Navy Electronics Lab, San Diego, Calif.

Test Results of SQS-23 Pair (AN/SQQ-23) Transmitter and the Ray-Etc. (U)

Aug 66 H J Klee

NEL-TM-1060
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TECHNICAL MEMORANDUM TH-1060

TEST RESULTS OF SQS-23/PAIR (AN/SQQ-23) TRANSMITTER AND THE RATHEON TR-197 TRANSDUCER (U)

16 August 1966

H. J. Klee (NEL Code 2140)

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This technical memorandum represents a portion of the work being done on NRL Problem J714, AN/SQS-23 Performance and Integration Retrofit (PAIR) Program. It should not be construed as a formal report as its primary intent is to present some of the problems confronting project personnel and some of the preliminary conclusions. While it was originally published in a different form, it is now being included in the technical memorandum series for sake of documentation uniformity and control. Limited outside distribution is intended.
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<td>stave #1, 5.5 kc</td>
</tr>
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<td>stave #4, 5.5 kc</td>
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</tr>
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Active testing of the SQS-23G/PAIR transmitter with Raytheon TR-197 transducer has been completed. This memorandum presents a preliminary summary of the results of the tests.

In all graphs and tables present herein, A + B refers to the transmitter drive and output connections. A + B means that transmitter A drives elements 1, 2, 3, 8 and 9 of a stave while transmitter B drives elements 4, 5, 6 and 7. In the A only, B only or the A or B mode, one transmitter drives the entire stave.

Graph 1 shows source level for all operating modes as a function of frequency. Fundamental source levels are very close to specified levels, but harmonic distortion caused harmonic source levels that are high enough (graphs 12 through 19) to be detrimental to VLS and sonic guided torpedoes. A major portion of these harmonics are generated within the "Class C" output stage of the SQS-23G transmitter. Significant reduction of the harmonic output could only be accomplished by redesign of the final stages of this power amplifier.

Graphs 2 through 7 show the variation in transducer element impedance for the TR-197 under normal PAIR operating conditions. The magnitude of the impedance varies from 200 to 1300 with phase angles from -90° to +30°. These highly variable reactive loads limit the maximum source level by high screen and plate dissipations in the transmitter output stage under the above operating conditions.

Graphs 8 through 11 present transmitter plate circuit dissipation and efficiency. Plate, screen grid, and drive voltage were adjusted to obtain the maximum possible source level consistent with the maximum power dissipation ratings for the output tubes. The output transformer was included
as part of the plate circuit for these measurements. The dissipation in this transformer must be subtracted from the plate circuit dissipation to obtain true element dissipation. At some frequencies the plate circuit dissipation exceeds the limit set at 520 watts. This is permissible since for most PAIR operating modes the average dissipation will be less than 520 watts.

Graphs 20 through 31 present the previously mentioned data as a function of operating transducer depth. At the one-half foot depth considerable cavitation was visible in the acoustic waveform and the maximum power dissipation in the output tubes was greatly exceeded. Because of the varying depth of the transducer during normal operation, a careful look at the long term reliability of the transmitter under these operating conditions is needed.

Patterns 1 through 6 are typical patterns of the SQS-23G/PAIR transmitter with a TR-197 transducer. The relatively high side lobe levels support the previous conclusion that the beamforming delays in the TCU are not proper to form the PAIR specified transmit beam, and that transmit beams will also be a function of the active transducer type installed.
| Equipment | SQS-23G
Maximum
Ratings
(1 unit) | PAIR Operating Requirements
(with TR-197 transducer) |
<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td><strong>1. High voltage K.G.s (PU-485)</strong></td>
<td></td>
</tr>
<tr>
<td>E</td>
<td>2700/2450 v.</td>
</tr>
<tr>
<td>I</td>
<td>16.0 A.</td>
</tr>
<tr>
<td>Duty cycle</td>
<td>0.9 sec. ON</td>
</tr>
<tr>
<td></td>
<td>11.1 sec. OFF</td>
</tr>
<tr>
<td><strong>2. Screen grid K.G.s (PU-519)</strong></td>
<td></td>
</tr>
<tr>
<td>E</td>
<td>875 v.</td>
</tr>
<tr>
<td>I</td>
<td>2.90 A.</td>
</tr>
<tr>
<td>Duty cycle</td>
<td>0.9 sec. ON</td>
</tr>
<tr>
<td></td>
<td>11.1 sec. OFF</td>
</tr>
<tr>
<td><strong>3. 325 volt K.G.s (PU-479)</strong></td>
<td></td>
</tr>
<tr>
<td>E</td>
<td>325 v.</td>
</tr>
<tr>
<td>I</td>
<td>3.0 A-0.9 sec.</td>
</tr>
<tr>
<td>Duty cycle</td>
<td>1.0 A-11.1 sec.</td>
</tr>
<tr>
<td><strong>4. 300/500 v. Bias supply</strong></td>
<td></td>
</tr>
<tr>
<td>E</td>
<td>300 v.</td>
</tr>
<tr>
<td>I</td>
<td>0.25 A.</td>
</tr>
<tr>
<td>Duty cycle</td>
<td>12 %</td>
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Table I
<table>
<thead>
<tr>
<th>Frequency (kHz)</th>
<th>DC Input Power (kW)</th>
<th>AC Output Power (kW)</th>
<th>Acoustic Power (kW)</th>
<th>Directivity Index (measured)</th>
<th>Directivity Index (Theor.)</th>
<th>Source Level (dB)</th>
<th>Efficiency (per cent)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.3</td>
<td>13.1</td>
<td>7.3</td>
<td>4.17</td>
<td>25.3</td>
<td>24.6</td>
<td>133.6</td>
<td>43.0</td>
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<tr>
<td>4.5</td>
<td>22.2</td>
<td>8.06</td>
<td>5.5</td>
<td>26.0</td>
<td>25.0</td>
<td>134.9</td>
<td>36.0</td>
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<tr>
<td>4.7</td>
<td>23.48</td>
<td>8.95</td>
<td>5.63</td>
<td>26.0</td>
<td>25.9</td>
<td>135.0</td>
<td>38.0</td>
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<tr>
<td>5.0</td>
<td>23.53</td>
<td>3.33</td>
<td>5.63</td>
<td>26.0</td>
<td>25.9</td>
<td>135.1</td>
<td>35.6</td>
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<tr>
<td>5.2</td>
<td>22.2</td>
<td>11.75</td>
<td>5.76</td>
<td>25.4</td>
<td>26.7</td>
<td>135.6</td>
<td>42.5</td>
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<tr>
<td>5.5</td>
<td>20.76</td>
<td>12.15</td>
<td>5.76</td>
<td>26.5</td>
<td>26.7</td>
<td>135.7</td>
<td>43.8</td>
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<td>5.7</td>
<td>18.57</td>
<td>10.18</td>
<td>5.91</td>
<td>26.9</td>
<td>27.0</td>
<td>136.5</td>
<td>54.0</td>
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</table>

Tabulated Data
SAS-23G/PAIM Transmitter
TR-197 Transducer
Mode A+B
8/8/66

E_b = 2500 volts
E_b2 = 500 volts
Drive to Trans = 0.14 vrms
TRANSducer INPUT impedance AND phase angle variation
Steve #12 V.S. Beam No.
TR-197 @ 4.5 KHz
Source level @ 134.9 db
T.C.U. in SLT 7½° Beam (Group A+B)
**Graph 4**

**Transducer Input Impedance and Phase Angle Variation**

**Stage 4.1 vs. Beam No.**
- Elements: 1 thru 8
- TR: 197 @ 0.5 kHz
- Source Level: 135.6 dB
- TCU in Slit 7½° Beam (Group A+B)

**Input Impedance Variation**

**Phase (Degrees)**

**Beam No.**

- 42, 43, 44, 45, 46, 47, 48, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11
Graph 5

TRANSDUCER INPUT IMPEDANCE AND PHASE ANGLE VARIATION
STAVE #4 VS. BEAM NO.
ELEMENTS 10 THRU 12
TR-137 @ 5.5 KHZ
SOURCE LEVEL @ 155.5 dB
T.C.U. IN 57.7° BEAM (GROUP A+B)
TRANSUDER INPUT IMPEDANCE AND PHASE ANGLE VARIATION
STATE #1 VS. FREQUENCY
MODEL: RGT (GROUP A+B)
TR-157 (RAYTHEON) ACTIVE TRANSUDER
SOURCE LEVEL: 134.9 dB @ 4.5 kHz
136.5 dB @ 5.5 kHz

TOTAL IMPEDANCE VARIATION

TOTAL PHASE ANGLE VARIATION

FREQUENCY (kHz)

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TRANSDUCER INPUT IMPEDANCE AND PHASE ANGLE VARIATION
STAGE # 4 VS. FREQUENCY
MODEL: PCT (GROUP A+B)
TR-197 (RAYTHEON) ACTIVE TRANSDUCER
SOURCE LEVEL 134.5 dB @ 4.5 KHz
136.5 dB @ 5.5 KHz

TOTAL IMPEDANCE VARIATION

TOTAL PHASE ANGLE VARIATION
CONFIDENTIAL

305-REG PAIR: TRANSMITTER PLATE DISSIPATION VS. FREQUENCY
STAGE # 1
MODEL: RD1 (GROUP A & B)
TR-127 (MATTHEW) ACTIVE TRANSISTORS
SOURCE LEVEL 154.8 dB @ 6.3 KHz
135.5 dB @ 55 kHz
(PLATE DISSIPATION INCLUDES P.A. OUTPUT NETWORK)
SOS-239/PAIR TRANSFIGGER PLATE DISSIPATION VS. FREQUENCY
STAGE #4
MODEL: RDI (GROUP A+B)
TR-197 (PANTHER) ACTIVE TRANSFIGGER
SOURCE LEVEL: 134.9 db @ 4.5 KHz
125.5 db @ 5.5 KHz
(PLATE DISSIPATION INCLUDES PA OUTPUT NETWORK)
CONFIDENTIAL

SQS-255/44R transmitter plate circuit efficiency vs. frequency.

Wave #1

Mode: RDT (GROUP A+B)

TR-197 (RAYTHEON) active transducer

Source level 134.8 dB @ 4.5 kHz

135.86 dB @ 5.5 kHz

Graph 10
CONFIDENTIAL

SQS-285/PAK TRANSMITTER PLATE CIRCUIT EFFICIENCY VS FREQUENCY
STATE # 4
MODE: PST (GROUP A + B)

TR-1ST (RAYTHEON) ACTIVE TRANSDUCER
SOURCE LEVEL 184.5 dB @ 4.5 KHz
186.5 dB @ 5.5 KHz

EFFICIENCY (PERCENT)
HARMONIC DISTORTION ANALYSIS
OF ACOUSTIC SIGNAL
TRANSUDER: TR-187
1.3 SECONDS OF C.M.
FILTER BAND WIDTH: 200 HZ
NOSE: OMAN
TRANSMISSION FREQUENCY: 7.5 KHZ

○ A+B
△ A ONLY NOCC
HARMONIC DISTORTION ANALYSIS
OF ACOUSTIC SIGNAL
TRANSUDER: TR-127
1.3 SECONDS OF CW
7° BEAM WIDTH
FILTER BAND WIDTH: 200 Hz
MODE: K097
TRANSMISSION FREQUENCY: 5.5 KHz

○ A+B
△ A ONLY XCC
HARMONIC DISTORTION ANALYSIS OF ACOUSTIC SIGNAL

TRANSDUCER: TR-197
1.3 SECONDS OF C.W.
7.5° BEAM WIDTH
FILTER BAND WIDTH: 200 Hz
MODE: RDT
TRANSMISSION FREQUENCY: 50 kHz

Graph 18.
HARMONIC DISTORTION ANALYSIS
OF ACOUSTIC SIGNAL
TRANSDUCER: TR-797
1.5 SECONDS OF C.W.
7.5° BEAM WIDTH
FILTER BAND WIDTH: 200 Hz
MODE: SL7
TRANSMISSION FREQUENCY: 5.5 KHz

- A+B
- A ONLY MCC
HARMONIC DISTORTION ANALYSIS OF ACOUSTIC SIGNAL
TRANSOUCER: TR-197
1.3 SECONDS OF C.W.
7.5 DEG BEAM WIDTH
FILTER BAND WIDTH: 200 Hz
MODE: S1T
TRANSMISSION FREQUENCY: 5.5 KHz

○ A+B
△ A ONLY MCC
HARMONIC DISTORTION ANALYSIS
OF ACUSTIC SIGNAL
TRANSODER: TR-197
1.3 SECONDS OF C.W.
FILTER BAND WIDTH: 200 HZ
MODE: OP/N
TRANSMISSION FREQUENCY: 4.5 KHZ

○ A+B
△ A ONLY NO C
HARMONIC DISTORTION ANALYSIS
OF ACOUSTIC SIGNAL
TRANSOUCER: TR-197
1/2 SECONDS OF C.W.
FILTER BAND WIDTH: 200 HZ
MODE: OPMII.
TRANSMISSION FREQUENCY: 4.5 KHZ

\[ A + B \]
\[ A \text{ ONLY MCC} \]

Graph 15
HARMONIC DISTORTION ANALYSIS
OF ACOUSTIC SIGNAL
TRANSDUCER: TR-197
1.3 SECONDS OF C.W.
7.5° BEAM WIDTH
FILTER BAND WIDTH: 200 HZ
MODE: RDT
TRANSMISSION FREQUENCY: 4.5 KHZ

• A+B
Δ A ONLY MCC
HARMONIC DISTORTION ANALYSIS
OF ACOUSTIC SIGNAL
TRANSUCER: TR-197
1.3 SECONDS OF C.W.
15° BEAM WIDTH
FILTER BAND WIDTH: 200 Hz
MODE: KDT
TRANSMISSION FREQUENCY: 4.5 kHz

A+B
HARMONIC DISTORTION ANALYSIS
OF ACOUSTIC SIGNAL
TRANSducer: TR-797
1/3 SECONDS OF C.N.
30 ± BEAM WIDTH
FILTER BAND WIDTH: 200 HZ
NOTE: SAL
TRANSMISSION FREQUENCY: 4.5 KHZ

- A+B
- A ONLY MCC
HARMONIC DISTORTION ANALYSIS
OF ACOUSTIC SIGNAL
TRANSDUCER: TR-197
1.3 SECONDS OF C.W.
7.5° BEAM WIDTH
FILTER BANDWIDTH: 200 Hz
MODE: SLT
TRANSMISSION FREQUENCY: 4.5 kHz

A+B
A ONLY M/C

Graph 13

FREQUENCY (KHz)
HARMONIC DISTORTION OF CHANNEL I
SQUEG/FM TRANSMITTER

X MEASURED ACROSS A 1/4 OHM DUMMY LOAD
○ MEASURED AT THE TRANSDUCER INPUT TERMINALS
TRANSMISSION FREQUENCY: 5.5 KHz
E_{11b} = 2.52 kVDC
E_{9b} = 330 VDC
DRIVE LEVEL @ 0.14 VRMS
CLIPPING LEVEL: ±50V, ±300V
HARMONIC DISTORTION OF CHANNEL I
SQU-W300/W6K TRANSMITTER

X: MEASURED ACROSS A 16.0 OHM DUMMY LOAD
O: MEASURED AT THE TRANSOBER INPUT TERMINALS
TRANSMISSION FREQUENCY: 4.5 KHZ

E_{in} = 2.52 VDC
E_{out} = 330 VDC
DRIVE LEVEL @ 0.14 WMS
CLIPPING LEVEL: +30V, -30V
Transducer input impedance and phase angle variation
State #1 vs operating depth
TR: 157 @ 4.5 kHz
Source level @ 134.9 dB
TCD in SLT 7 1/2 beam (GROUP A & B)
Depth is to top of transducer
CONFIDENTIAL

TOTAL IMPEDANCE VARIATION

TRANSDUCER: INPUT IMPEDANCE AND PHASE ANGLE VARIATION
STAVE # A VS. OPERATING DEPTH
TR-157 @ 4.5 KHz
SOURCE LEVEL 134.5 dB @ 20 FT DEPTH
T.C.A. IN SLT-7 3/8 BEAM (GROUP A+B)
DEPTH IS TO TOP OF TRANSDUCER

TOTAL PHASE ANGLE VARIATION
Transducer input impedance and phase angle variation
Stage #1 vs. operating depth
TR-127 @ 5.5 kHz
Source level 124.5 dB @ 20 ft depth
T.C.H. in slt 7/8° beam (group A & B)
Depth is to top of transducer

Graph 22
SOS-15G/PAIR TRANSMITTER PLATE DISSIPATION VS.
TR-197 RAYTHEON TRANSDUCER OPERATING DEPTH
FREQUENCY: 4.5 KHz, STAGE I, CHANNEL 1 O
SOURCE LEVEL 124.9 db @ 20 ft. DEPTH, CHANNEL 2 X
DEPTH IS TO TOP OF TRANSDUCER
T.C.U. IN SLT 7° BEAM (GROUP A-E)
(PLATE DISSIPATION INCLUDES R.A. OUTPUT NETWORK)
SQS-233/PAIR TRANSVERSE PLATE DISSIPATION VS.
TR-197 RAYTHEON TRANSDUCER OPERATING DEPTH
FREQUENCY: 4.5 KHZ, STAVE 4, CHANNEL 4, O
SOURCE LEVEL: 134.9 dB @ 20 FT.
DEPTH: CH 25 X
DEPTH IS TO TOP OF TRANSDUCER.
ACO IN SLT 7/2° BEAM (GROUP A+B)
(PLATE DISSIPATION INCLUDES ALL OUTPUT NETWORK)

Graph 25
SQS-235/PAIR TRANSMITTER PLATE DISSIPATION VS.
TR-19T. RAITHON TRANSDUCER OPERATING DEPTH
FREQUENCY: 6.5 KHZ
STAGE 1: CHANNEL 10
SOURCE LEVEL 135.8 dB @ 20 FT DEPTH
CHANNEL 25 X
DEPTH IS TO TOP OF TRANSDUCER.
T.C.D. IN SLT 7 1/2 DEG (GROUP A & B)
PLATE DISSIPATION INCLUDES PA OUTPUT NETWORK

Graph 26
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SSE-225/PAIR TRANSMITTER PLATE DISSIPATION VS.
TH-157 RAYTHEON TRANSUDER OPERATING DEPTH
FREQUENCY: 5.5 KHZ  STAGE 4   CHANNEL 3  X
SOURCE LEVEL 155.5 DB @ 20 FT. DEPTH   CHANNEL 23 X
DEPTH: IS TO TOP OF TRANSUDER
T.G.U. IN SLT. 7/4 DEGREE (GROUP A-B)
(PLATE DISSIPATION INCLUDES PA. OUTPUT NETWORK)
SQS-22G PAIR TRANSMITTER PLATE CIRCUIT EFFICIENCY VS.
TR-137 RAYTHEON TRANSDUCER OPERATING DEPTH.
FREQUENCY: 4.5 KHE STAB I CHANNEL 1 0
SOURCE LEVEL 134.3 dB @ 20FT. DEPTH CHANNEL 25 X
DEPTH IS TO TOP OF TRANSDUCER.
T.C.U. IN SLT 7 1/2° BEAM (GROUP A & E)
SQS-236 PAIR TRANSMITTER PLATE CIRCUIT EFFICIENCY VS.
TR-137 RAYTHEON TRANSMITTER OPERATING DEPTH
FREQUENCY 4.5 KHZ STAGE 4 CHANNEL 4 O
SOURCE LEVEL 134.9 db @20FT DEPTH CHANNEL 28 X
DEPTH IS TO TOP OF TRANSDUCER
T.C.U. IN SLT 7% BEAM (GROUP A+I)

Graph 29.
SQS-235/FMAR TRANSMITTER FLATE CIRCUIT EFFICIENCY VS.
TR-197 RAYTHEON TRANSDUCER OPERATING DEPTH
FREQUENCY: 5.5 KHz; STAVE 1, CHANNEL 1, O
SOURCE LEVEL 125, 6.46 @ 20 FT. DEPTH CHANNEL 25, X
DEPTH IS TO TOP OF TRANSDUCER.
T.C.U. IN SLT 71/2° BEAM (GROUP A+B)
CONFFENTIAL

SGS-225/PHA Transmitter Plate Circuit Efficiency vs.
TR-107 Raytheon Transducer Operating Depth
Frequency: 5.5 KHz. Stave 4. Channel 4.0
Source Level 1955 dB @ 20ft. Depth
Channel 28 X
Depth is to Top of Transducer
T.C.U. III SlT: 7½° Beam (Group A + B)

Graph 31
DIRECTIVITY PATTERN

TR 197 - Transducer
SLT 3.5 Khz Meled 118
BW 30°
DIRECTIVITY PATTERN

U.S. NAVY ELECTRONICS LABORATORY
TRANSUDER CALIBRATION FACILITY
SAN DIEGO, CALIFORNIA 92152