electrical activity generated by the brain in response to sensory stimulation. This technique is especially useful in testing the vision of small children, because their judgment and response are not reliable. It can also be used to test adults and to detect malingerers.

Both Dr White and Dr Harter continue their research in how information is processed in the visual systems. In addition to his work at NELC funded by the Office of Naval Research (61153N RR0410102; NELC N528), Dr White currently conducts studies in the vision laboratory at Children's Hospital and Health Center in San Diego. His subjects are patients at the hospital, children referred from other area medical institutions, and adult volunteers.

Dr Harter conducts vision research at the University of North Carolina, Greensboro. At NELC, his research was primarily concerned with perceptual and motor processes and various physiology measures. His current interests are the development of vision of infants, beginning at 6 days of age, and binocular vision, or how the brain puts together images from both eyes.

The vision testing procedure perfected by Dr White and Dr Harter is also in use at Naval Regional Medical Center, San Diego, where adult patients are studied to determine the degradation of the visual system in certain types of diseases. It is also planned that these developmental studies will be extended to Naval Training Center.

The size of this award, the largest ever given at this Center, was based on evaluation by the Clinical Specialities Branch, Research Division, Bureau of Medicine and Surgery. Savings were estimated to be $33 614 a year.

POSTGRADUATE STUDY

Four NELC employees who have worked on IR or IED projects were selected for long-term training assignments for postgraduate study during the 1975-1976 academic year.

ME Aklufi studied metallurgy at Polytechnic Institute of New York to give the Microelectronics Division an increased capability in semiconductor devices, particularly those involving silicon on insulating substrates.

K Bromley studied communication theory and optical information processing at University of California, San Diego (UCSD). His work has been research and development in electro-optical information processing techniques and devices for Navy communication and surveillance systems.

LB Stotts took classes in applied physics and optics at UCSD which applied to material and fabrications development for integrated optical logic elements and waveguide couplers.

EJ Wells, Jr, also attended UCSD in Computer Science to obtain a broader background in computer software and systems architecture for application in the analysis and synthesis of advanced automatic control systems.

For 1976-1977 LG Meiners was selected to attend Colorado State University, Fort Collins, where he is taking courses and working on a joint research program among Princeton University, Colorado State University, and NELC and sponsored by ONR on compound semiconductor interfaces.

MEETINGS

HH Wieder was chairman of the Technical Program for the Third Annual Conference on the Physics of Semiconductor Interfaces, San Diego, CA, 3—5 February 1976. This conference, sponsored by the Office of Naval Research and the Army Research Office, Durham, was held at NELC because of the semiconductor interface work being done here on the IR program.

D Rubin is Chairman of the 1977 IEEE International Microwave Symposium to be held 22—24 June 1977 in San Diego. He is a past chairman of the San Diego IEEE Microwave Theory and Techniques Group.

Dr HF Taylor served on the program committee for the IEEE/OSA Topical Meeting on Integrated Optics held in Salt Lake City, UT, January 1976 and is on the program committee for the 1977 IEEE International Microwave Symposium to be held in San Diego, CA, in June 1977. He was selected for inclusion in Who's Who in Engineering and Dictionary of International Biography.

Patent Activity

Independent Research

PATENTS ISSUED

I Lagnado (NELC)
HJ Whitehouse (NUC)
Signal Processing Imager Array Using Charge Transfer Concepts

A charge-coupled device (CCD) for combining the properties of signal processing and image measurement in a single charge transfer device to perform convolution and correlation. The integration of dissimilar functional operations in a single device reduces hardware duplication, simplifies system implementation, reduces maintainability costs, and improves performance and reliability (by the mere fact of reducing complexity).

Reduces hardware duplication, improving performance and reliability for optical sensors in Navy applications.

Patent 3 940 602 (Navy Case 56 691) Serial 508 472 Filed 23 September 1974 Issued 24 February 1976

DL Saul
Miniaturized Millimetre Wave Frequency Discriminator

A discriminator, in some suitable form, is a key part of an instantaneous frequency measuring (IFM) receiver. A receiver of the IFM type has the ability to monitor continuously all frequencies within a designated frequency band, a property very useful for certain types of surveillance operations. The IFM receiver's military and naval use has become widespread at microwave frequencies up to 18 GHz.

Allows major size reduction in discriminators used in Fleet.

Patent 3 956 706 (Navy Case 57 804) Serial 546 367 Filed 3 February 1975 Issued 11 May 1976

DL Saul
Improved Millimetre Waveguide to Microstrip Transition

An improved means of transferring guided electromagnetic signals from dominant mode rectangular waveguide to microstrip transmission line at frequencies extending into the millimetre wave region. Wideband operation is a keynote feature, with high-efficiency performance (as evidenced by low VSWR and low insertion loss) over at least a 3:2 band of frequencies; ie, over at least a full standard waveguide frequency band. The initial development was done for the 26.5—40-GHz band, but the design can be scaled dimensionally to cover higher or lower bands.

Allows size and weight reduction for aircraft and submarine applications

Patent 3 969 691 (Navy Case 57 530) Serial 586 113 Filed 11 June 1975 Issued 13 July 1976

NM Davis

Apparatus and Method for Manufacturing Improved Zone-Melted, Thin Film Samples

The purpose of this apparatus is to crystallize films of a compound or elemental semiconductor on a low thermal conductivity substrate by means of moving a molten zone through the film. The molten zone is produced by heat from a hot wire held in close proximity to the film/substrate. The atmosphere surrounding the molten zone is controlled; that is, can be a vacuum or gaseous atmosphere of selected composition and pressure. The apparatus is designed to be modular in construction to allow ease in experimental modification and application.

Navy Case 53 632 Serial 267 338 Filed 29 June 1972

HF Taylor
AL Lewis

Broadband Optical Coupler

An optical coupler for introducing light signals into an optical data bus and also picking off signals from such a data bus.

Use in electro-optic communication and data processing systems.

Navy Case 55 909 Serial 469 199 Filed 13 May 1974

LJ Johnson

Variable Input Power Supply

An electronic power supply apparatus for use with a wide range of input voltages. A series switch type regulator is caused to regulate at two voltages (65 and 8 volts). This is done by sensing the regulated voltage and by means of gate circuits switching from one mode of regulating to the other without loss of efficiency.

Navy Case 56 508 Serial 617 924 Filed 29 September 1975

HE Rast
HH Caspers

Wide Aperture Optical Communications Detector

Provides a narrowband detection of optical signals over a large field of view. Most narrowband detectors are confined to a small aperture or field of view due to the necessity of using filters which require normal incidence and, hence, narrow field of view. This invention depends for its filtering action on an entirely different principle, thereby allowing large apertures.

Navy Case 58 110 Serial 652 037 Filed 26 January 1976

WJ Schade

A Stimulated Raman Scattering Resonator

A stimulated Raman scattering resonator which generates stimulated Raman scattering within an optical resonator and provides regeneration and unidirectional emission of radiation. A focusing mirror is provided for the pumping radiation and is combined with the stimulated Raman scattering resonator within a single optical structure. A semi-confocal type resonator having one totally reflecting plain mirror and one partially reflecting spherical mirror is employed to increase pumping irradiance. Improved optical communications systems will result.

Navy Case 58 111 Serial 654 824 Filed 3 February 1976

DL Lile
NM Davis
Optical Microprobe

This patent describes a technique for measuring the properties of a semiconductor at a specific point. It has potential application in diagnosing device faults and in improving circuit and, hence, system reliability.

Navy Case 58 669 Serial 673 223 Filed 2 April 1976

D Rubin
Broadband Millimetre Wave Amplifier

A method is utilized for externally varying the gain and bandwidth of a millimetre wave Gunn amplifier. The Gunn diode is varied in position vertically between the broad walls of reduced height waveguide. The introduction of the relatively large cylindrical heat sink of the diode creates a discontinuity which acts to counter the parasitic reactance of the diode in its mount. The effect is a very pronounced broadening of the frequency range at which amplification takes place.

Useful for surveillance receivers operating at millimetre wave frequencies.

Navy Case 58 774 Serial 622 285 Filed 10 October 1975

I Lagnado
RW Means
High-Frequency, CCD Adder and Multiplier

This device is a novel implementation of an analog multiplier to extend the application of CCD to variable, unknown impulse response filter.

Simplifies hardware interface and mechanization for signal processing systems.

Navy Case 59 466 Serial 661 689 Filed 26 February 1976

HF Taylor
An Electro-Optic Binary Adder

An array of electro-optic modulators with a suitable electrode structure for performing fast parallel addition of binary numbers.

Use in electro-optic data processing and computation systems.

Navy Case 59 524 Serial 700 683 Filed 28 June 1976

FR Borkat
RW Kataoka
Continuous Noninvasive Blood Pressure Monitor

A continuous noninvasive blood pressure monitoring system includes a resilient enclosure such as a flexible bladder, for instance, which is adapted to be inflated to a desired pressure and is retained in position immediately over a superficial artery of the person whose blood pressure is to be monitored.

Use in intensive care medical centers.

Navy Case 59 860 Serial 624 090 Filed 20 October 1975

HF Taylor

Optical Analog/Digital Converter

Array of thin-film, integrated optical modulators for fast conversion of analog signals to a digital representation.

Use in electro-optic data processing and computation systems.

Navy Case 59 926 Serial 727 744 Filed September 1976

CW Wilmsen
HH Wieder

Double-Layer Oxide Gate Insulators for Field-Effect Transistors

Double-layer oxide gate insulators for field-effect transistors are fabricated using gate insulating layers which are compatible with III-V intermetallic compounds. Specifically, indium phosphide is anodized to form the first layer and silicon dioxide is deposited over the first layer to form the second layer. Better transistors will be available for higher frequencies.

Navy Case 60 199 Serial 702 377 Filed 2 July 1976

INVENTION DISCLOSURES AUTHORIZED

HF Taylor

Optical Waveguide Photoemissive Detector

A device for coupling an optical waveguide to a photoemissive film for sensitive, high-speed detection of light signals to be used in electro-optic communication and data-processing systems.

Navy Case 59 925 Authorized for preparation of a patent application 30 January 1976

DA Collins
DL Lile

Process and Technique for Growing a Good Insulating Layer on InP

This patent describes a method for growing an electrically insulating layer on InP. It has application to device passivation and FET fabrication and thus potentially involves the area of future integrated circuitry.

Navy Case 60 430 Authorized for preparation of a patent application 23 June 1976

DISCLOSURES SUBMITTED

LJ Johnson

Integrated Ceramic Materials

A method for manufacturing ceramic integrated circuits by extruding batched ceramic materials to form blocks of specified cross sections, stacking cross sections from different blocks in a specified manner, and placing the stack in a furnace, having a predetermined temperature-time profile

Navy Case 61 234 Disclosure submitted to NELC Patent Counsel 13 August 1976

WE Richards and HF Taylor, "Large Aperture Phased Element Modulator/Antenna," a device for modulating, deflecting, or forming a large-aperture light beam, disclosure submitted.

A patent disclosure for CCD Analog and Digital Convolvers and Correlators was made by I Lagnado (NELC) and JW Bond, JN Alsup, JM Speiser, and HJ Whitehouse (NUC) in July 1976

Independent Exploratory Development

PATENTS ISSUED

DN Williams

Fiber Optic-to-Electronic Interface

A fiber optic-to-electronic interface circuit.

Use in interfacing electronic equipments with electro-optic systems and improve Naval communication and data transfer systems.

Patent 3 886 351 (Navy Case 55 085) Serial 449 814 Filed 11 March 1974 Issued 27 May 1975

RL Lebduska

Fiber Optic Cable Connector

A fiber optic cable connector of identical halves which press-fit together, with the terminals spring loaded to maintain the highly polished cable ends in close contact; a ferrule being provided to maintain the cable ends in perfect alignment and to act as a reservoir for the liquid inducing material that may be inserted between the cable ends to enhance optical transmission.

Fiber optics will have increasing use in Naval communication and data transfer systems.

Patent 3 904 269 (Navy Case 56 390) Serial 437 428 Filed 28 January 1974 Issued 9 September 1975

LB Stotts

Improved Optical Coupler

A passive optical coupler employing the distinctive wavelength sensitivity and polarized directional responsivity of different cholesteric liquid crystal materials to selectively couple out optically transmitted data and information from a common optical bus.

Use in electro-optic communication and data transmission systems.

Patent 3 909 113 (Navy Case 56 703) Serial 465 962 Filed 1 May 1974 Issued 30 September 1975

K Bromley
M Monahan
RP Bocker

Multichannel Optical Correlation System

An electro-optical device employing a light emitting diode, optical transparency, and charge-coupled device can perform multichannel simultaneous cross correlations for analysis of large volumes of data.

Patent 3 937 942 (Navy Case 56 119) Serial 484 632 Filed 1 July 1974 Issued 10 February 1976

A Roth
GM Holma

Closest-Point-Of-Approach Calculator

A manually operative, programmed (dedicated) calculator that computes the range, bearing, and time of closest point of approach of any or all of five selected target ships, and also their course and speed.

Can be used to avoid collision between ships.

Patent 3 939 334 (Navy Case 56 072) Serial 537 971 Filed 2 January 1975 Issued 17 February 1976

DW Doherty
EJ Wells, Jr
Universal Modularized Digital Controller

A miniaturized digital controller for use in a servomechanism system controlled by a signal from a computer or other digital data source.

Useful for antenna tracking, gunfire control systems, and any analog powerdrive driven by digital command.

Patent 3 958 109 (Navy Case 55 860) Serial 542 485 Filed 20 January 1975 Issued 18 May 1976

RL Lebduska
Focusing Coupling Device for Multi-Optical Fiber Cable

A connector for splicing the severed ends of multifiber cables comprising a funnel-shaped tubular section for receiving each cable end. The funnel-shaped tube forces the fibers of each corresponding cable end into a focusing relation with the adjacent cable end with a suitable junction between the cable ends using an index-matching fluid to permit high light transfer between the cable ends.

Fiber optics has increasing use in Naval communications and data transfer systems.

Patent 3 963 308 (Navy Case 56 071) Serial 373 583 Filed 25 June 1973 Issued 15 June 1976

CLAIMS ALLOWED, PENDING ISSUE

JA Cocci
ML Schiff
PCM Synchronization and Multiplexing System

The invention comprises apparatus for obtaining transmitter-receiver synchronization in an audio transceiver which employs pulse code modulation. The apparatus also provides demultiplexing of time multiplexed signals on the same data channel. The main advantage of the apparatus is that only one frame of data is lost for any one sync error.

May be implemented inexpensively by means of conventional digital integrated circuitry.

Navy Case 56 908 Serial 530 794 Filed 9 December 1974

PATENT APPLICATIONS FILED

LB Stotts
Improved Optical Transmit-Receive Coupler

A liquid crystal grating for coupling light into fiber optics.

Use in electro-optic communications and data transmission systems.

Navy Case 55 645 Serial 457 002 Filed 1 April 1974

R Bocker
K Bromley
M Monahan
L Stotts
Electro-Optical Spectrum Analyzer

An electro-optical device capable of performing a one-dimensional finite Fourier transform on temporal signals in real time. In addition to the Fourier transform capability, the device is also capable of performing matrix multiplication of a one-dimensional column vector by a two-dimensional matrix, yielding a one-dimensional column vector.

This will make possible computation of complex mathematical transformations in real time for data analysis.

Navy Case 56 834 Serial 542 524 Filed 20 January 1975

JC Lawrence
A Roth
Variable-to-Block-With-Prefix Source Coding Technique

A data compression technique for use with general sources and comprising a direct generalization of run-length coding. The technique is also operable with sources of time-varying and nonstationary statistics.

Will permit improved secure communication systems.

Navy Case 57 173 Serial 546 051 Filed 31 January 1975

JH Provencher
Multibeam Adaptive Array

A compact antenna using adaptive circuits in conjunction with hybrid matrices to provide multiple-beam capability, nulling and/or jamming techniques, and high power concentration on a target (directivity) is implemented in a single radiating structure.

Allows size reduction and minimizes space requirements of radar systems.

Navy Case 58 672 Serial 647 828 Filed 9 January 1976

JE Kershaw
Low-Loss Tunable Filter

An especially designed low-loss variable capacitor integrated with a helical resonator and housing results in a performance level not obtainable by any other known method. The capacitor tunes the helical resonator over greater than an octave range in the demonstration model, which can operate at power levels up to 250 watts, and which makes up one section of a three-section filter. The filter is used as one channel of a multicoupler in one application and as an inline automatically tuned filter in other applications for Naval and Marine Corps communication systems.

Navy Case 59 309 Serial 689 147 Filed 24 May 1976

EJ Pasahow
C Nuese
Programmable Data Terminal Set

The Programmable Data Terminal Set (PDTS) performs the modulation and demodulation of data in a computer-to-computer digital communication link. The PDTS uses a general-purpose digital computer to perform the signal processing functions, this traditionally has been done in special-purpose hardwired devices

Navy Case 60 353 Serial 674 025 Filed 5 April 1976

RP Bocker

Incoherent Optical Ambiguity Function Generator

An electro-optical device capable of computing the two-dimensional narrowband radar ambiguity function which economizes on size, weight, and power consumption.

LB Stotts
PS Catano
WE Martin

Generalized Logic Element for Integrated Optical Circuits

Provides a means to perform logic operations, such as AND, NAND, NOR, OR, and exclusive OR, and other related phenomena, eg, bistable multivibrator, in optical circuits.

Use in electro-optic data processing and computation systems.

Navy Case 59 831 Authorized for preparation of a patent application 26 January 1976

PS Catano
WE Richards

Multi-Spectral Imaging Systems

A device for presenting on a common real-time display simultaneous viewing of spectrally distinct video images.

Navy Case 58 711 Application authorized

DISCLOSURES SUBMITTED

CH Louie
SH Young

Liquid Crystal Display Controller

A set of MSI digital driver electronics used to update and change the information content of a solid-state matrix electrode liquid crystal cell containing 100 × 100 resolution elements. This controller can be easily expanded to operate on various liquid crystal array sizes, such as 200 × 200, and can operate on a sequential or random-access basis.

Navy Case 61 149 Disclosure submitted to NELC Patent Counsel 21 September 1976

Active Projects for FY76 and FYTQ

Independent Research

61152N, ZR000 0101

NELC Project	Title	Principal Investigator	NELC Mail Code	AUTOVON 933-	FY76 Funding $k	FYTQ Funding $k	Research Requirement	DDC Accession No
Z194	All Digital Signal Processing Functions Using CCDs	Dr I Lagnado	4800	6877	88	20	ZR021 03 01	DN 487535
Z195	Solid-State Device Reliability and Vulnerability	Dr CR Zeisse	4600	6591	250	44	ZR011 02 01	DN 487536
Z102	III-V Semiconductor MIS Device Technology	Dr DL Lile	4600	6591	205	43	ZR021 02 01	DN 587501
Z103	Advanced Integrated Material for Power Electronics Reliability	LJ Johnson	4300	2752	30	--	ZR021 03 02	DN 587502
Z104	High-Speed Electro-Optic Devices	Dr HF Taylor	2500	6641	120	–	ZR011 12 01	DN 587503
Z105	Intercept and Identification of Spread-Spectrum Signals	RA Dillard	3300	2395	80	20	ZR021 05 01	DN 587504
Z107	Continuous Blood Pressure Monitoring	Dr J Silva	3400	6471	55	--	ZR041 01 01	DN 587506
Z110	Communication Disturbance Prediction – Solar Flares	MP Bleiweiss	2200	7705	48	–	ZR021 01 01	DN 687514
Z111	Millimetre Wave Solid-State Devices	D Rubin	2300	7097	100	–	ZR021 03 03	DN 687515
Z112	Electronic Determination of Speech Intelligibility	E Schiller	3400	7372	50	6	ZR021 03 04	DN 687516
Z113	Ion Implantation	Dr I Lagnado	4800	6877	33	16	ZR021 02 02	DN 687543
Z114	Advanced Concepts of the CORDIC Algorithm	GL Haviland	4800	6877	44	25	ZR021 03 04	DN 687547
Z115	Optical A/D Converter	Dr HF Taylor	2500	6641	25	25	ZR011 12 03	DN 687578
Z116	Molecular Vapor Dissociation Laser	Dr EJ Schimitschek	2500	7975	17	17	ZR011 07 01	DN 687585
Z117	Blue Green Propagation through Clouds	HG Hughes	2200	7703		15	ZR011 07 02	DN 687625
Z118	Electrochromics and Liquid Crystals	P Soltan	2500	6641	–	13	ZR011 07 03	DN 687626
Z119	Lawrence Source Coding	Dr DW Gage	3200	6515	-	19	ZR014 08 01	DN 687627
Z120	Capacitor Dielectric Breakdown Investigation	NK Wagner	4600	6591	–	15	ZR022 06 01	DN 687628
Z274	Real-Time Mask for Electro Optic Processor (IED)	Dr RP Bocker	2500	6641	30	--	ZR011 12 02	NA (IED)

Independent Exploratory Development

62766N

NELC Project	Title	Principal Investigator	NELC Mail Code	AUTOVON 933-	FY 76 Funding $k	FYTQ Funding $k	ED Task Area
Z269†	Low Cost Electronics	JH Townsend	4400	7295	96		ZF61 512
Z274	Real-Time Mask for Electro-Optical Processor	Dr RP Bocker	2500	6641	19*	·	ZF61 212
Z275	Optical Covert Communications Using Laser Transceivers (OCCULT)	Dr GC Mooradian	2500	7975	238	9	ZF61 212
Z277†	Tactical Data Network --Programmable Data Terminal Set	RE Kelly	3200	6515	107		ZF61 212
Z280†	Signal Processing for USMC Light weight Battlefield Surveillance Radar	LH Bossert	2300	2626	11		ZF61 112
Z284†	Intelligence Analysis Automation	Dr S[illegible]	230	7911	12		ZF61 112
Z285†	Vhf-FM Antenna: AJ Techniques	Dr P Hansen	2100	7336	2		ZF61 212
Z286†	Microprocessor Support System	Dr R Martinez	4300	[illegible]860	25		ZF61 512
Z287	Millimetre Wave Solid-State Devices (former Z111)	D Rubin	2300	[illegible]3		35	ZF61 512
Z288	Hf Radial Wire Ground Plane Analysis for Marine Corps	JM Horn	2100	2421		13	ZF61 212
Z289	ECCM for Agile Radars	BF Summers, Jr	2300	7407		25	ZF61 112
Z290	Infrared Image Enhancement by Video Processing	PS Catano	2500	7230		7	ZF61 112
Z291	C^2 Distributed Design and Validation Process	Dr RN Goss	5200	7431		37	ZF61 212
Z292	An Adaptable Shipboard Tactical Data Distribution System	LCDR HC Schleicher	3300	6227		33	ZF61 212

†Terminated 11-5-75
*+$30k IR

ED Task Area	DDC Accession No
ZF61 112	DN 587612
ZF61 212	DN 587613
ZF61 512	DN 587614

Active Projects for FY76 and FYTQ

Independent Research

61152N, ZR000 0101

NELC Project	Title	Principal Investigator	NELC Mail Code	AUTOVON 933	FY76 Funding $k	FYTQ Funding $k	Research Requirement	DDC Accession No
Z194	All Digital Signal Processing Functions Using CCDs	Dr I Lagnado	4800	6877	88	20	ZR021 03 01	DN 487535
Z195	Solid-State Device Reliability and Vulnerability	Dr CR Zeisse	4600	6591	250	44	ZR011 02 01	DN 487536
Z102	III V Semiconductor MIS Device Technology	Dr DL Lile	4600	6591	205	43	ZR021 02 01	DN 587501
Z103	Advanced Integrated Material for Power Electronics Reliability	LJ Johnson	4300	2752	30		ZR021 03 02	DN 587502
Z104	High Speed Electro-Optic Devices	Dr HF Taylor	2500	6641	120		ZR011 12 01	DN 587503
Z105	Intercept and Identification of Spread Spectrum Signals	RA Dillard	3300	2395	80	20	ZR021 05 01	DN 587504
Z107	Continuous Blood Pressure Monitoring	Dr J Silva	3400	6471	55		ZR041 01 01	DN 587506
Z110	Communication Disturbance Prediction Solar Flares	MP Bleiweiss	2200	7705	48		ZR021 01 01	DN 687514
Z111	Millimetre Wave Solid State Devices	D Rubin	2300	7097	100		ZR021 03 03	DN 687515
Z112	Electronic Determination of Speech Intelligibility	E Schiller	3400	7372	50	6	ZR021 03 04	DN 687516
Z113	Ion Implantation	Dr I Lagnado	4800	6877	33	16	ZR021 02 02	DN 687543
Z114	Advanced Concepts of the CORDIC Algorithm	GL Haviland	4800	6877	44	25	ZR021 03 04	DN 687547
Z115	Optical A-D Converter	Dr HF Taylor	2500	6641	25	25	ZR011 12 03	DN 687578
Z116	Molecular Vapor Dissociation Laser	Dr EJ Schimitschek	2500	7975	17	17	ZR011 07 01	DN 687585
Z117	Blue Green Propagation through Clouds	HG Hughes	2200	7703		15	ZR011 07 02	DN 687625
Z118	Electrochromics and Liquid Crystals	P Soltan	2500	6641		13	ZR011 07 03	DN 687626
Z119	Lawrence Source Coding	Dr DW Gage	3200	6515		19	ZR014 08 01	DN 687627
Z120	Capacitor Dielectric Breakdown Investigation	NK Wagner	4600	6591		15	ZR022 06 01	DN 687628
Z274	Real Time Mask for Electro Optic Processor (IED)	Dr RP Bocker	2500	6641	30		ZR011 12 02	NA (IED)

Projects Terminated in FY76 and FY7T

Independent Research

NELC Project	Title	DDC Accession No	Reason for Termination
Z103	Advanced Integrated Material for Power Electronics Reliability	DN 587502	The approach was not promising at the present state of the art.
Z107	Blood Pressure Monitoring	DN 587506	Feasibility established. Naval Medical Research and Development Center provided FY77 funding for refinement and application. (NELC S111 $45k)
Z110	Communication Disturbance Prediction – Solar Flares	DN 687514	Funding preempted
Z111	Millimetre Wave Solid-State Devices	DN 687515	Transferred to IED ZF61 512 (NELC Z287)
Z112	Electronic Determination of Speech Intelligibility	DN 687516	Completed. Data from different tests did not agree. Proposal made to National Bureau of Standards for additional work.
Z113	Ion Implantation	DN 687543	Completed. Useful technique for fabricating compound semiconductors
Z115	Optical A/D Converter	DN 687578	To be continued under NAVELEX block program in electro optics 62762N XF54 583 007 (NELC F215 $100k)
Z119	Lawrence Source Coding	DN 687627	To be terminated 30 November 76. Preprocessing equipment required would be more complex than the Lawrence encoder itself

Independent Exploratory Development

NELC Project	Title	DDC Accession No	Reason for Termination
Z269	Low Cost Electronics	DN 587614	5 November 1975 Congressional funding cut
Z274	Real-Time Mask for Electro-Optical Processor	DN 587613	Completed. Results to be used in bioacoustic communications program.
Z275	Optical Covert Communications Using Laser Transceivers (OCCULT)	DN 587613	Completed. Automatic tracking and acquisition equipment will be used in Extended Line of Sight Communications project
Z277	Tactical Data Network - Programmable Data Terminal Set	DN 587613	5 November 1975 Congressional funding cut. Led to Low Cost Link 11 PDTS which has completed acceptance tests in preparation for OPEVAL 63519N XCC09 (NELC B193).
Z280	Signal Processing for USMC Lightweight Battlefield Surveillance Radar	DN 587612	5 November 1975 Congressional funding cut Feasibility model of signal processor was developed on 62712N XF12 151 001 for USMC lightweight Doppler radar (NELC D217)
Z284	Intelligence Analysis Automation	DN 587612	5 November 1975 Congressional funding cut
Z285	Vhf-FM Antenna AJ Techniques	DN 587613	5 November 1975 Congressional funding cut
Z286	Microprocessor Support System	DN 587614	5 November 1975 Congressional funding cut

Multisponsored IR/IED Projects for FY76 and FYTQ

IR/IED PROJECT				OTHER FUNDING			
NELC Project	Title	Funding	Amount	NELC Project	Funding	Amount	DDC Accession No
Z110	Communication Disturbance Prediction -- Solar Flares	ZR021 01	$ 48k	M207 M403	62759N WF52 551 717 62101F AFCRL	$ 45k 36k	DN 034000 DN 112106
Z111	Millimetre Wave Solid-State Devices	ZR021 03	$100k	B227	11403N XSB11	$ 6k*	DN 587515
Z274	Real-Time Mask for Electro-Optical Processor	ZF61-212	$ 19k	· B195B	61152N ZR011 12 62721N XF21 222 025	$ 30k $155k	DN 587613 DN 687522

*Mixer for submarine communications terminal for Survivable Satellite Communications System

Projects for FY77

Independent Research

61152N, ZR000 0101

NELC Project	Title	Principal Investigator	Mail Code	AUTOVON 933-	FY77* Funding	Research Requirement	DDC Accession No
Z194	All Digital Signal Processing Functions Using CCDs	Dr I Lagnado	4800	6877	$ 84k	ZR021 03 01	DN 487535
Z195	Solid-State Device Reliability and Vulnerability	Dr CR Zeisse	4600	6591	175	ZR011 02 01	DN 487536
Z102	III-V Semiconductor MIS Device Technology	Dr DL Lile	4600	6591	169	ZR021 02 01	DN 587501
Z104	High-Speed Electro-Optic Devices	Dr HF Taylor	2500	7975	100	ZR011 12 01	DN 587503
Z105	Intercept and Identification of Spread-Spectrum Signals	RA Dillard	3300	2395	90	ZR021 05 01	DN 587504
Z114	Advanced Concepts of the CORDIC Algorithm	GL Haviland	4800	6877	85	ZR021 03 04	DN 687547
Z116	Molecular Vapor Dissociation Laser	Dr EJ Schimitschek	2500	7975	75	ZR011 07 01	DN 687585
Z117	Blue-Green Propagation Through Clouds	HG Hughes	2200	7703	149	ZR011 07 02	DN 687625
Z118	Electrochromics and Liquid Crystals	P Soltan	2500	6641	50	ZR011 07 03	DN 687626
Z119	Lawrence Source Coding	Dr DW Gage	3200	6515	6**	ZR014 08 01	DN 687627
Z120	Capacitor Dielectric Breakdown Investigation	NK Wagner	4600	6591	55	ZR022 06 01	DN 687628
Z121	Large Aperture Optical Modulator	Dr GC Mooradian	2500	7975	124	ZR011 12 04	DN 787501

*Includes FYTQ carry over of $22k

**To be terminated 30 November 1976

Independent Exploratory Development

62766N

NELC Project	Title	Principal Investigator	NELC Mail Code	AUTOVON 933-	FY77 Funding	ED Task Area	DDC Accession No
Z287	Millimetre Wave Solid-State Devices (former Z111)	D Rubin	2300	2358	$ 90k	ZF62 512	DN 587614
Z288	Hf Radial Wire Ground Plane Analysis for Marine Corps	JM Horn	2100	2421	52	ZF61 212	DN 587613
Z289	ECCM for Agile Radars	BF Summers, Jr	2300	7407	90	ZF61 112	DN 587612
Z290	Infrared Image Enhancement by Video Processing	PS Catano	2500	7200	25	ZF61 112	DN 587612
Z291	C^2 Distributed Design and Validation Process	Dr RN Goss	5200	7431	133	ZF61 212	DN 587613
Z292	An Adaptable Shipboard Tactical Data Distribution System	LCDR HC Schleicher	3300	6227	133	ZF61 212	DN 587613

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This document is an overview of the NELC IR and IED programs. It summarizes the accomplishments achieved within each project in FY76 and FYTQ. Longer articles are presented on three of the most significant projects – (1) Optical Covert Communications Using Laser Transceivers (OCCULT), (2) III-V Semiconductor MIS Device Technology, and (3) Continuous Blood Pressure Monitoring.

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