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EVALUATION STUDIES OF TELEMETRY SYSTEM COMPONENTS

by
Richard H. Marks

Northeastern University
Electronics Research Laboratory
Boston, Massachusetts 02115

SCIENTIFIC REPORT NO. 1

11 January 1977

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Prepared for

Air Force Geophysics Laboratory
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Hanscom AFB, Massachusetts 01731

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number) This report contains the results of a program for the evaluation of commercial airborne telemetry system equipment. A number of RF telemetry transmitters were tested. The test procedures and results are given for all the equipment evaluated.			

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<u>Manufacturer</u>	<u>Type</u>	<u>Serial No.</u>	<u>Freq. (MHz)</u>	
Conic	CTB-200-0.5H	200B277	242.0	13
Conic	CTB-200-0.5H	200B279	242.0	16
Conic	CTB-200-0.5H	200B280	242.0	18
Conic	CTP-402	402P192	234.0	20
Vector	T105S	1959	2279.5	24
Vector	T105S	1960	2279.5	28
Vector	T105S	2037	2215.5	31
Vector	T105S	2039	2215.5	34
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INTRODUCTION

A comparative evaluation of commercial telemetry equipment is being conducted under contract from Air Force Geophysics Laboratory, Bedford, Massachusetts (contract F19628-76-C-0111) from 13 February 1976 through the present. During the span of this contract, major manufacturers of certain categories of airborne system components are asked to submit their products on consignment. In each instance the electrical characteristics are measured and compared against the manufacturer's published specifications. The results of these tests are classified as proprietary information and made available to AFGL and the individual manufacturers concerned. Complete results of all components tested during the period 13 February 1976 through 11 January 1977 are included in this report.

This evaluation program was initiated in April 1958 (under contract AF19(604)-3506) as a means of insuring the receipt of working units. Since that time, the program has expanded to the point where all manufacturers are invited to participate. RF Transmitters and Subcarrier Oscillators are the two main categories of components tested to date. The first section of this report details the test performed, equipment used and the procedures followed. The second section contains a tabulation of the equipment tested and the resulting data.

RF Telemetry Transmitters

A. Evaluation Test Procedure for RF Telemetry Transmitter

Test I. Time Drift

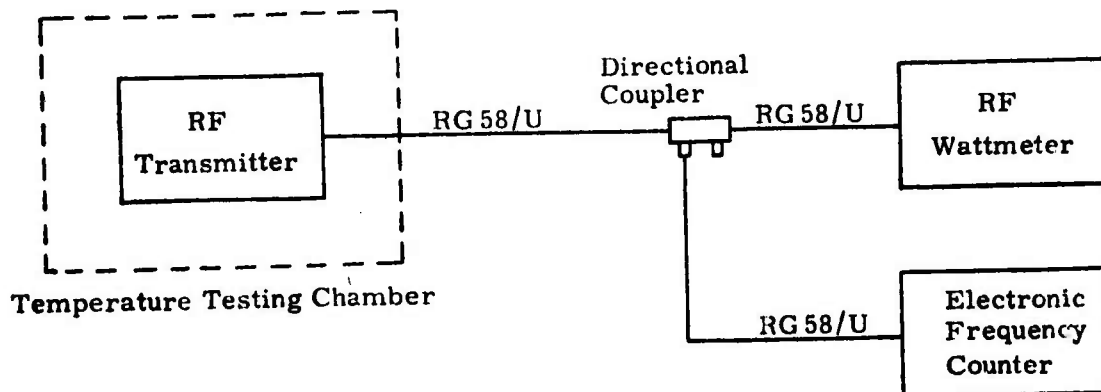


FIGURE 1.

Step 1. Place the RF Transmitter inside the temperature testing chamber. Set the temperature at $+30^{\circ}\text{C}$. Wire test equipment as shown in Figure 1. Ground the modulation input terminal. Use recommended B+ Supply voltage. Without allowing a warm-up period, turn on the supply voltage. Measure the output frequency and output power at the time intervals shown on Transmitter Data Sheet 1. Record the following observations on Data Sheet 1:

- (a) Time of observation;
- (b) Output frequency in MHz;
- (c) Output power in watts.

Step 2. Results

- (a) Plot the Frequency Drift in % of Carrier Frequency, f_c , versus Time on Graph Sheet 1;
- (b) Plot the Output Power versus Time on Graph Sheet 1.

Evaluation Tests - Data Sheet 1
RF Telemetry Transmitter

Make: _____ ; Type: _____ ; Serial Number: _____ ;
Carrier Frequency (c): _____ MHz ; Date: _____ ; By: _____ ;

I. Time Drift

Time Minutes	Output Frequency Mhz	Drift in % of Carrier Frequency	Output Power Watts
0			
1			
2			
3			
4			
5			
10			
15			
20			
25			
30			
40			
50			
60			
70			
80			
90			
100			
110			
120			

II. Temperature Stability

Temperature °C	Output Frequency Mhz	Shift in % of Carrier Frequency	Output Power Watts	Input Current	Incide- ntal FM

III. B+ Voltage Regulation

B+ Voltage Variation %	Output Frequency Mhz	Shift in % of Carrier Frequency	Output Power Watts
+10			
+5			
0			
-5			
-10			

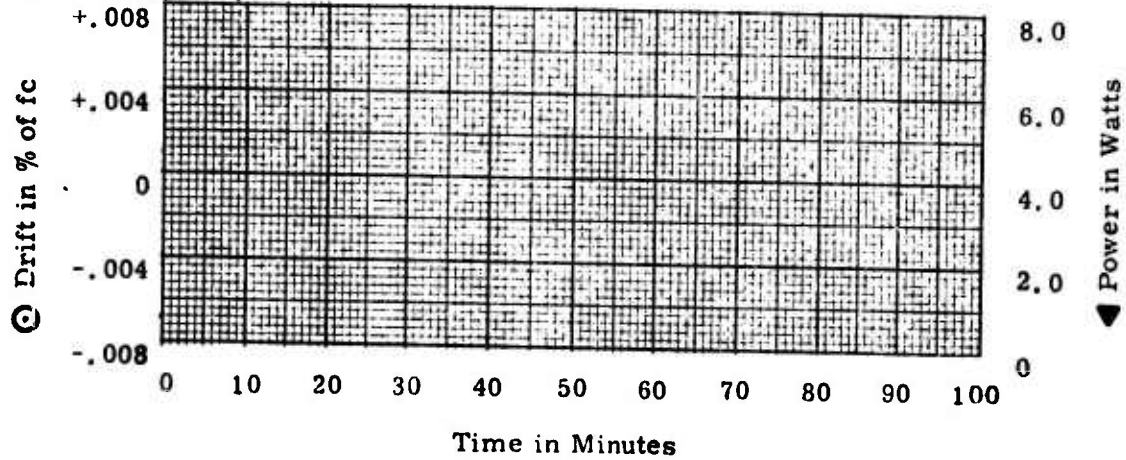
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Evaluation Tests - RF Telemetry Transmitter - Sheet 1

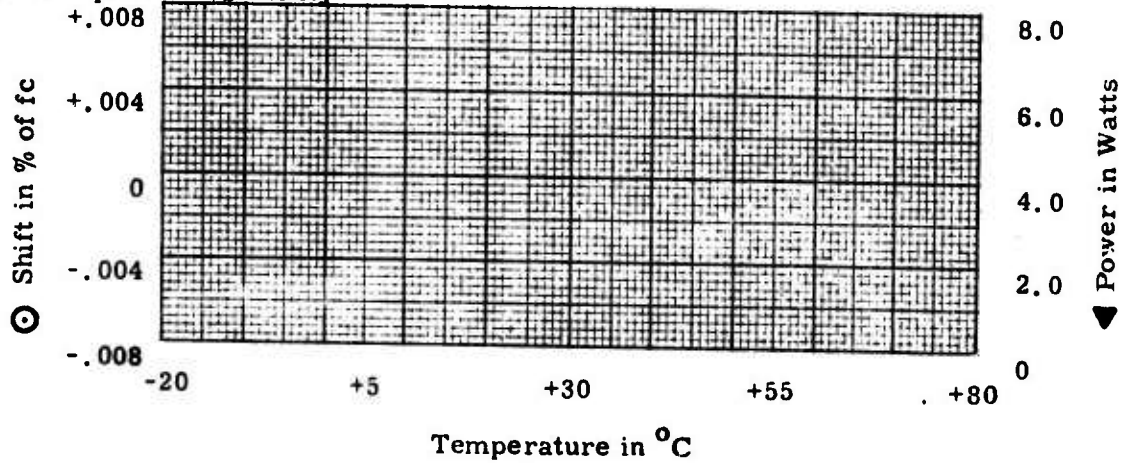
Make: _____; Type: _____; Serial Number: _____;

Carrier Frequency f_c : _____ MHz; Date: _____; By: _____;

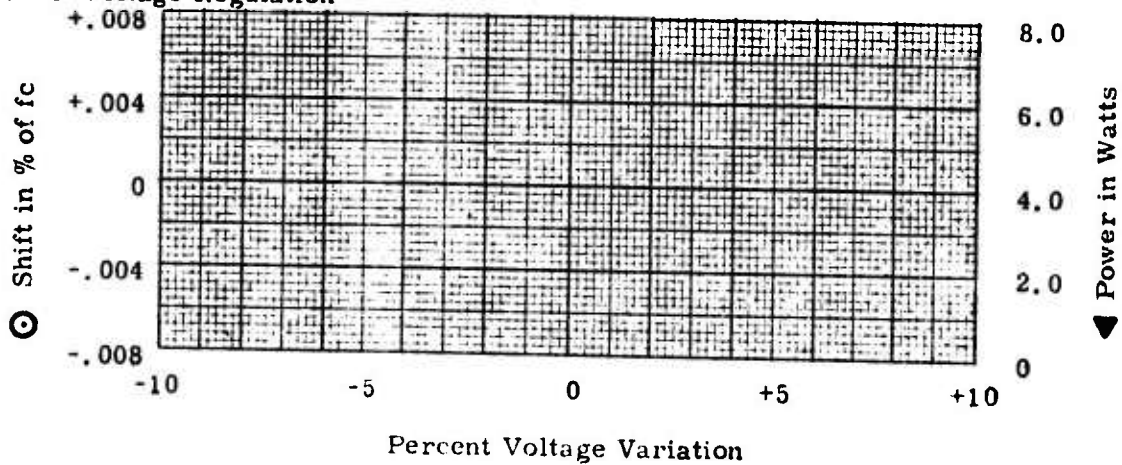
I. Time Drift



II. Temperature Stability



III. B⁺ Voltage Regulation



Test II. Temperature Stability Tests

- Step 1. With the temperature testing chamber set at $+30^{\circ}\text{C}$, wire test equipment as shown in Figure 1. Using recommended B+ supply voltage, allow a sufficient warm-up period before proceeding to Step 2.
- Step 2. Ground the modulation input terminal of the transmitter. Measure the output power and the carrier frequency. Record the following observations on Data Sheet 1:
- (a) Temperature in $^{\circ}\text{C}$;
 - (b) Output power in watts;
 - (c) Output frequency in MHz;
 - (d) Input current in amps;
 - (e) Incidental FM in Hz.
- Step 3. Repeat Steps 1 and 2 for the following temperatures: -20°C , $+5^{\circ}\text{C}$, 55°C and 80°C .
- Step 4. Calculate the frequency shift in % of fc. Plot the % frequency shift versus temperature on Graph Sheet 1. Also plot the output power versus temperature on Graph Sheet 1.

Test III. Voltage Regulation

- Step 1. Use equipment set up shown in Figure 1. With the temperature of the chamber set at 30°C , vary the B+ supply voltage from -10% to $+10\%$. Record and compute the following on Data Sheet 1.
- (a) B+ supply in % of recommended value;
 - (b) Frequency shift in % of fc;
 - (c) Output power in watts.
- Step 2. Results
Plot the % frequency shift and output power versus B+ supply variations on Graph Sheet 1.

Tests IV and V. Modulation Response and Linearity Tests

- Step 1. With the temperature testing chamber set at $+30^{\circ}\text{C}$, wire the test equipment as shown in Figure 2. Using recommended B+ supply voltage, allow a sufficient warm-up period before proceeding to Step 2.
- Step 2. Set the audio oscillator at each of the modulating frequencies indicated in Data Sheet 2A. Adjust the output level of the oscillator for the nominal deviation (E_4). Repeat for 25%, 50%, 75% and 125% of nominal deviation. Record the following observations on Data Sheet 2A.
- (a) Oven temperature in $^{\circ}\text{C}$;
 - (b) Modulating voltages E_1 , E_2 , E_3 , E_4 , E_5 ;
 - (c) Frequency deviation in KHz;
 - (d) Distortion.
- Step 3. Repeat Steps 1 and 2 using modulating voltage E_4 , for the following temperatures; -20°C , $+5^{\circ}\text{C}$, 55°C and 80°C and record on Data Sheet 2.

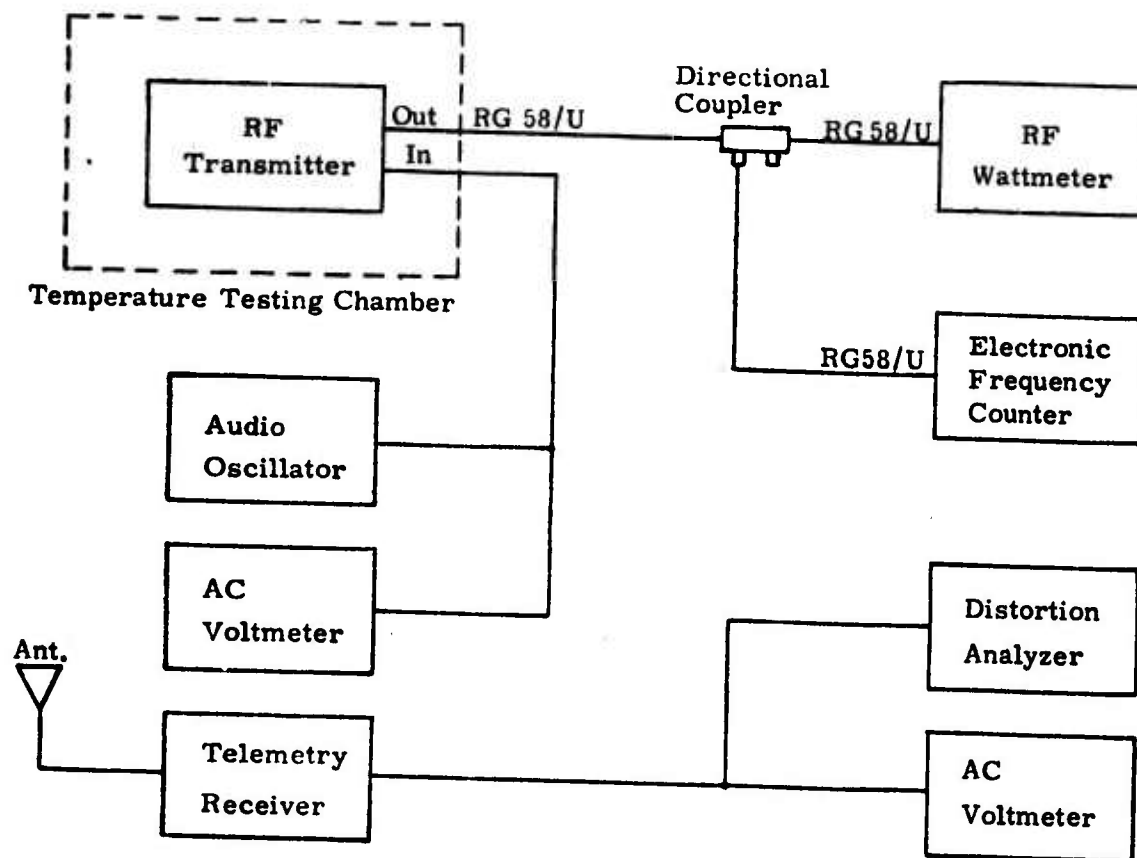


FIGURE 2

Evaluation Tests - Data Sheet
RF Telemetry Transmitter

Make: _____; Type: _____; Serial No: _____;
Carrier Frequency fc: _____; Mhz Date: _____; By: _____;

II MODULATION RESPONSE VS TEMPERATURE

T = _____ °c; Modulation Voltage = _____ Volts

Modulating Frequency fm Khz	Deviation Δf_c in Khz	DB = 20 Log $\frac{\Delta f_c}{\Delta f_{co}}$		Distortion
		$\Delta f_c / \Delta f_{co}$	DB	
.4				
.6				
.8				
1				
2				
4				
6				
8				
10				
20				
40				
60				
80				
100				
200				
300				
400				
500				

$$\Delta f_{co} = \sqrt{\Delta f_{c \text{ Min}} \times \Delta f_{c \text{ Max}}}$$

Evaluation Tests - Data Sheet 2A
RF Telemetry Transmitter

Make: _____; Type: _____; Serial No: _____;
Carrier Frequency f_c : _____; Mhz Date: _____; By: _____;

LINEARITY VS FREQUENCY
T = AMBIENT

Modulating Frequency fm Khz	Deviation Δf_c in Khz					Distortion
	E1	E2	E3	E4	E5	
.4						
.6						
.8						
1						
2						
4						
6						
8						
10						
20						
40						
60						
80						
100						
200						
300						
400						
500						

Step 4. Calculations and Results

- (a) Linearity at Ambient - Plot deviation versus modulating frequency for the five modulating voltages on Graph Sheet 2.
- (b) Modulation Response - Calculate the modulation response in db using information from Data Sheet 2. Plot modulation response versus modulating frequency for the five different temperatures on Graph Sheet 2.

Test VI. Spurious Emission (Antenna Conducted)

- Step 1.** Tune the band elimination filter for maximum attenuation at the carrier frequency of the transmitter under test. The amount of attenuation should be such that the transmitter rf output is attenuated to -40dbm. Make a frequency response of the filter and spectrum analyzer and plot the response curve.

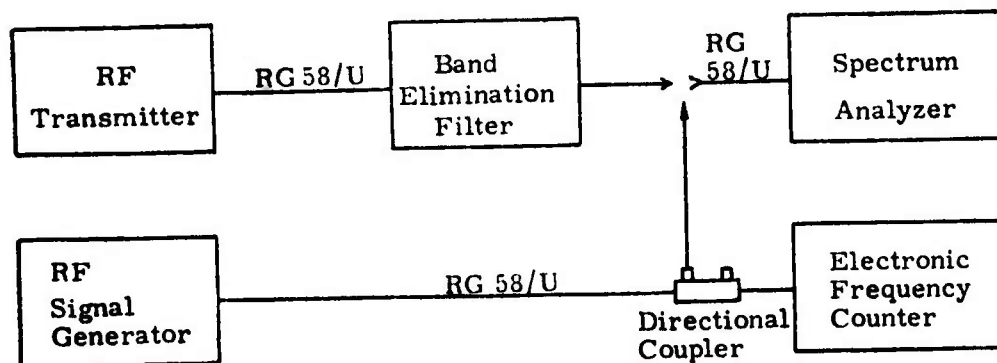


FIGURE 3.

- Step 2.** Use equipment set-up shown in Figure 3. Identify and measure the spurious frequencies present using the spectrum analyzer. The frequency may be measured accurately by comparison with a known frequency from the signal generator.
- Step 3.** Use the frequency response obtained in Step 1 to make appropriate amplitude corrections. Record the frequencies and amplitudes of the spurious emissions on Result Sheet 3.

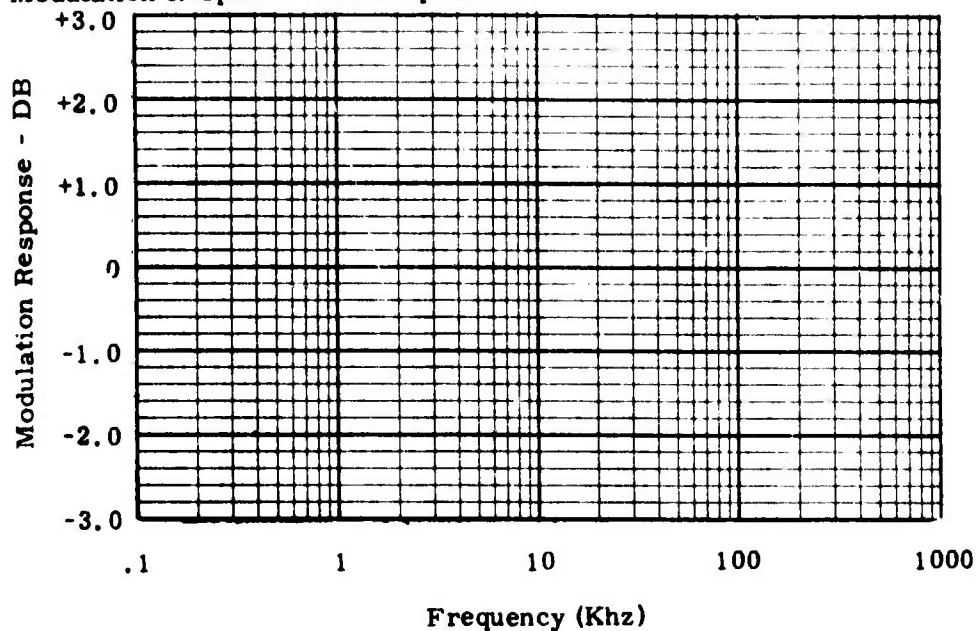
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Evaluation Tests - RF Telemetry Transmitter - Sheet 2

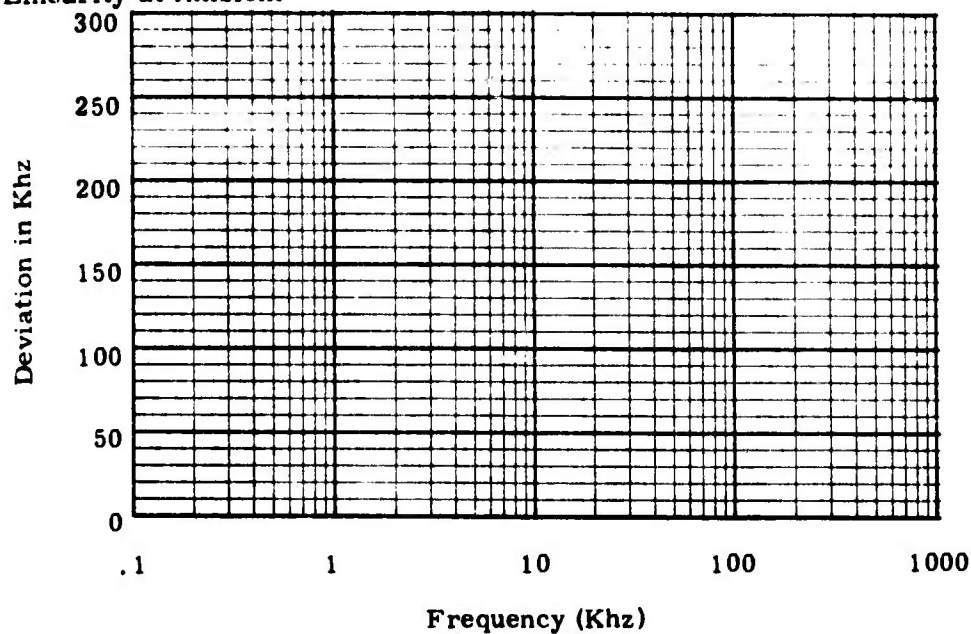
Make: _____; Type: _____; Serial Number: _____;

Carrier Frequency f_c : _____ MHz; Date: _____; By: _____;

IV. Modulation Response vs. Temperature



V. Linearity at Ambient



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Evaluation Tests - RF Telemetry Transmitter - Sheet 3

Make: _____; Type: _____; Serial Number: _____
 Carrier Frequency f_c : _____ MHz; Date: _____; By: _____

VI. Spurious Emission (Antenna Conducted)

Frequency Mhz	DB Down from f_c	Identification

NOTE: W.S.M.R. Regulation No. 105-2-60 requirement is $55 + 10 \log P_t$ DB Down from carrier.

VII. Miscellaneous

1. Maximum Distortion _____
2. Incidental FM _____
3. Power Requirement _____
4. Efficiency _____
5. O.C. & S.C. Protection _____
6. Other Checks _____

Test VII. Miscellaneous

- Step 1. Record maximum distortion from Data Sheet 2.
- Step 2. Record maximum incidental FM from Data Sheet 1.
- Step 3. Compute power requirements and efficiency from information on Data Sheet 1.
- Step 4. Perform open circuit and short circuit tests and record if the transmitter is within the manufacturer's specifications.

B. Test Results for RF Transmitters

Table 1 contains information regarding the manufacture, type and number of transmitters tested during the period of 13 February 1976 to 11 January 1977. The remainder of this chapter contains the test results for each transmitter in the order listed in the table.

Table 1

<u>Manufacturer</u>	<u>Type</u>	<u>Number Tested</u>
Conic	CTB-200-0.5H	3
Conic	CTP-402	1
Vector	T105S	4
Vector	T110 TVS	1
Vector	T202S	1

Evaluation Tests - Proprietary Information Sheet

RF Telemetry Transmitters

Make: Conic;

Type: CTB-200 Series;

Manufacturer's Specifications

<u>Frequency Range</u>	Crystal Controlled (single frequency), VHF Telemetry Band 215-260 mc (other frequencies available on special order).
<u>Center Frequency Stability</u>	0.01% under environmental operating conditions.
<u>Power Output</u>	Choice of 0.5, 1.5 or 5 watts nominal - Terminated into 50 ohms resistive with 28 VDC supply.
<u>Power Requirements</u>	28 VDC at 1.0 amperes maximum. Can be operated at voltages from 24-30 VDC.
<u>Radio Frequency Interference</u>	Satisfies the requirements of IRIG 106-66 for antenna conducted and radiated and MIL-I-26600 for box and power line conducted and radiated.
<u>Construction</u>	Modular printed circuit construction. Boxes and cover are cast with integral shielding provided by the casting.
<u>Environmental</u>	Temperature range: -30°C to $+80^{\circ}\text{C}$. Shock: Each axis, 100 G for 11 milliseconds duration. Pressure: Tested to 250,000 ft. Vibration: Each axis, 20 G peak from 20 cps to 2000 cps. Length 3.6 inches - Width 1.8 inches - Height 1.3 inches. Less than 6 ounces.
<u>Case Size</u>	Length 3.6 inches - Width 1.8 inches - Height 1.3 inches.
<u>Weight</u>	Less than 6 ounces.

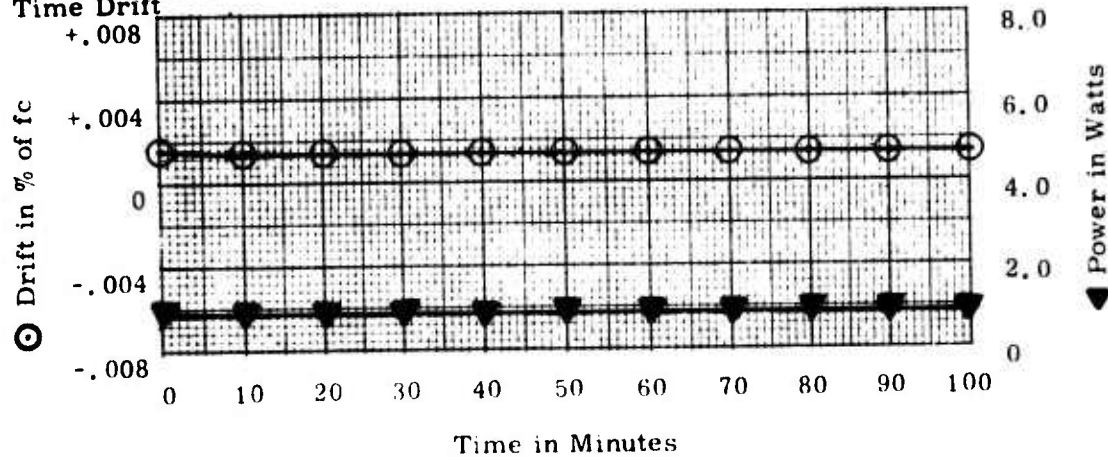
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Evaluation Tests - RF Telemetry Transmitter - Sheet 1

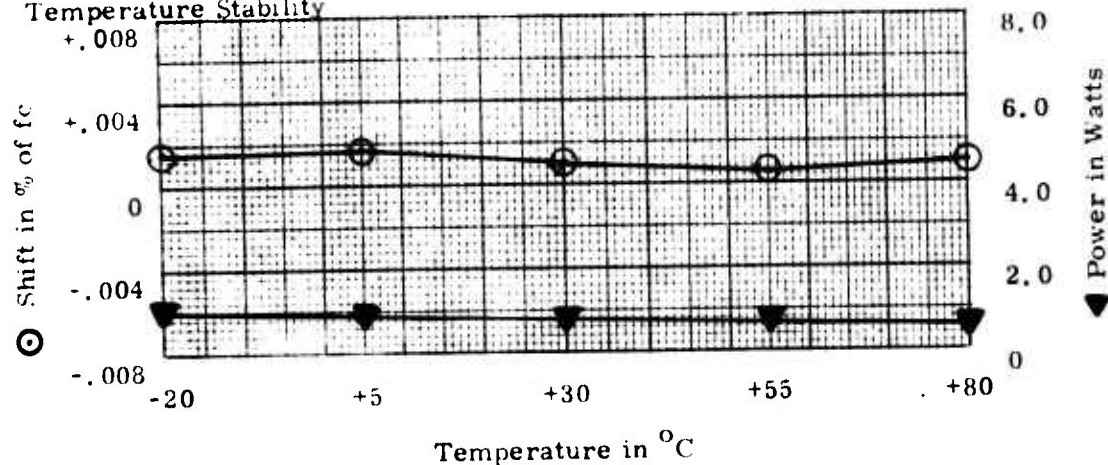
Make: CONIC ; Type: CTB-200-0.5H ; Serial Number: 200B277 ;

Carrier Frequency f_c : 242.0 MHz; Date: 6/28/76 ; By: KYL ;

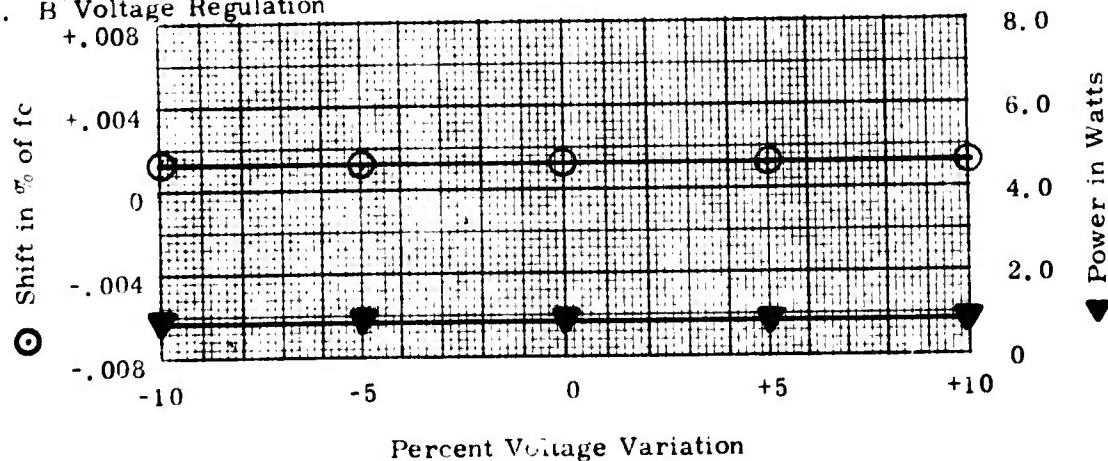
I. Time Drift



II. Temperature Stability



III. B⁺ Voltage Regulation



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Evaluation Tests RF Telemetry Transmitter - Sheet 3

Make Conic Type CTB-200-0.5H Serial Number 200 B 277
 Carrier Frequency fc 242.0 MHz Date 6/8/76 By K.Y.L.

VI. Spurious Emission (Antenna Conducted)

Frequency Mhz	DB Down from fc	Identification
50	84 ± 3	$fc - 4fx$
121	109 ± 3	$1/2fc$
242.0	0	carrier frequency
774	90 ± 3	$3fc + fc$

NOTE: W.S.M.R. Regulation No. 105-2-60 requirement is $55 + 10 \log P_t$ DB Down from carrier.

VII. Miscellaneous

1. Maximum Distortion N/A
2. Incidental FM N/A
3. Power Requirement 5.35 watts
4. Efficiency 18.0%
5. O.C. & S.C. Protection OK
6. Other Checks No carrier shift with 5:1 V.S.W.R.
Reverse polarity OK

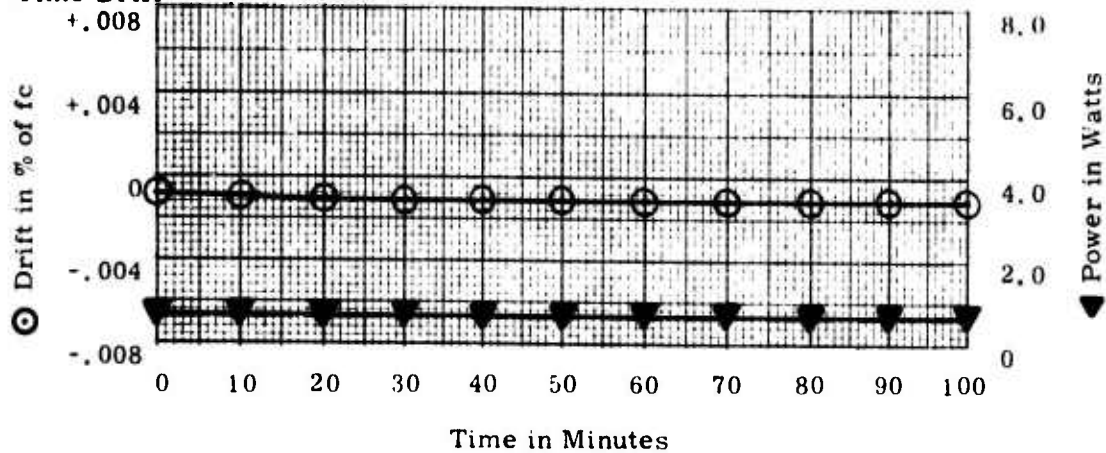
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Evaluation Tests - RF Telemetry Transmitter - Sheet 1

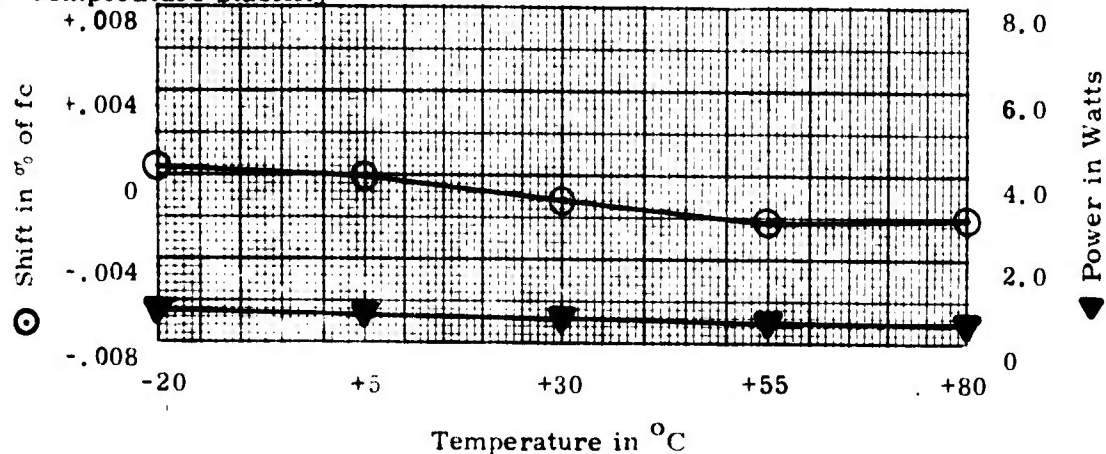
Make: **CONIC** ; Type: **CTB-200-0.5H** ; Serial Number: **200B279** ;

Carrier Frequency f_c : **242.0** MHz, Date **6/30/76** ; By: **KYL** ;

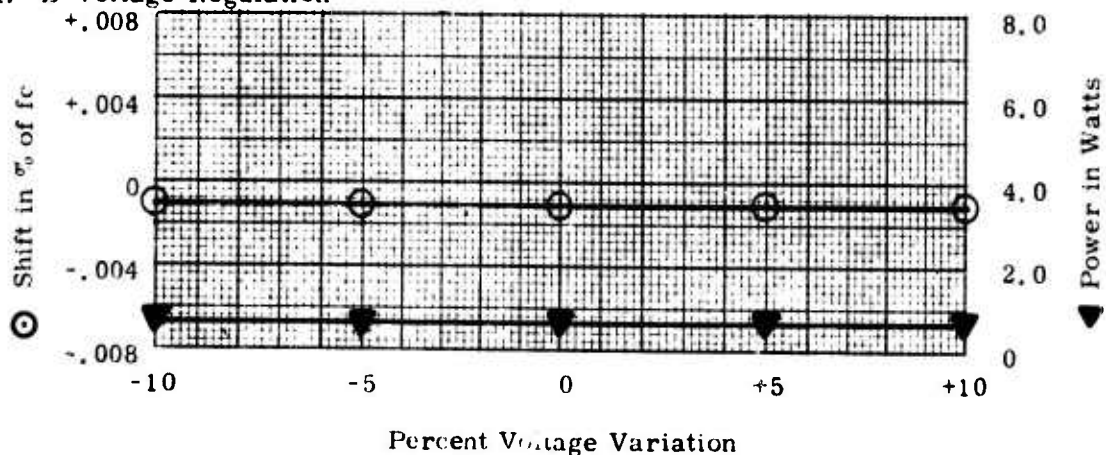
I. Time Drift



II. Temperature Stability



III. B⁺ Voltage Regulation



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Evaluation Tests - RF Telemetry Transmitter - Sheet 3

Make: Conic, Type: CTB-200-0.5H, Serial Number: 200 B 279
 Carrier Frequency f_c : 242.0 MHz; Date: 6/30/76; By: K.Y.L.

VI. Spurious Emission (Antenna Conducted)

Frequency Mhz	DB Down from f_c	Identification
82	72 ± 3	$f_c - 8f_x$
121	117 ± 3	$1/2f_c$
162	82 ± 3	$f_c - 4f_x$
242.0	0	carrier frequency
262	80 ± 3	$f_c + f_x$
462	72 ± 3	$f_c + 11f_x$
484	112 ± 3	$2f_c$
524	98 ± 3	$2f_c + 2f_x$
544	72 ± 3	$2f_c + 3f_x$

NOTE: W. S. M. R. Regulation No. 105-2-60 requirement is $55 + 10 \log P_t$ DB Down from carrier.

VII. Miscellaneous

1. Maximum Distortion N/A
2. Incidental FM N/A
3. Power Requirement 4.51 watts
4. Efficiency 16%
5. O.C. & S.C. Protection OK
6. Other Checks No carrier shift with V.S.W.R.
Reverse polarity OK

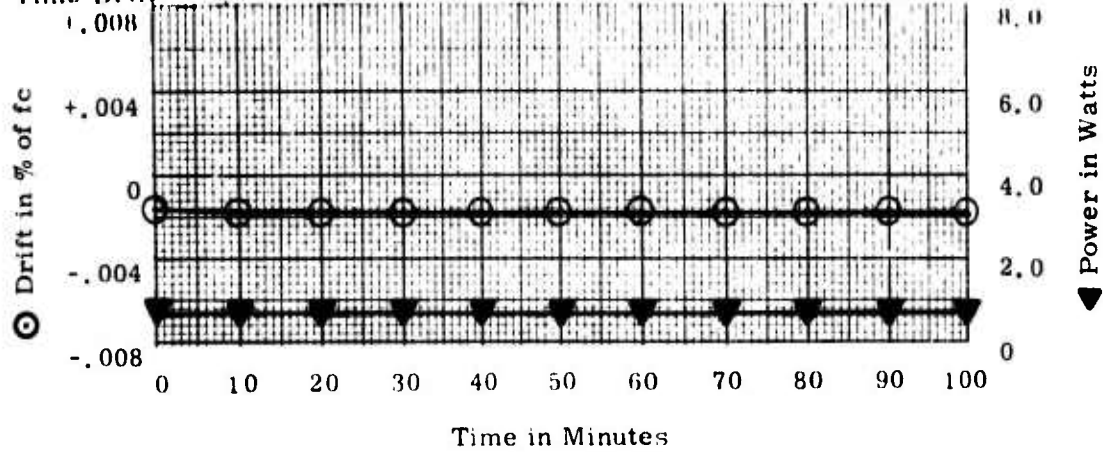
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Evaluation Tests - RF Telemetry Transmitter - Sheet 1

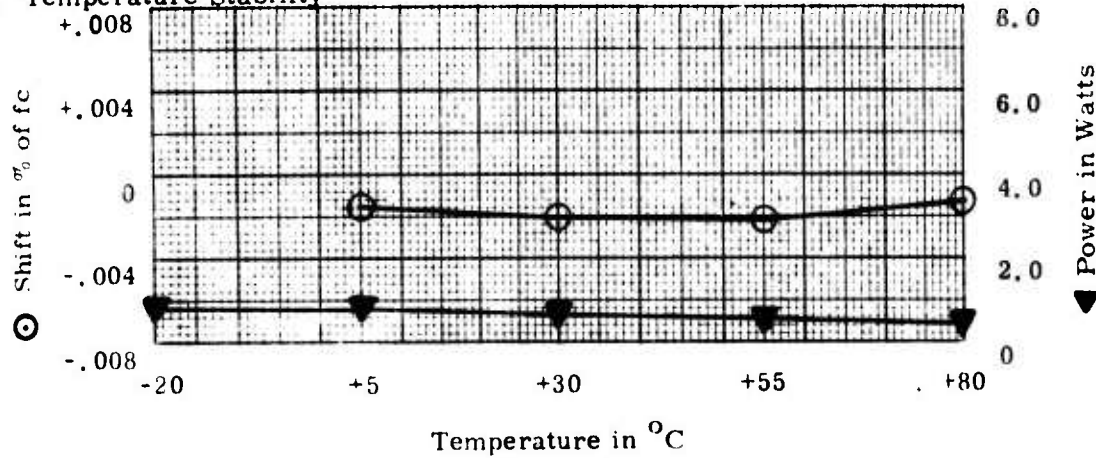
Make: **CONIC** Type: **CTB-200-0.5H** Serial Number: **200B280**

Carrier Frequency f_c : **242.0** MHz Date: **6/29/76** By: **KYL**

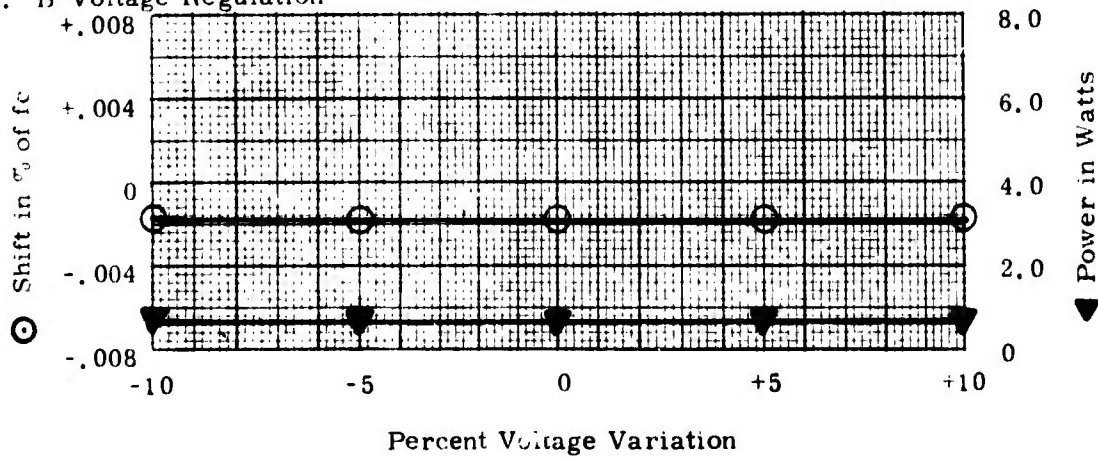
I. Time Drift



II. Temperature Stability



III. B^+ Voltage Regulation



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Evaluation Tests RF Telemetry Transmitter - Sheet 3

Make Conic Type: CTB-200-0.5H Serial Number: 200 B 280
 Carrier Frequency f_c : 242.0 MHz Date: 6/29/76 By: K.Y.L.

VI. Spurious Emission (Antenna Conducted)

Frequency Mhz	DB Down from f_c	Identification
All spurious	emmissions meet	Specif ications

NOTE: W.S.M.R. Regulation No. 105-2-60 requirement is $55+10\log P_t$ DB Down from carrier.

VII. Miscellaneous

1. Maximum Distortion N/A
2. Incidental FM N/A
3. Power Requirement 4.96 watts
4. Efficiency 15%
5. O.C. & S.C. Protection OK
6. Other Checks No carrier shift with 5:1 V.S.W.R.
Reverse polarity OK

Evaluation Tests - Proprietary Information Sheet

RF Telemetry Transmitters

Make: Conic;

Type: CTP - 402;

Manufacturer's Specifications

Frequency Range

Crystal Controlled (single frequency) VHF Telemetry
Band 225 - 260 MHz.

Center Frequency Stability

0.01% under environmental operating conditions.

Power Output

2 watts minimum - terminated into 50 ohms with 28 ± 4
Vdc supply over specified temperature range.

Carrier Deviation

± 250 kHz

Modulation Characteristics

Type

FM

Deviation Sensitivity

up to ± 150 kHz/volt p-p (factory set)

Input Impedance

10 K ohms resistive minimum, shunted by 30 pf

Frequency Response

± 1.5 dB from 10 Hz to 500 kHz

Power Requirements

28 ± 4 Vdc at 450 milliamperes maximum

Radio Frequency Interference

Satisfies the requirements of IRIG 106-69 for antenna
conducted and radiated and MIL - I - 26600 for box
power line conducted and radiated.

Temperature

- 30°C to +80°C, MIL-STD-810 as follows:
Low Temperature, Method 502
High Temperature, Method 501
Temperature Shock, Method 503

Humidity

MIL-STD-810, Method 507

Acceleration

100 g's in each direction of any three mutual perpen-
dicular axes.

Shock

100 g's 11 millisecond duration (half sine pulse) in
each direction of any three mutually perpendicular axes.

Vibration

20 G peak sine (20-2000 Hz) or $.3 G^2$ /cps random in any
axis.

Weight

Less than 12 ounces.

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Evaluation Tests - RF Telemetry Transmitter - Sheet 3

Make: Conic Type: CTB-200-0.5H Serial Number: 200 B 280
 Carrier Frequency fc: 242.0 MHz Date: 6/29/76 By: K.Y.L.

VI. Spurious Emission (Antenna Conducted)

Frequency Mhz	DB Down from fc	Identification
All spurious	emmissions meet	Specif ications

NOTE: W.S.M.R. Regulation No. 105-2-60 requirement is $55+10 \log P_t$ DB Down from carrier.

VII. Miscellaneous

1. Maximum Distortion N/A
2. Incidental FM N/A
3. Power Requirement 4.96 watts
4. Efficiency 15%
5. O.C. & S.C. Protection OK
6. Other Checks No carrier shift with 5:1 V.S.W.R.
Reverse polarity OK

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Evaluation Tests

RF Telemetry Transmitter

Sheet 1

Make: Conic

Type: CTP 402

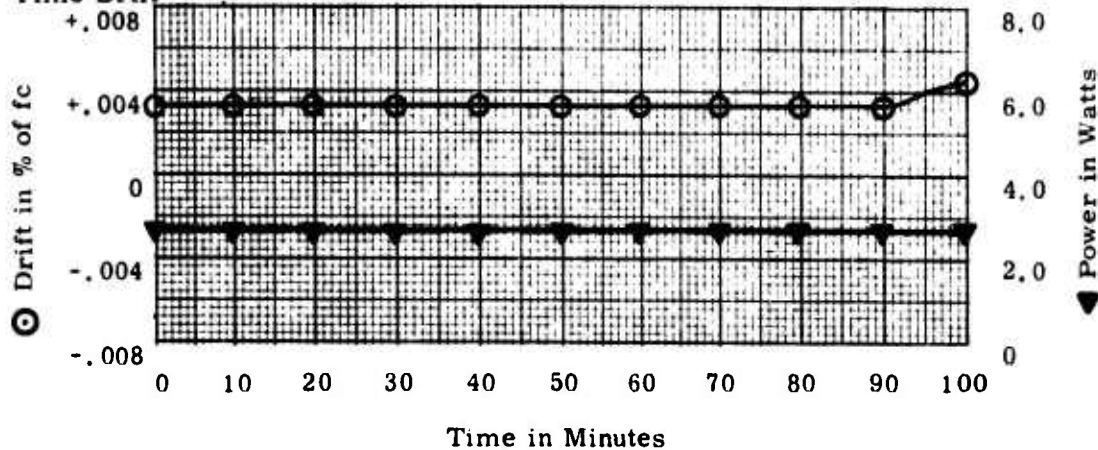
Serial Number: 402 P 192

Carrier Frequency f_c : 234.0MHz

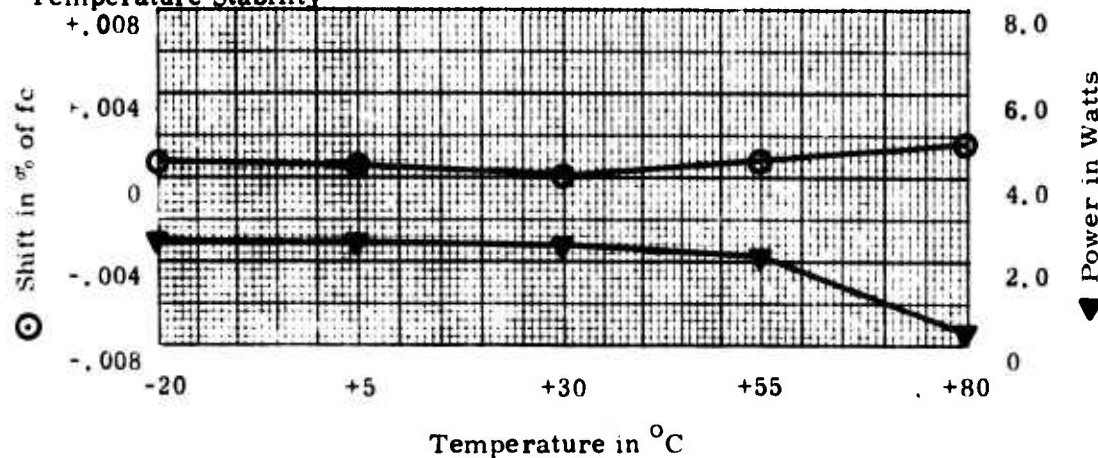
Date: 8/4/76

By: K.Y.L.

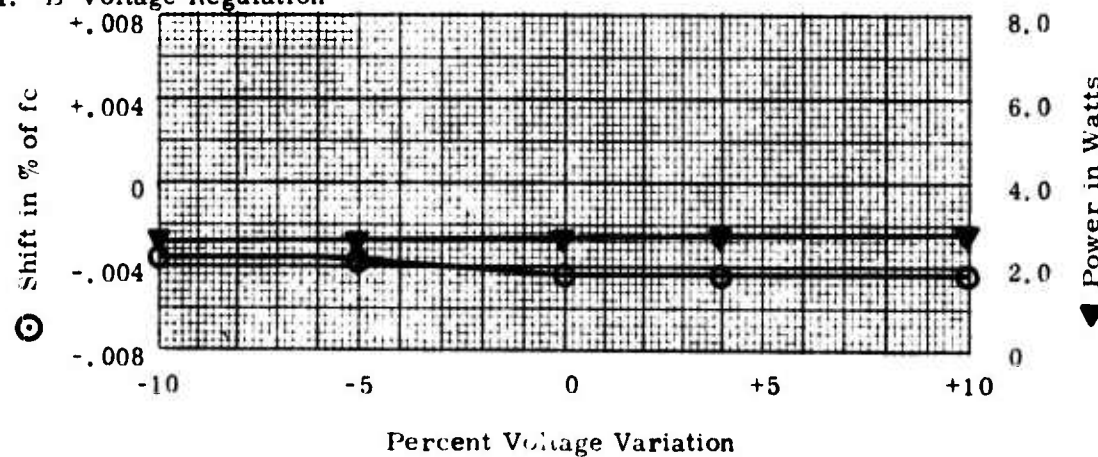
I. Time Drift



II. Temperature Stability



III. Voltage Regulation

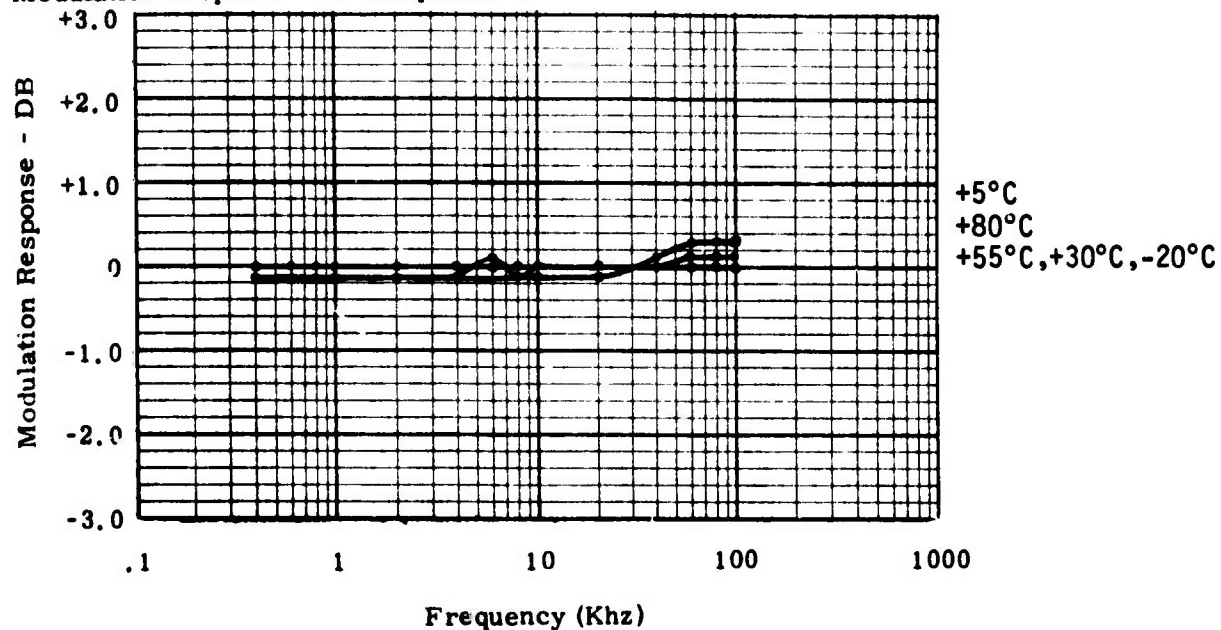


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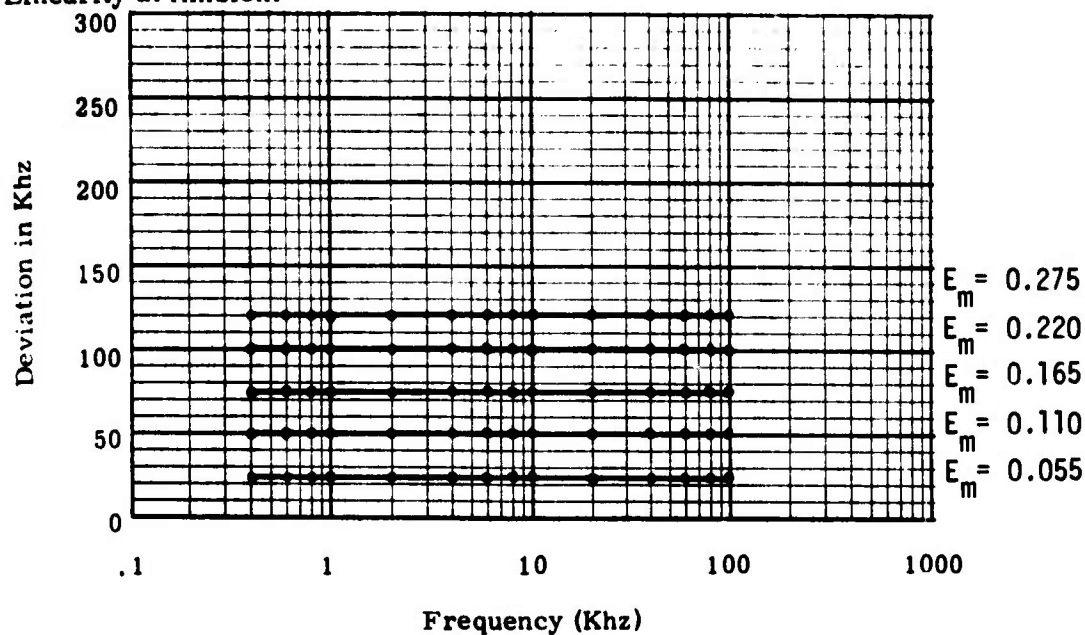
Evaluation Tests - RF Telemetry Transmitter - Sheet 2

Make: Conic ; Type: CTP 402 ; Serial Number: 402 P 192 ;
 Carrier Frequency f_c : 234.0 MHz; Date: 8/4/76 ; By: K.Y.L. ;

IV. Modulation Response vs. Temperature



V. Linearity at Ambient



NORTHEASTERN UNIVERSITY

Evaluation Tests - RF Telemetry Transmitter - Sheet 3

Make: Conic; Type: CTP 402; Serial Number: 402 P 192;
 Carrier Frequency fc: 234.0 MHz; Date: 8/4/76; By: K.Y.L.

VI. Spurious Emission (Antenna Conducted)

Frequency Mhz	DB Down from fc	Identification
178	53 ± 3	fc - 28fx
188	45 ± 3	fc - 23fx
224	41 ± 3	fc - 5fx
228	35 ± 3	fc - 3fx
234.0	0	carrier frequency
278	46 ± 3	fc + 22fx
282	67 ± 3	fc + 24fx
286	66 ± 3	fc + 26fx
468	44 ± 3	2fc

NOTE: W.S.M.R. Regulation No. 105-2-60 requirement is $55 + 10 \log P_t$ DB Down from carrier.

VII. Miscellaneous

1. Maximum Distortion 1.5%
2. Incidental FM <500 Hz Peak
3. Power Requirement 9.8 watts
4. Efficiency 27.6%
5. O.C. & S.C. Protection OK
6. Other Checks No carrier shift with 5:1 V.S.W.R.
Reverse polarity OK

Evaluation Tests - Proprietary Information Sheet

RF Telemetry Transmitters

Make: Vector;

Type: T105S;

Manufacturer's Specifications

<u>RF Power Output</u>	5 watts minimum into 50 ohm load with VSWR up to 1.5:1.
<u>RF Load</u>	Stable operation into any load impedance. Output circulator allows continuous operation into open or short circuit.
<u>Output Frequency</u>	Crystal controlled center frequency for S-band (between 2200-2300 MHz).
<u>Output Frequency Stability</u>	+ 0.003% of specified, including setting tolerance and drift due to environment.
<u>Harmonic and Spurious Outputs</u>	In accordance with IRIG 106-69
<u>Modulation Type</u>	FM (PM available).
<u>Input Impedance</u>	50 ohms to 100 kilohm.
<u>Deviation Sensitivity</u>	up to +750 kHz/volt rms.
<u>Frequency Response</u>	DC to 1 MHz $\pm$ 1.0dB.
<u>Deviation Capability</u>	$\pm$ 900 kHz maximum.
<u>Linearity</u>	1.0% maximum, best straight line for; $\pm$ 750 kHz deviation.
<u>Total Harmonic Distortion</u>	1.0% maximum for; $\pm$ 500 kHz deviation.
<u>Input Voltage</u>	28 $\pm$ 4 volts. Reverse polarity protection provided.
<u>Input Current</u>	2.0 A maximum.
<u>Weight</u>	16 oz. maximum.
<u>Vibration</u>	Sinusoidal at 20 g from 20 to 200 cps in each axis.
<u>Shock</u>	1/2 sine at 50g fro 11 milliseconds in each axis.
<u>Altitude</u>	Unlimited.

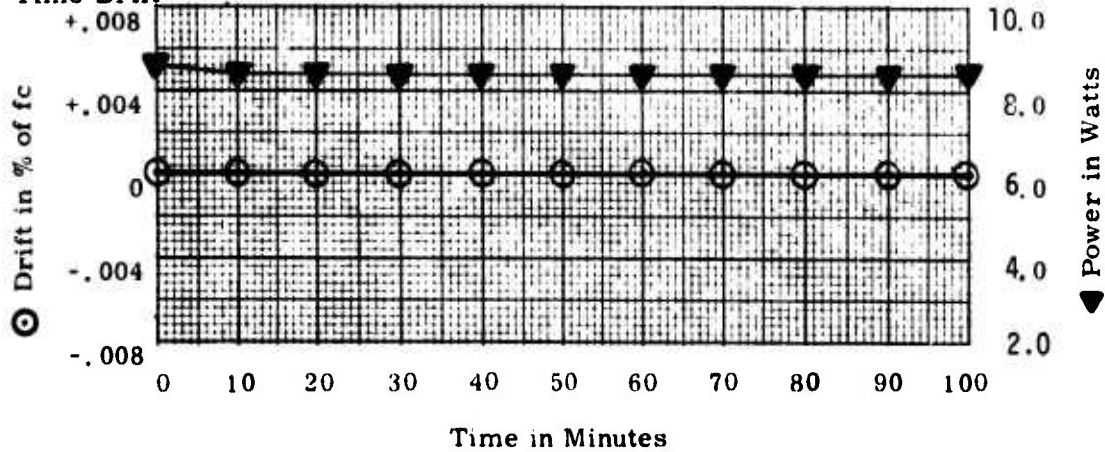
NORTHEASTERN UNIVERSITY

Evaluation Tests - RF Telemetry Transmitter - Sheet 1

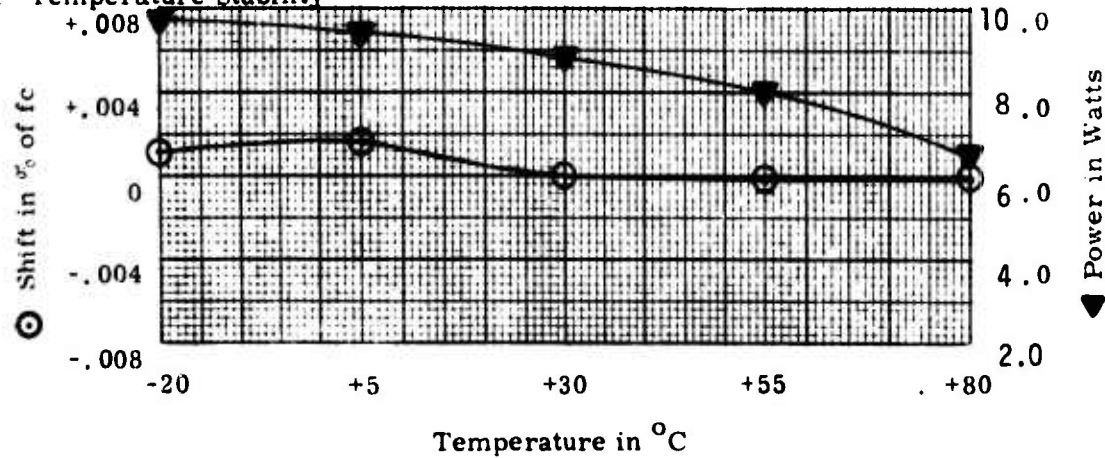
Make: Vector , Type: T105S , Serial Number: 1959

Carrier Frequency f_c : 2279.5 MHz , Date: 9/27/76 , By: KYL & JLW

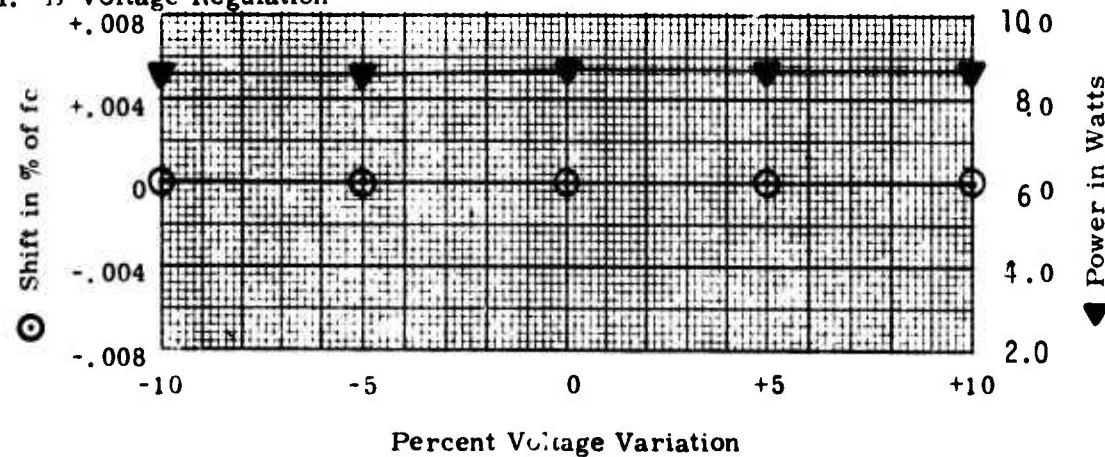
I. Time Drift



II. Temperature Stability



III. B⁺ Voltage Regulation

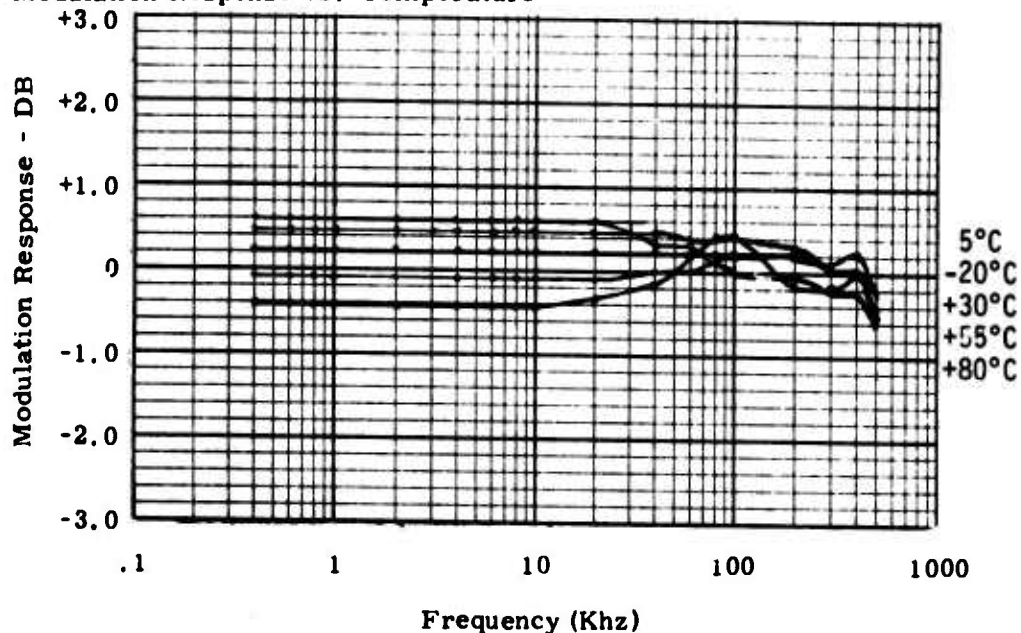


NORTHEASTERN UNIVERSITY

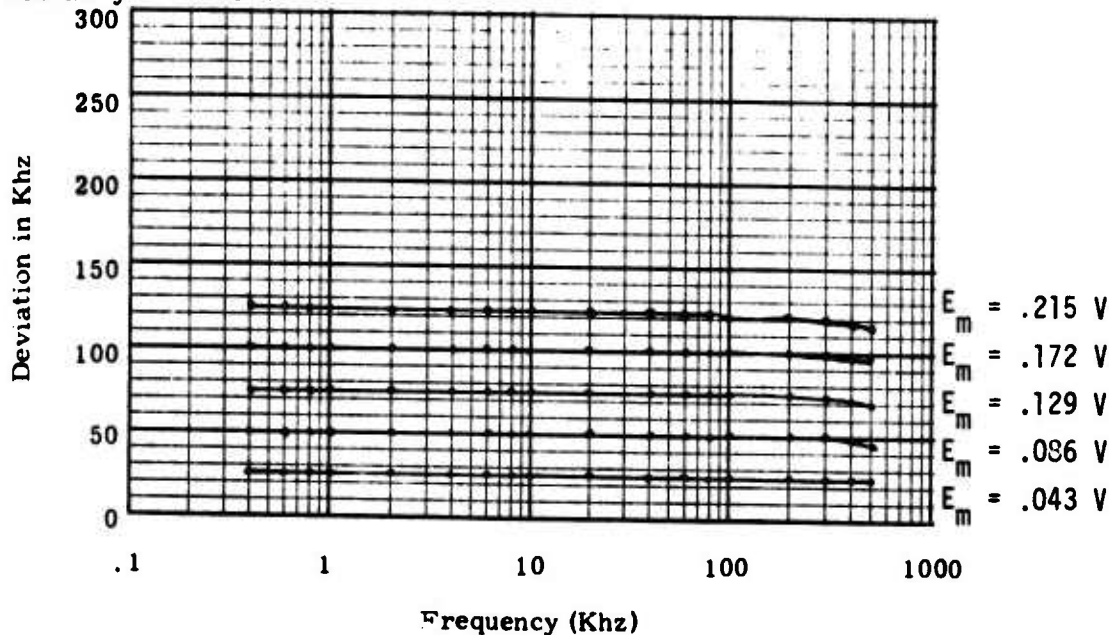
Evaluation Tests - RF Telemetry Transmitter - Sheet 2

Make: Vector; Type: T105S; Serial Number: 1959
 Carrier Frequency f_c : 2279.5 MHz; Date: 9/27/76; By: KYL & JLW

IV. Modulation Response vs. Temperature



V. Linearity at Ambient



NORTHEASTERN UNIVERSITY

Evaluation Tests - RF Telemetry Transmitter - Sheet 3

Make: Vector, Type: T105S, Serial Number: 1959
 Carrier Frequency fc: 2279.5 MHz, Date: 9/27/76; By: KYL & JLW

VI. Spurious Emission (Antenna Conducted)

Frequency Mhz	DB Down from fc	Identification
2.219.5	78 ± 3	fc - 3fx
2.239.5	93 ± 3	fc - 2fx
2.259.5	64 ± 3	fc - fx
2.279.5	0	carrier frequency
2.299.5	66 ± 3	fc + fx
2.339.5	88 ± 3	fc + 3fx

NOTE: W.S.M.R. Regulation No. 105-2-60 requirement is $55 + 10 \log P_t$ DB Down from carrier.

VII. Miscellaneous

1. Maximum Distortion <1.0%
2. Incidental FM <500 Hz PEAK
3. Power Requirement 51.8 watt
4. Efficiency 18.73%
5. O.C. & S.C. Protection OK
6. Other Checks 5:1 VSWR Test = OK
Reverse polarity = OK

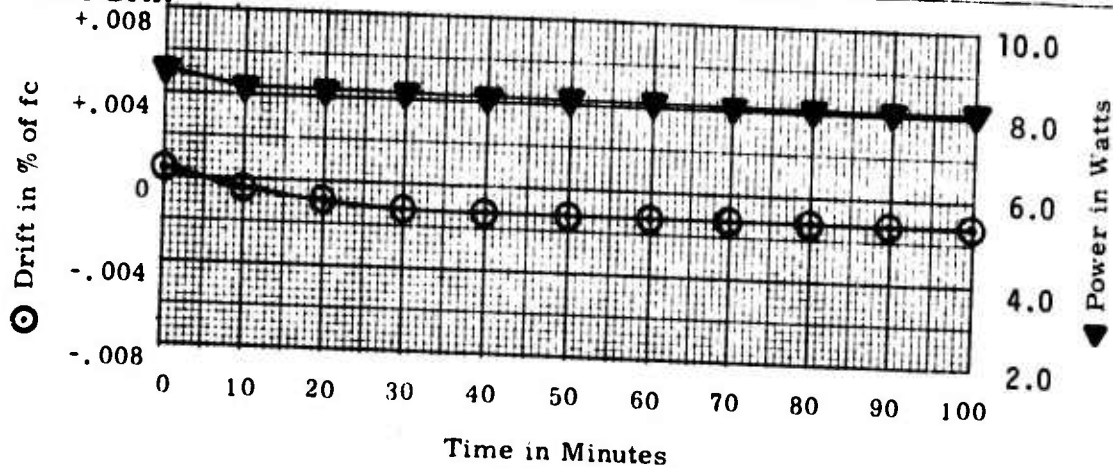
NORTHEASTERN UNIVERSITY

Evaluation Tests - RF Telemetry Transmitter - Sheet 1

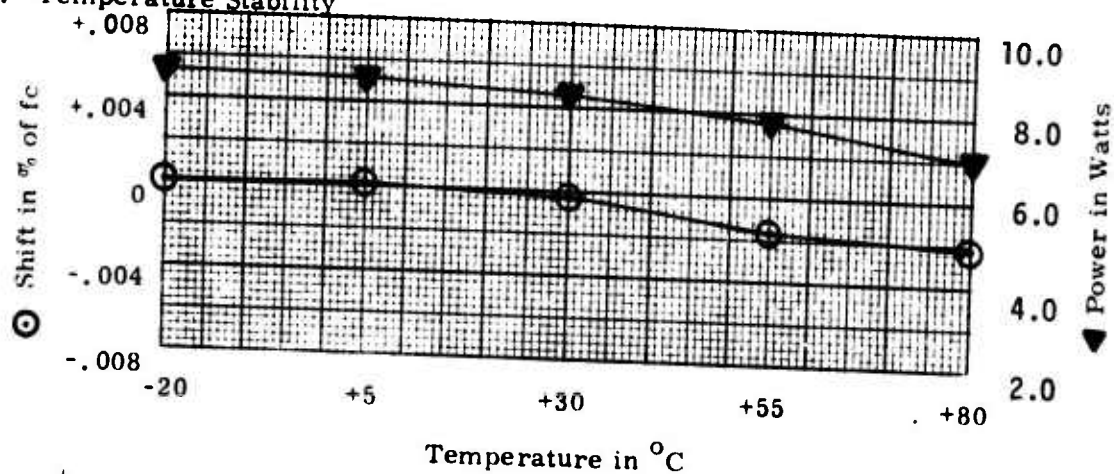
Make: Vector ; Type: T105S ; Serial Number: 1960

Carrier Frequency f_c : 2279.5 MHz; Date: 9/23/76 ; By: JLW

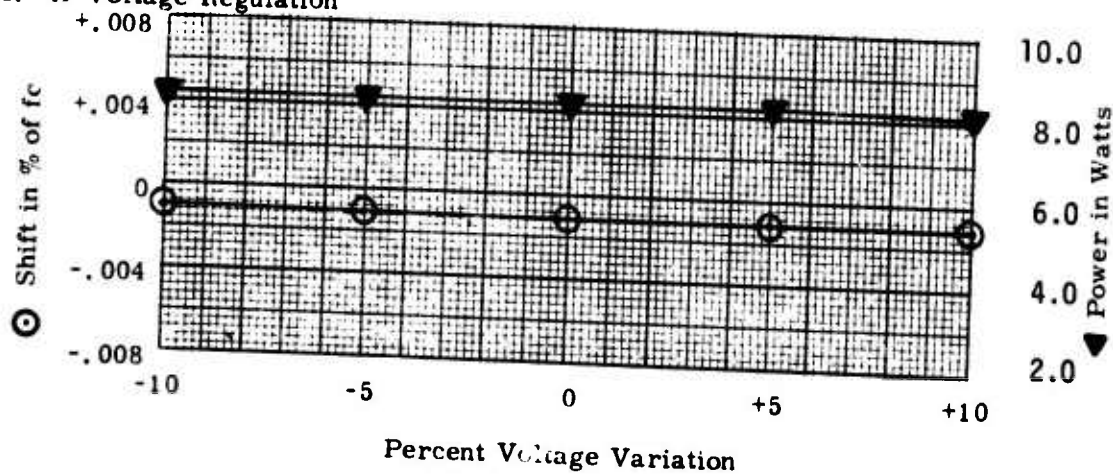
I. Time Drift



II. Temperature Stability



III. B⁺ Voltage Regulation

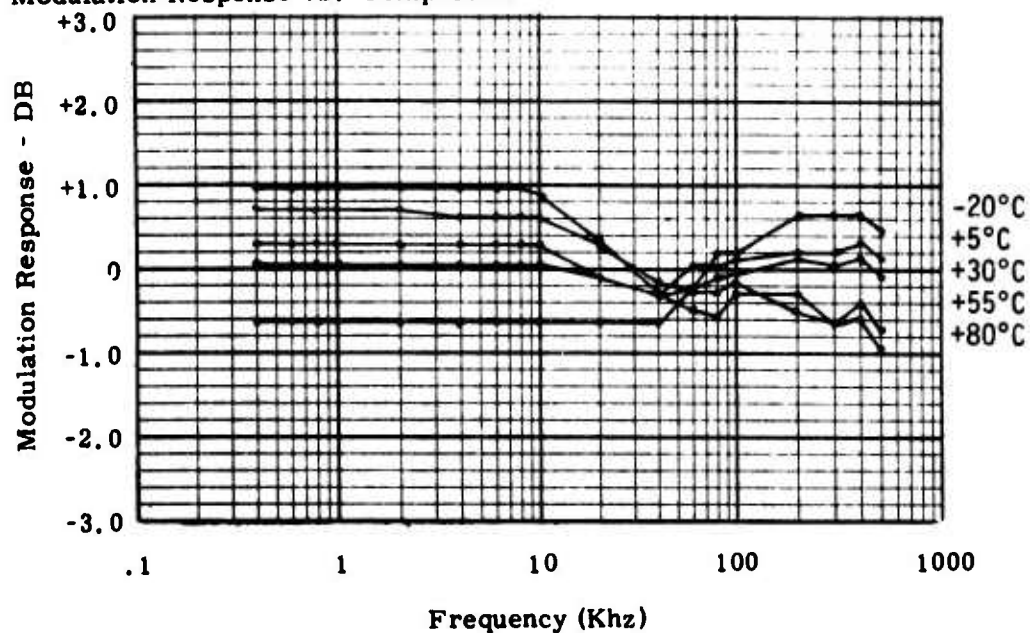


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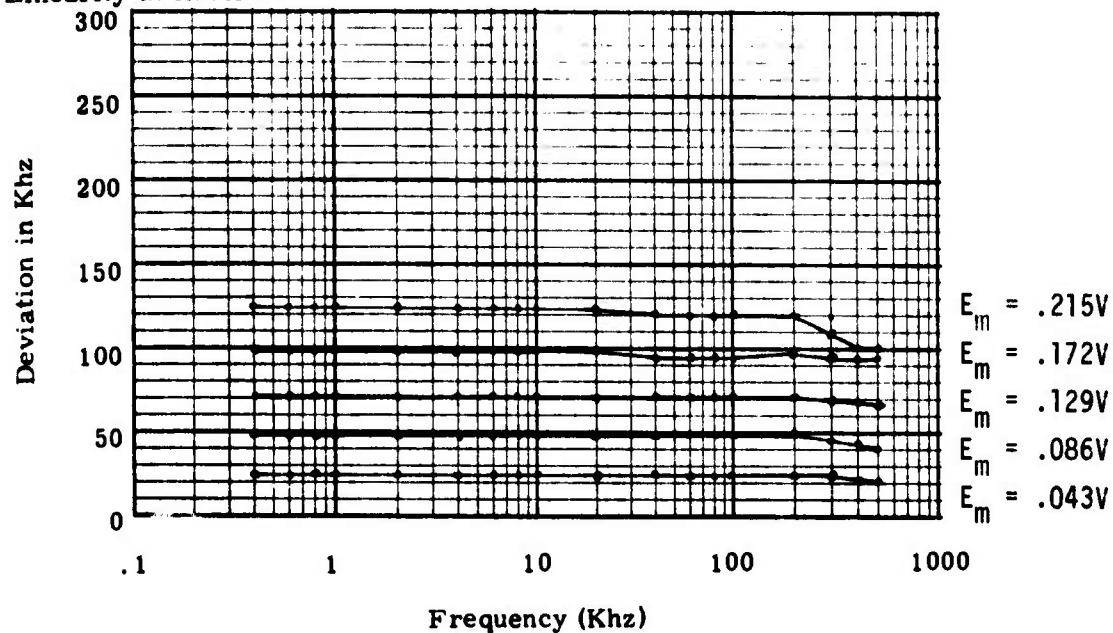
Evaluation Tests - RF Telemetry Transmitter - Sheet 2

Make: Vector ; Type: T105S ; Serial Number: 1960 ;
 Carrier Frequency f_c : 2279.5 MHz; Date: 9/23/76 ; By: JLW ;

IV. Modulation Response vs. Temperature



V. Linearity at Ambient



NORTHEASTERN UNIVERSITY

Evaluation Tests RF Telemetry Transmitter - Sheet 3

Make: Vector Type: T105S Serial Number: 1960
 Carrier Frequency f_c : 2279.5 MHz; Date: 9/23/76 ; By: JLW

VI. Spurious Emission (Antenna Conducted)

Frequency Mhz	DB Down from f_c	Identification
2218.0	74 ± 3	$f_c - 3f_x$
2238.5	81 ± 3	$f_c - 2f_x$
2259.0	76 ± 3	$f_c - f_x$
2279.5	0	carrier frequency
2300.0	78 ± 3	$f_c + f_x$
2320.5	87 ± 3	$f_c + 2f_x$
2341.0	80 ± 3	$f_c + 3f_x$

NOTE: W.S.M.R. Regulation No. 105-2-60 requirement is $55 + 10 \log P_t$ DB Down from carrier.

VII. Miscellaneous

1. Maximum Distortion <1.8%
2. Incidental FM <500 Hz PEAK
3. Power Requirement 49 watts
4. Efficiency 17%
5. O.C. & S.C. Protection OK
6. Other Checks Reverse Polarity OK
5:1 VSWR OK

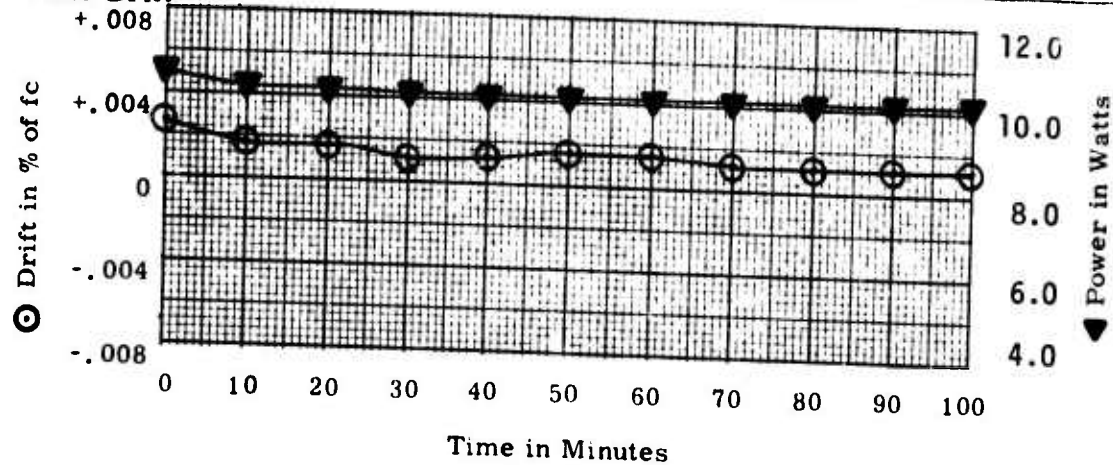
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Evaluation Tests - RF Telemetry Transmitter - Sheet 1

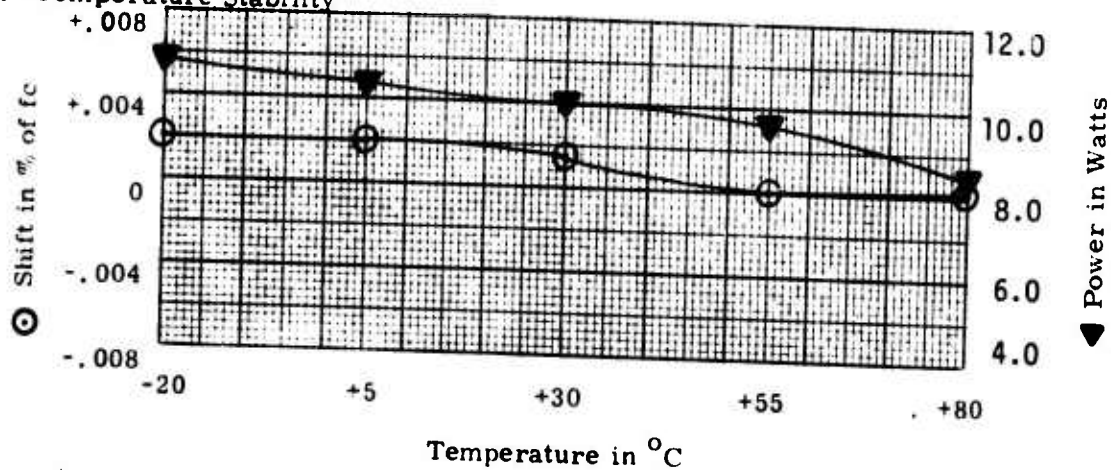
Make: Vector, Type: T105S, Serial Number: 2037

Carrier Frequency f_c : 2215.5 MHz, Date: 10/5/76, By: JLW

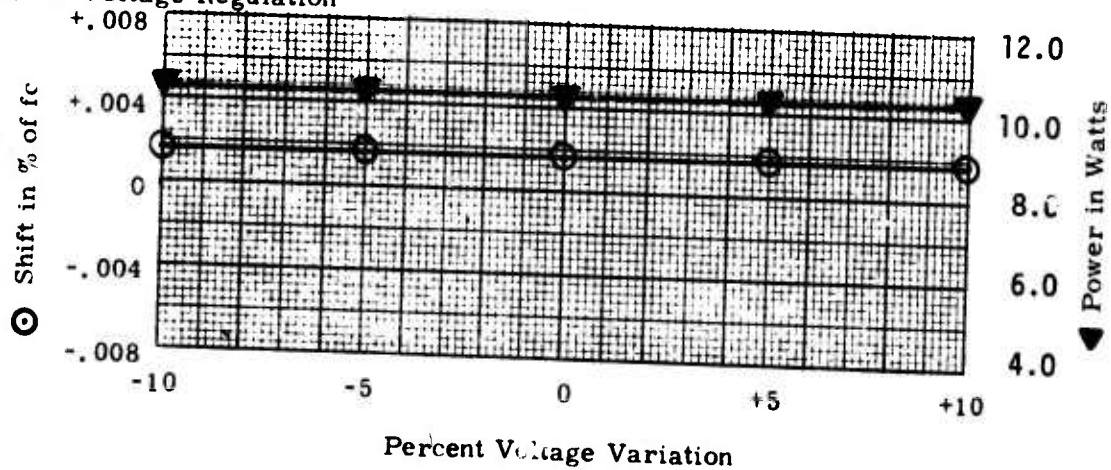
I. Time Drift



II. Temperature Stability



III. B⁺ Voltage Regulation

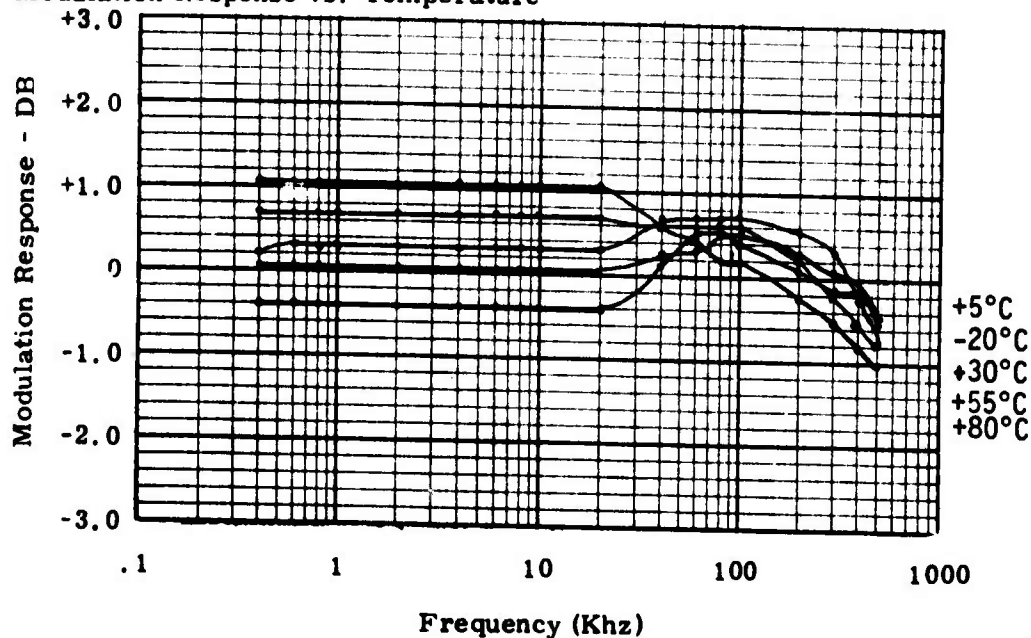


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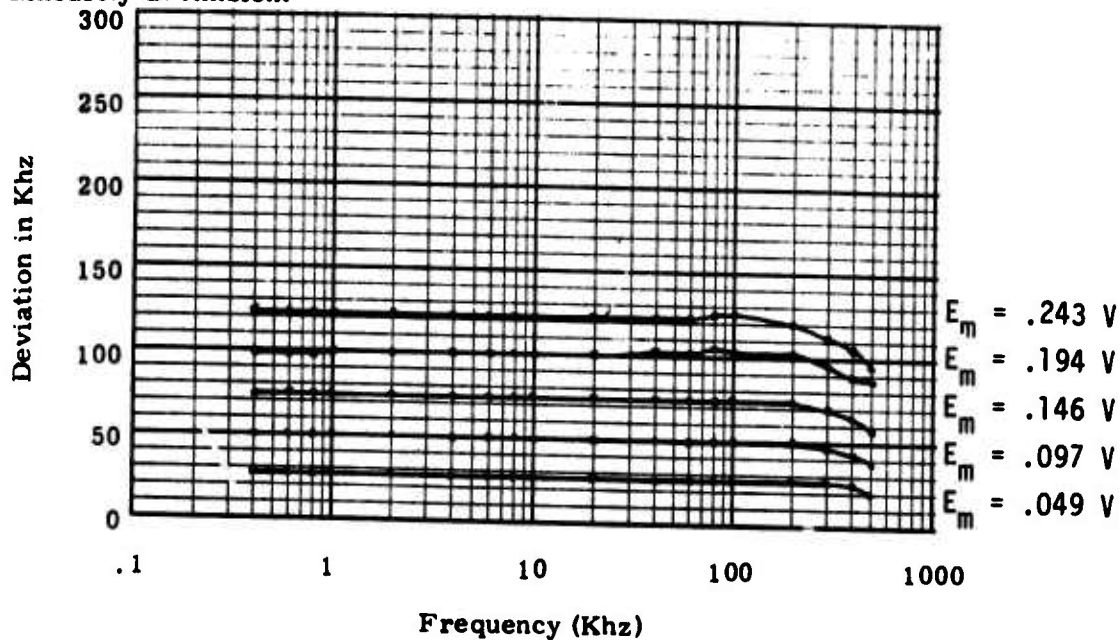
Evaluation Tests - RF Telemetry Transmitter - Sheet 2

Make: Vector ; Type: T105S ; Serial Number: 2037 ;
 Carrier Frequency f_c : 2215.5 MHz; Date: 10/5/76 ; By: JLW

IV. Modulation Response vs. Temperature



V. Linearity at Ambient



NORTHEASTERN UNIVERSITY

Evaluation Tests RF Telemetry Transmitter - Sheet 3

Make: Vector Type: T105S Serial Number: 2037
 Carrier Frequency f_c : 2215.5 MHz; Date: 10/5/76 ; By: JLW

VI. Spurious Emission (Antenna Conducted)

Frequency Mhz	DB Down from f_c	Identification
2155.5	75 ± 3	$f_c - 3f_x$
2175.5	84 ± 3	$f_c - 2f_x$
2195.5	79 ± 3	$f_c - f_x$
2215.5	0	carrier frequency
2235.5	84 ± 3	$f_c - f_x$
2256.5	88 ± 3	$f_c + 2f_x$
2275.5	79 ± 3	$f_c + 3f_x$
2955.5	66 ± 3	$f_c + 37f_x$
3695.5	63 ± 3	$f_c + 74f_x$

NOTE: W. S. M. R. Regulation No. 105-2-60 requirement is $55 + 10 \log P_t$ DB Down from carrier.

VII. Miscellaneous

1. Maximum Distortion <1.50%
2. Incidental FM <500 Hz PEAK
3. Power Requirement 50.40 watts max
4. Efficiency 21.43% max
5. O.C. & S.C. Protection OK
6. Other Checks Reverse voltage Test OK
5:1 VSWR Test OK

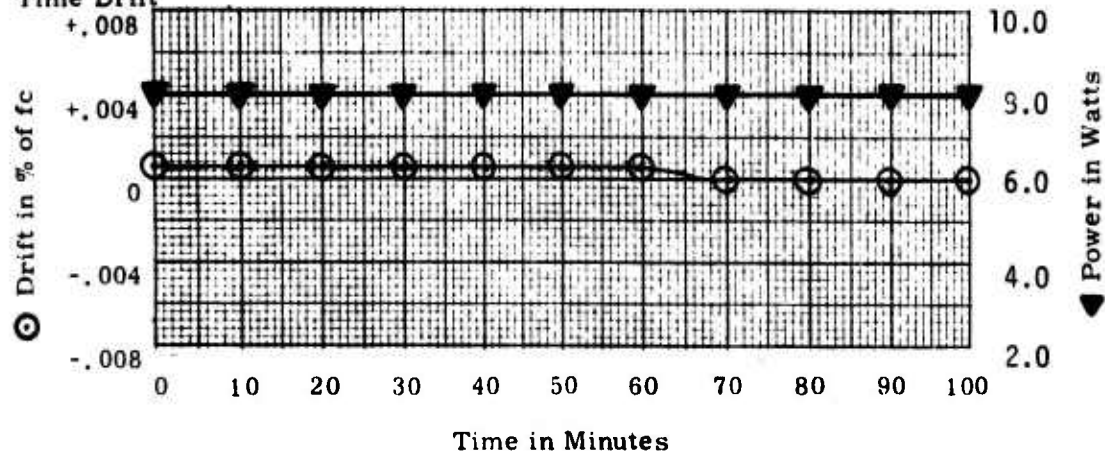
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Evaluation Tests - RF Telemetry Transmitter - Sheet 1

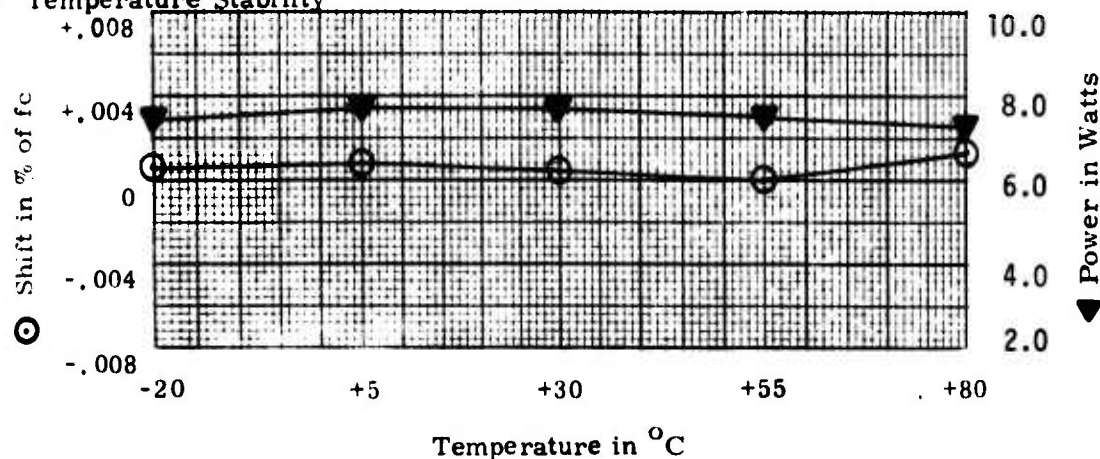
Make: Vector ; Type: T105S ; Serial Number: 2039 ;

Carrier Frequency f_c : 2215.5 MHz, Date: 10/1/76 ; By: KYL & JLW ;

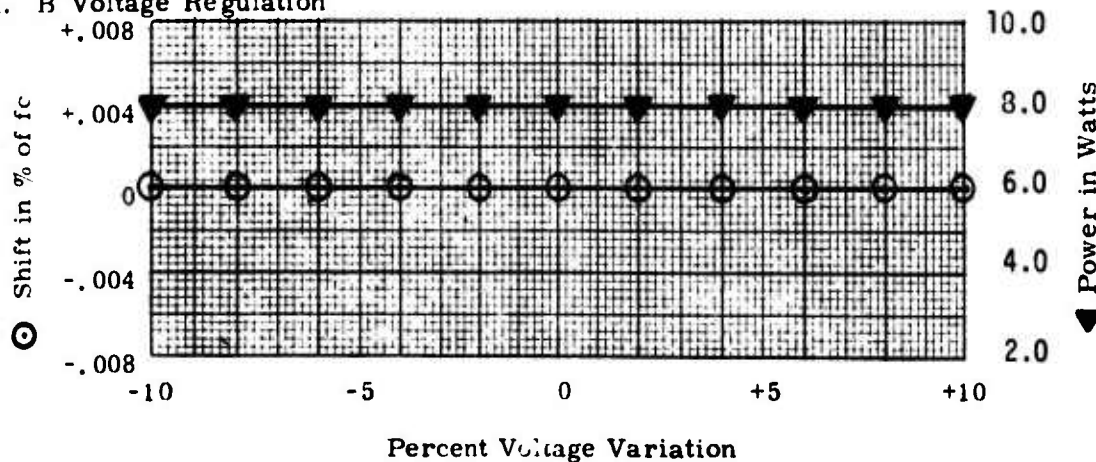
I. Time Drift



II. Temperature Stability



III. B^+ Voltage Regulation

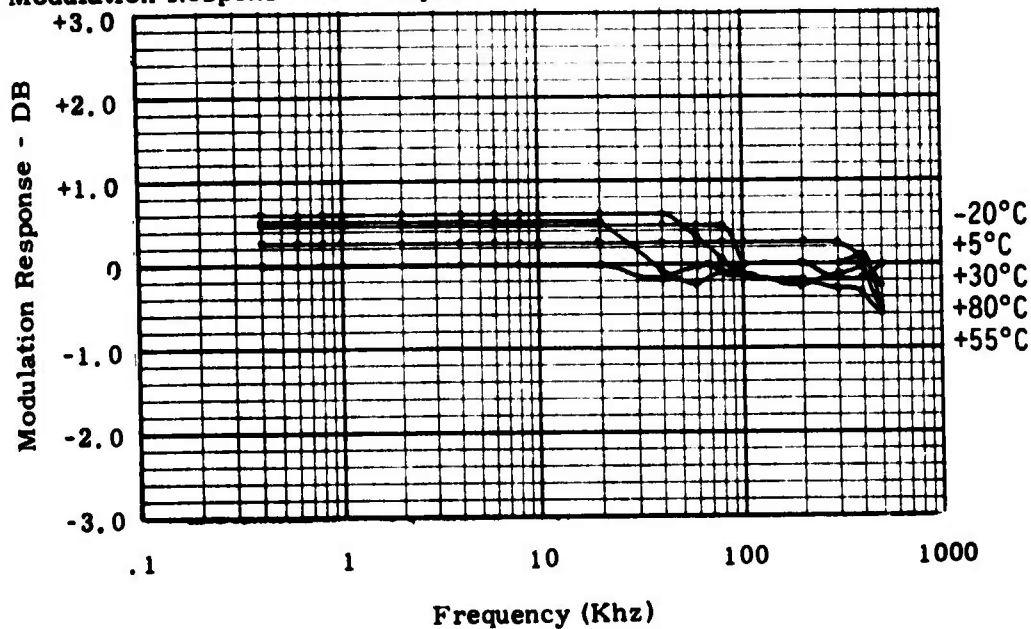


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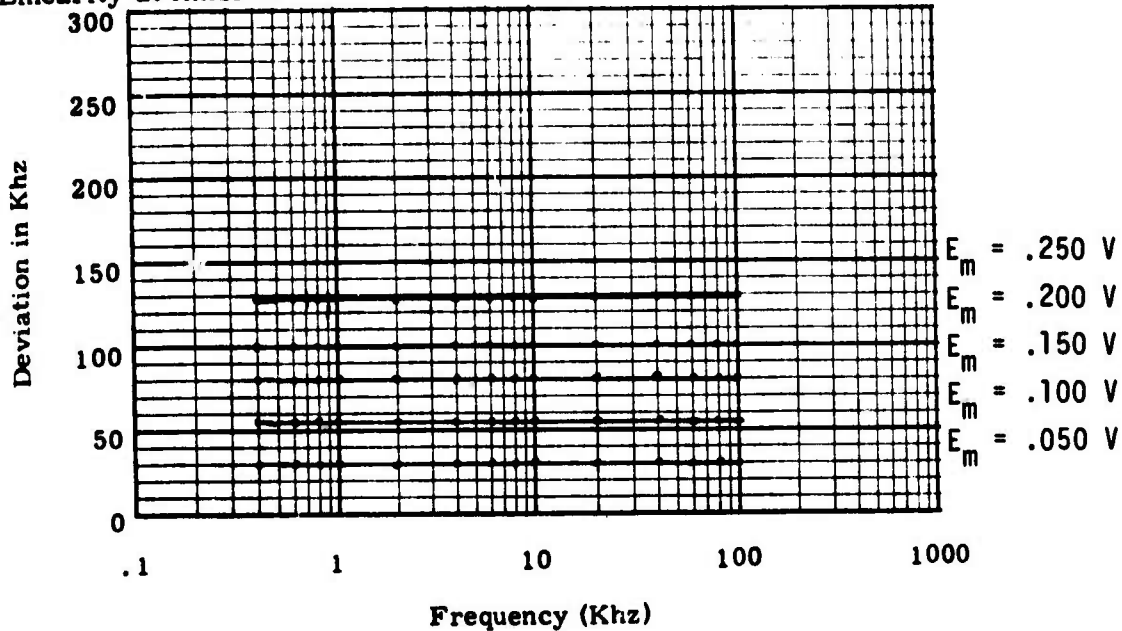
Evaluation Tests - RF Telemetry Transmitter - Sheet 2

Make: Vector ; Type: T105S ; Serial Number: 2039 ;
 Carrier Frequency f_c : 2215.5 MHz; Date: 10/1/76 ; By: KYL & JLW ;

IV. Modulation Response vs. Temperature



V. Linearity at Ambient



NORTHEASTERN UNIVERSITY

Evaluation Tests RF Telemetry Transmitter - Sheet 3

Make: Vector Type: T105S Serial Number: 2039
 Carrier Frequency f_c : 2215.5 MHz Date: 10/1/76 By: KYL & JLW

VI. Spurious Emission (Antenna Conducted)

Frequency Mhz	DB Down from f_c	Identification
2155.5	92 ± 3	$f_c - 3f_x$
2195.5	83 ± 3	$f_c - f_x$
2215.5	0	carrier frequency
2235.5	86 ± 3	$f_c + f_x$

NOTE: W.S.M.R. Regulation No. 105-2-60 requirement is $55 + 10 \log P_t$ DB Down from carrier.

VII. Miscellaneous

1. Maximum Distortion <1.0%
2. Incidental FM <500 Hz PEAK
3. Power Requirement 51.8 watts
4. Efficiency 15.25%
5. O.C. & S.C. Protection OK
6. Other Checks Reverse polarity OK
5:1 VSWR Test OK

Evaluation Tests - Proprietary Information Sheet

RF Telemetry Transmitters

Make: Vector;

Type: T110TV;

Manufacturer's Specifications

RF Power Output

10 watts minimum into 50 ohm load.

RF Load

Stable operation into any load impedance. Output circulator allows continuous operation into open or short circuit.

Output Frequency

Factory set crystal controlled center frequency in the 1710 to 1850 MHz low S-band. Standard S and L band available.

Output Frequency Stability

$\pm 0.02\%$ of specified, including setting tolerance and drift due to environment ($\pm 0.01\%$ available).

Harmonic and Spurious Outputs

In accordance with IRIG 106-71.

Modulation Type

FM

Input Impedance

75 ohms standard.

Deviation Sensitivity

± 6 MHz/volt rms standard, higher deviation sensitivity available.

Frequency Response

10 Hz to 6 MHz ± 1.5 dB, up to 10 MHz available. Pre-emphasis in accordance with CCIR-405 optional.

Deviation Capability

± 6 MHz maximum.

Linearity

2.0% maximum, best straight line; ± 5 MHz deviation.

Total Harmonic Distortion

2.0% maximum for ± 5 MHz deviation.

Baseplate Temperature

-20° to $+70^{\circ}$ C.

Vibration

Sinusoidal at 20g from 20 to 2000 cps in each axis.

Acceleration

100 g, each axis.

Altitude

Unlimited.

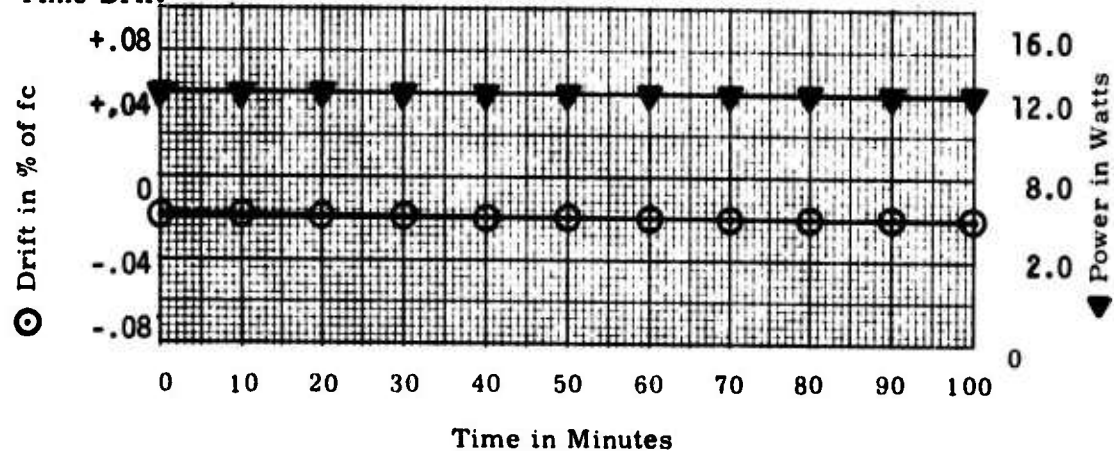
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Evaluation Tests - RF Telemetry Transmitter - Sheet 1

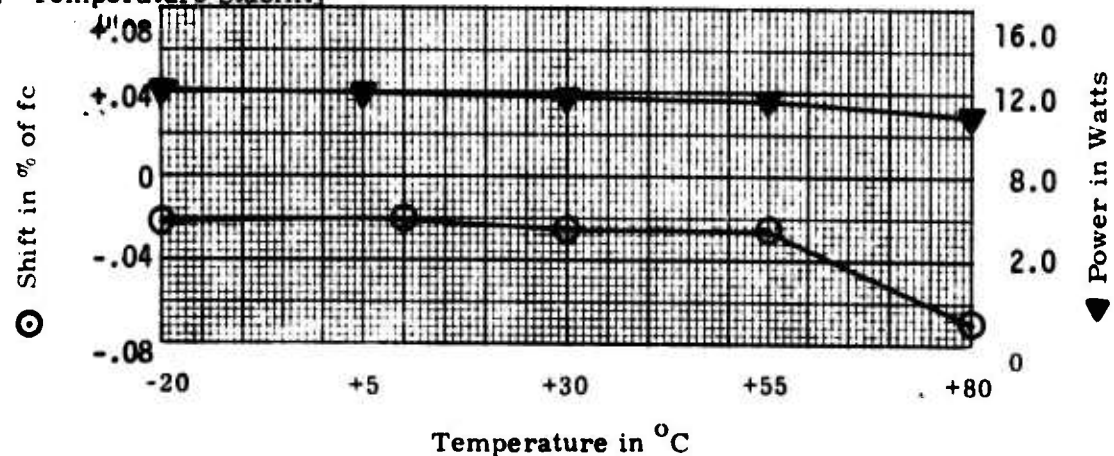
Make: VECTOR , Type: T110TVS , Serial Number: 1819 ;

Carrier Frequency f_c : 2215.5 MHz; Date: 7/14/76 ; By: KYL ;

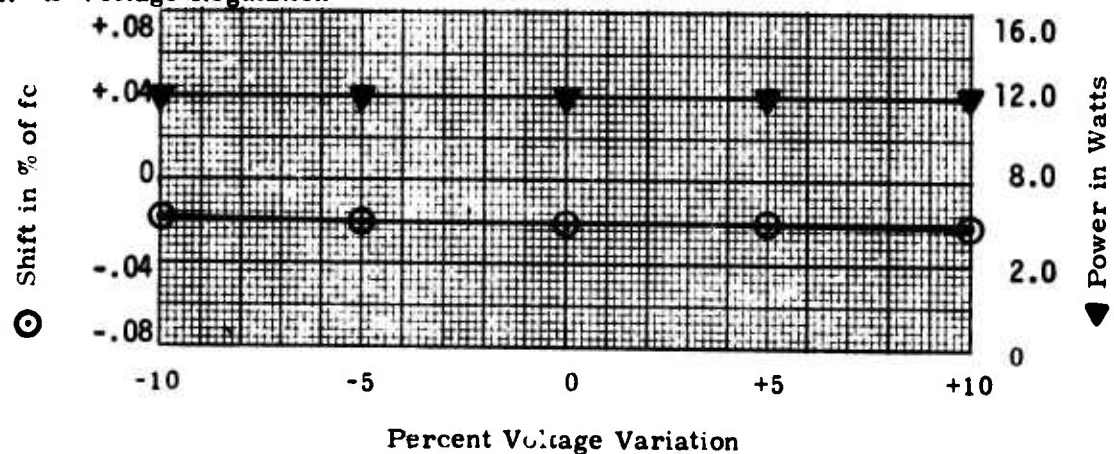
I. Time Drift



II. Temperature Stability



III. B⁺ Voltage Regulation

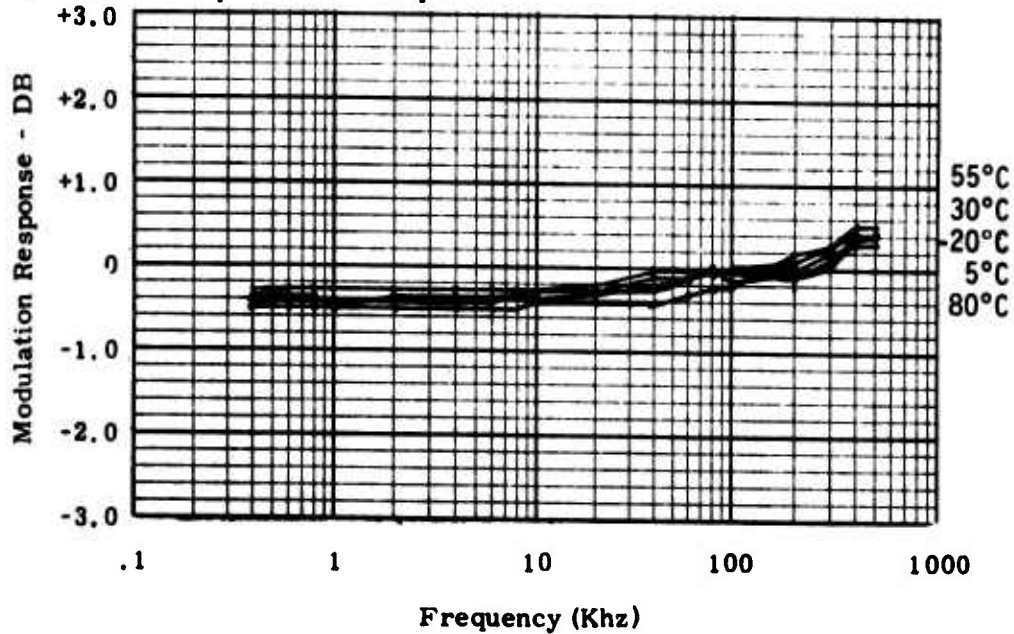


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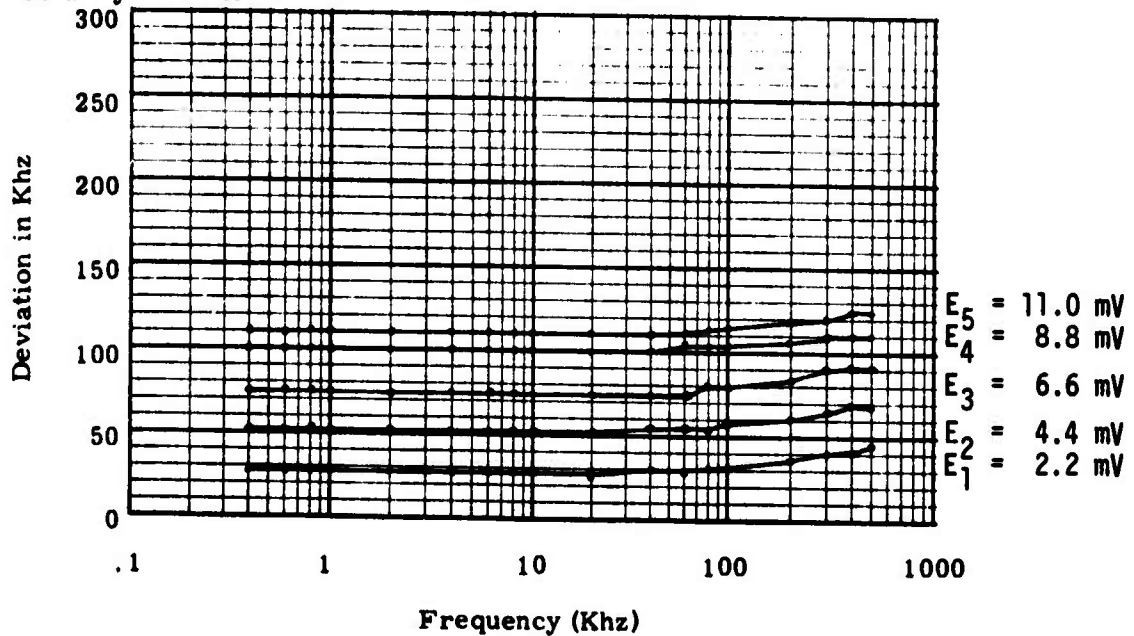
Evaluation Tests - RF Telemetry Transmitter - Sheet 2

Make: Vector ; Type: T110TVS ; Serial Number: 1819 ;
 Carrier Frequency f_c : 2215.5 MHz, Date: 7/14/76 ; By: KYL ;

IV. Modulation Response vs. Temperature



V. Linearity at Ambient



NORTHEASTERN UNIVERSITY

Evaluation Tests - RF Telemetry Transmitter - Sheet 3

Make: VECTOR; Type: T110TVS; Serial Number: 1819;
 Carrier Frequency f_c : 2215.5 MHz; Date: 7/14/76; By: KYL

VI. Spurious Emission (Antenna Conducted)

Frequency Mhz	DB Down from f_c	Identification
5170.0	91 ± 3	$7/3 f_c$
4430.0	102 ± 3	$2 f_c$
2215.5	0	carrier frequency
1476.0	65 ± 3	$2/3 f_c$

NOTE: W.S.M.R. Regulation No. 105-2-60 requirement is $55 + 10 \log P_t$ DB Down from carrier.

VII. Miscellaneous

1. Maximum Distortion < 1.85%
2. Incidental FM < 500 Hz PEAK
3. Power Requirement 106.4 watts
4. Efficiency 11.23%
5. O.C. & S.C. Protection OK
6. Other Checks 5:1 VSWR Test OK.

Evaluation Tests - Proprietary Information Sheet

RF Telemetry Transmitters

Make: Vector;

Type: T-202S;

Manufacturer's Specifications

<u>RF Power Output</u>	2 watts minimum into 50 ohm load with VSWR up to 1.5:1.
<u>RF Load</u>	Stable operation into any load impedance. Output circulator allows continuous operation into open or short circuit.
<u>Output Frequency</u>	Crystal controlled center frequency for S-band (between 2200-2300 MHz).
<u>Output Frequency Stability</u>	+0.003% of specified, including setting tolerance and drift due to environment.
<u>Harmonic and Spurious Outputs</u>	In accordance with IRIG 106-71.
<u>Modulation Type</u>	FM (PM available).
<u>Input Impedance</u>	50 ohms to 100 kilohm.
<u>Deviation Sensitivity</u>	Up to ± 750 kHz/volt rms.
<u>Frequency Response</u>	DC to 1 MHz ± 1.5 dB.
<u>Deviation Capability</u>	± 1000 kHz maximum.
<u>Linearity</u>	1.0% maximum, best straight line.
<u>Total Harmonic Distortion</u>	1.0% maximum for; ± 500 KHz deviation.
<u>Input Voltage</u>	28 ± 4 volts, with reverse polarity protection.
<u>Input Current.</u>	1.0 amp maximum.
<u>Baseplate Temperature</u>	-25 $^{\circ}$ C to +85 $^{\circ}$ C
<u>Vibration</u>	Sinusoidal at 20g from 20 to 2000 cps in each axis.
<u>Acceleration</u>	100g, each axis.
<u>Altitude</u>	Unlimited.

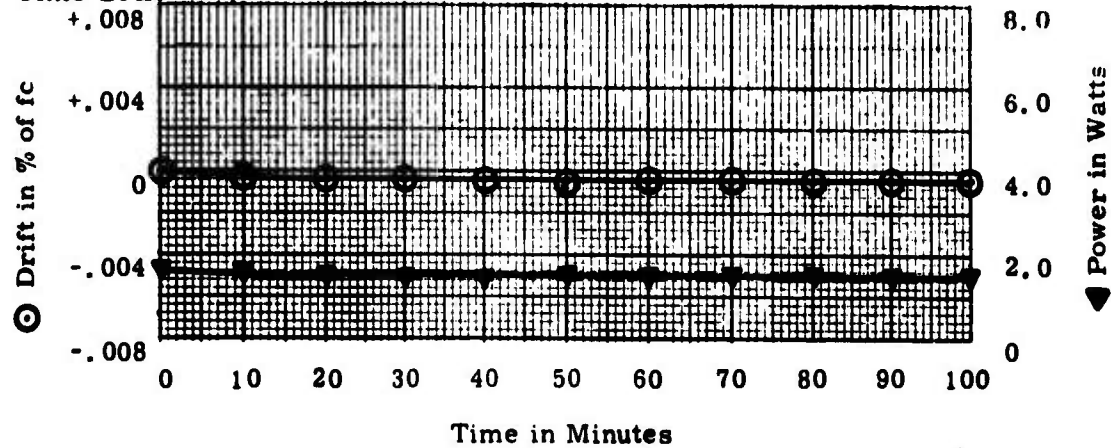
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Evaluation Tests - RF Telemetry Transmitter - Sheet 1

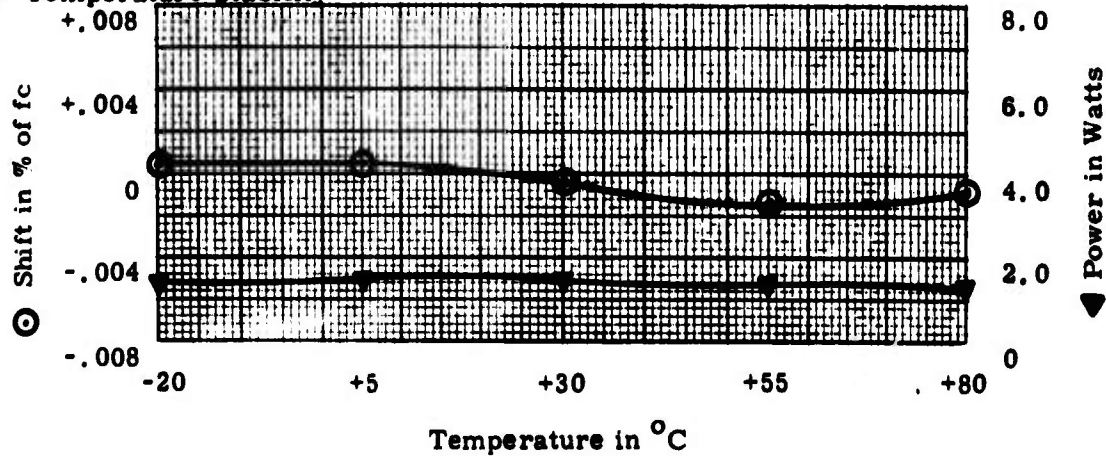
Make: **VECTOR** ; Type: **T202S** ; Serial Number: **312**

Carrier Frequency f_c : **2251.5 MHz** ; Date: **6/25/76** ; By: **KSB**

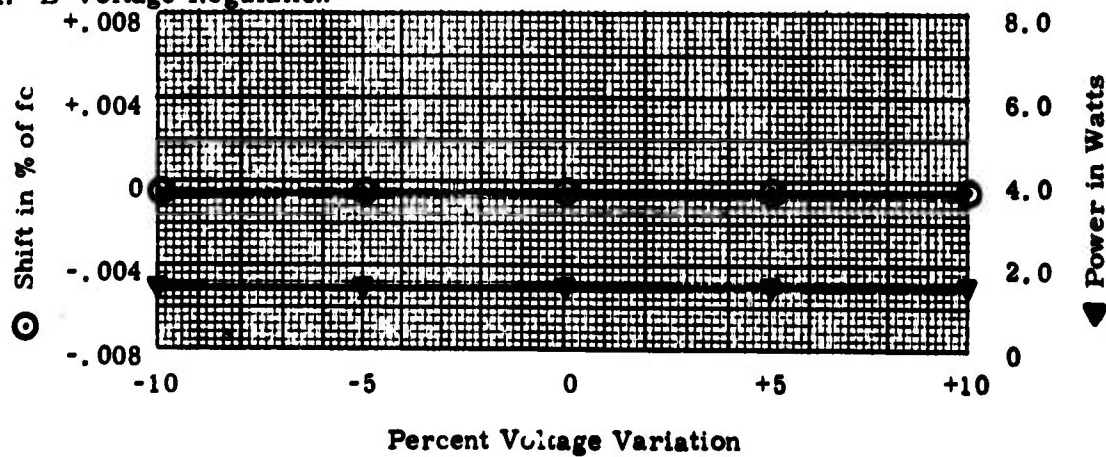
I. Time Drift



II. Temperature Stability



III. B^+ Voltage Regulation

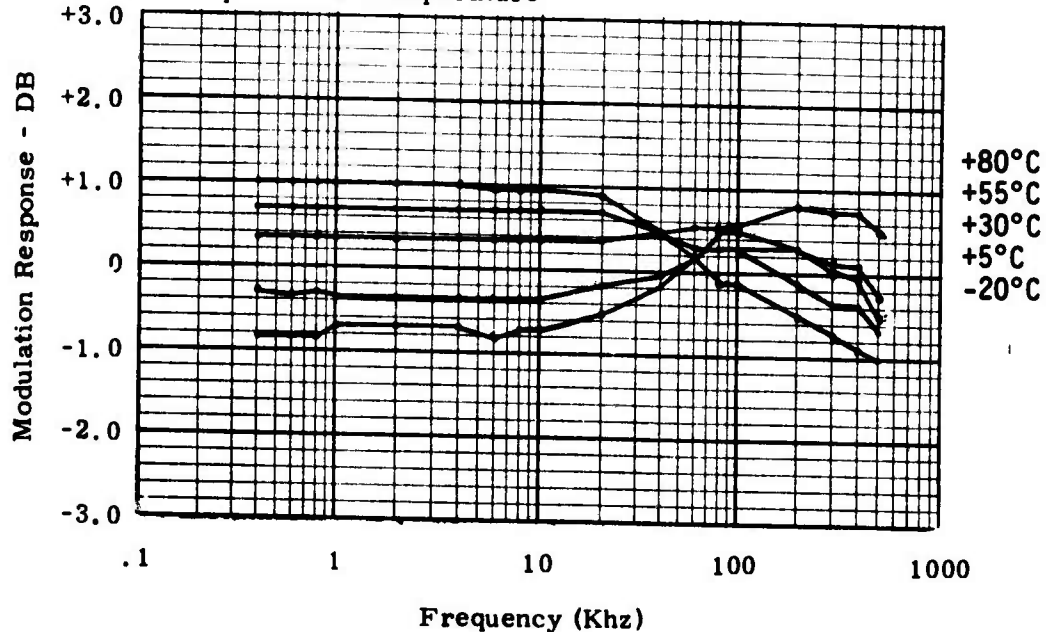


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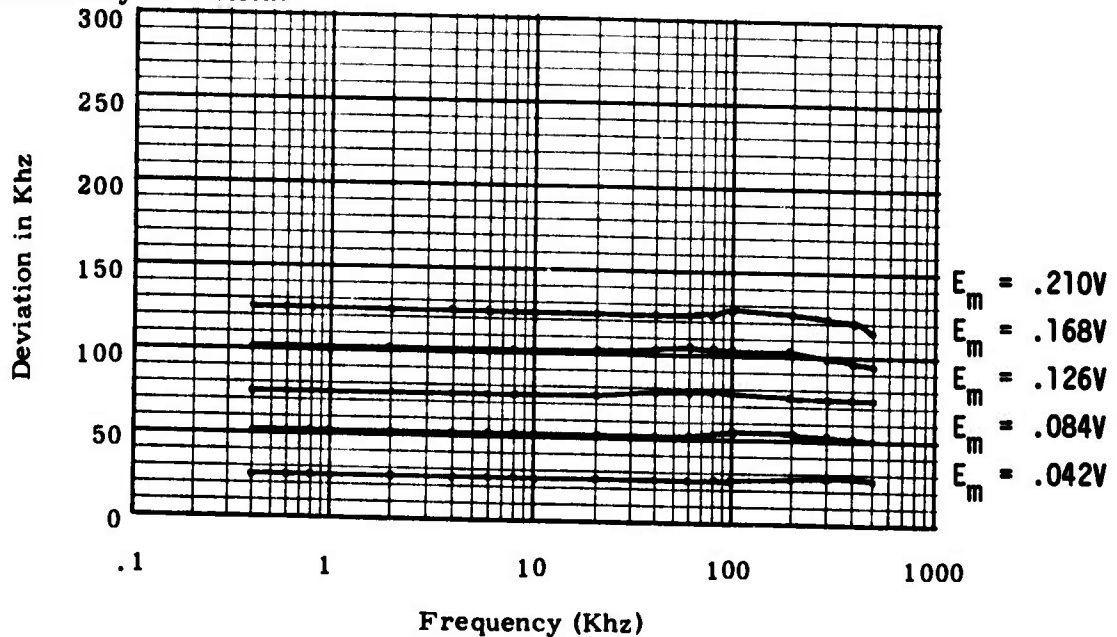
Evaluation Tests - RF Telemetry Transmitter - Sheet 2

Make: VECTOR; Type: T202S; Serial Number: 312
 Carrier Frequency f_c : 2251.5 MHz; Date: 6/25/76; By: KSB

IV. Modulation Response vs. Temperature



V. Linearity at Ambient



NORTHEASTERN UNIVERSITY

Evaluation Tests - RF Telemetry Transmitter - Sheet 3

Make: VECTOR ; Type: T202S ; Serial Number: 312 ;
 Carrier Frequency f_c : 2251.5 MHz; Date: 6/25/76 ; By: KSB ;

VI. Spurious Emission (Antenna Conducted)

Frequency Mhz	DB Down from f_c	Identification
2132	77 ± 3	$f_c - 6f_x$
2152	105 ± 3	$f_c - 5f_x$
2191	73 ± 3	$f_c - 3f_x$
2212	90 ± 3	$f_c - 2f_x$
2232	79 ± 3	$f_c - f_x$
2251.5	0	carrier frequency
2272	81 ± 3	$f_c + f_x$
2292	90 ± 3	$f_c + 2f_x$
2312	66 ± 3	$f_c + 3f_x$
2352	102 ± 3	$f_c + 5f_x$
2372	76 ± 3	$f_c + 6f_x$
4503	84 ± 3	$2f_c$

NOTE: W.S.M.R. Regulation No. 105-2-60 requirement is $55+10\log P_t$ DB Down from carrier.

VII. Miscellaneous

1. Maximum Distortion 1.95%
2. Incidental FM <500 Hz PEAK
3. Power Requirement 13.9 watts
4. Efficiency 11.0%
5. O.C. & S.C. Protection OK
6. Other Checks freq. at 5:1 VSWR = 2251.4895
carrier shift = .0000% of f_c at 5:1 VSWR

PERSONNEL

J. Spencer Rochefort, Professor of Electrical Engineering, Principal Investigator

Lawrence J. O'Connor, Senior Research Associate of Electrical Engineering.

Richard H. Marks, Technician, Electrical Engineering.

Joel L. Warsof, Research Fellow, Electrical Engineering

Kwang Y. Lee, Project Assistant.

Kim S. Brastow, Project Assistant.