HYAK LABORATORIES, INC.
7011 CALAMO STREET, SUITE 107
SPRINGFIELD, VIRGINIA 22150
(703) 451-1188
FAX (703) 644-7492

9190

ENGINEERING STATEMENT

For Type Acceptance of

LITTON MARINE SYSTEMS

Type No. 65831A

FCC ID: BT9BVT30

I am an Electronic Engineer, a principal in the firm of Hyak Laboratories, Inc., Springfield Virginia. My education and experience are a matter of record with the Federal Communication Commission.

Hyak Laboratories, Inc. has been authorized by Litton Marine Systems, to make Type Acceptance measurements on the marine radar system. These tests were made by me or under my supervision in our Springfield laboratory.

Test data required by the FCC for Type Acceptance are included in this report. It is submitted that the above mentioned device meets FCC requirements and Type Acceptance is requested.

Rowland S. Johnson

Dated: September 9, 1998

A. INTRODUCTION

The following data are submitted in connection with this request for type acceptance of the Litton Marine radar system in accordance with Part 2, Subpart J of the FCC Rules.

The 65831A is a "S" band marine radar transmitter used with "Bridgemaster" 180/250 display units and various antenna systems for marine radar applications.

B. GENERAL INFORMATION REQUIRED FOR TYPE ACCEPTANCE (Paragraph 2.983 of the Rules)

(a) Name of applicant: Litton Marine Systems
(b) Identification of equipment: FCC ID: BT9BVT30

(1) The equipment identification label is shown in Appendix 1.
(2) Photographs of the equipment are included in Appendix 2.

(c) Quantity production is planned.
(d) Technical description:

(1) 109M6P0N emission
(2) Frequency range: 2900 - 3100 MHz
(3) Rated power of the transmitter is 30 kW
(4) The 65831A complies with the power limitations of Parts 80.
(5) The nominal dc voltage and dc currents at magnetron:

dc voltage (peak)	dc current (peak)
8 kilovolts	9 amperes

(6) Function of each active semi-conductor device: See Appendix 3.

(7) Circuit diagram is included in Appendix 4
(8) A draft instruction book is submitted as Appendix 5.
(9) The transmitter tune-up procedure is included in Appendix 6.
(10) A description of circuits for stabilizing frequency is included in Appendix 7.
(11) A description of circuits and devices employed for suppression of spurious radiation and for limiting modulation is included in Appendix 8.
(12) (Not applicable)

B. GENERAL INFORMATION REQUIRED FOR TYPE ACCEPTANCE (Continued)

(e) Data for 2.985 through 2.997 follow this section B.

(h) (Not applicable)
(I) (Not applicable)

C. RF POWER OUTPUT (Paragraph 2.985(a) of the Rules)

RF power output into a HP 5912A dummy load was measured with a HP S752D directional coupler, HP S5382C attenuator, and HP 432A power meter with HP 478A thermocouple sensor.

The power meter was corrected for directional coupler attenuation and sensor calibration.

Table 1
RF Power Output

				Units
Measured PRR	1730	1730	791	PPS
Pulse Length (microseconds)	0.054	0.260	0.875	uS
Average Power	2.1	15.5	19.1	W
Duty Cycle (PRRxPulse Length)	93.4	449.8	692.1	$(x10^{-6})$
Peak Power (Ave. PWR/Duty Cycle)	22.9	28.0	28.2	kW

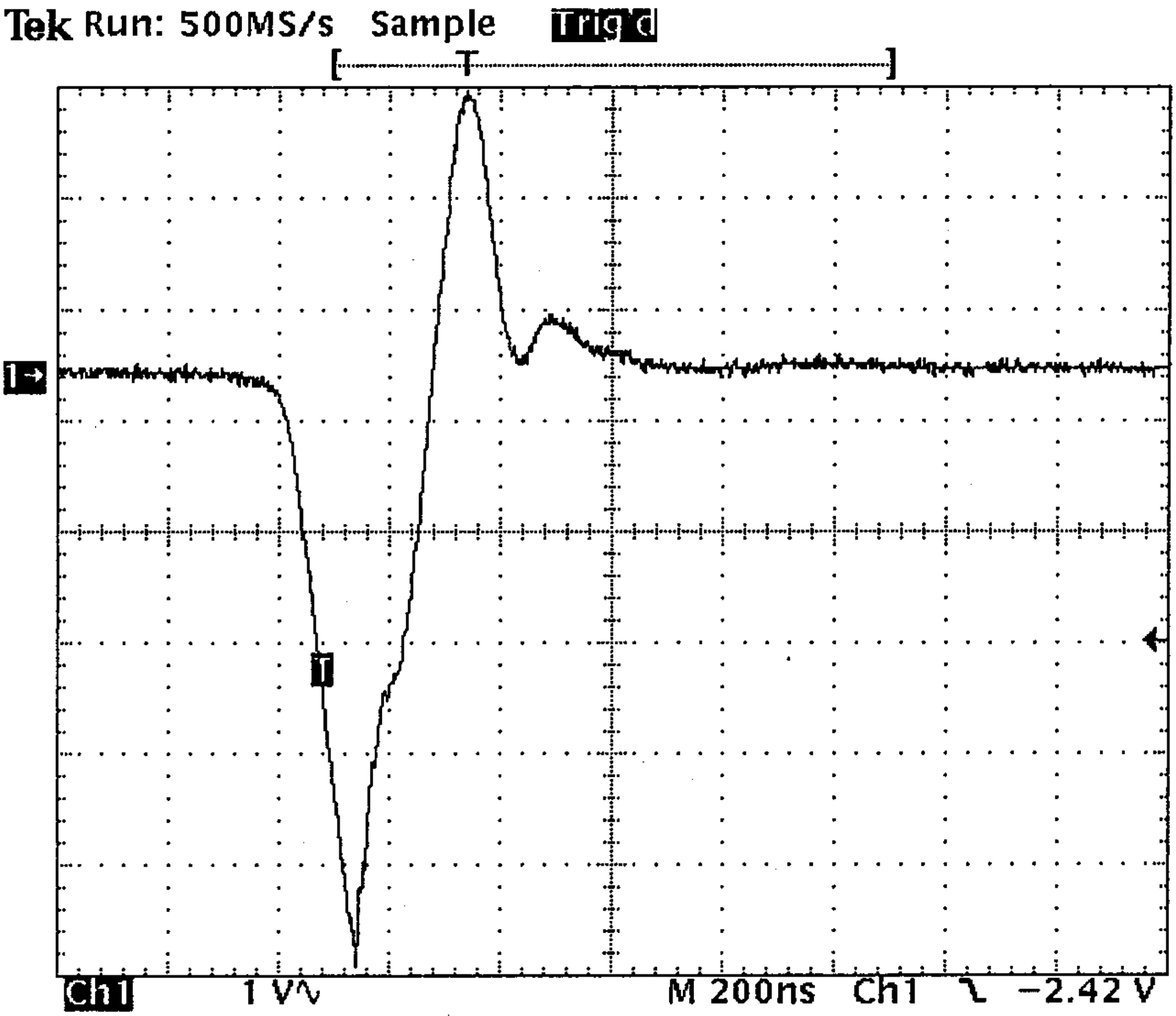
D. MODULATION CHARACTERISTICS (Paragraph 2.987 of the Rules)

1. Magnetron pulse input was measured with a Tektronix 2232 digital storage oscilloscope and Tektronix 6015 high voltage probe; and recorded on an HP C2106A printer. Oscilloscope display for each pulse width are included as Figures 1a, 1b and 1c for pulse widths of 0.054, 0.260 and 0.875 microseconds respectively.

2. Graphs of occupied bandwidth for pulse widths of 0.054, 0.260 and 0.875 microseconds are included as Figures 2a, 2b and 2c respectively. The plots were made with Tektronix 494P spectrum analyzer and HP 7550 plotter coupled via the analyzer's IEEE 488 Port.

   Analysis of the plots demonstrated that 99% of the spectral density is within a 109.6 MHz bandwidth as used in the emission designator. (See Appendix A for analysis technique).

MAGNETRON CONTROL PULSE



Nominal Pulse Width: 0.054 microseconds

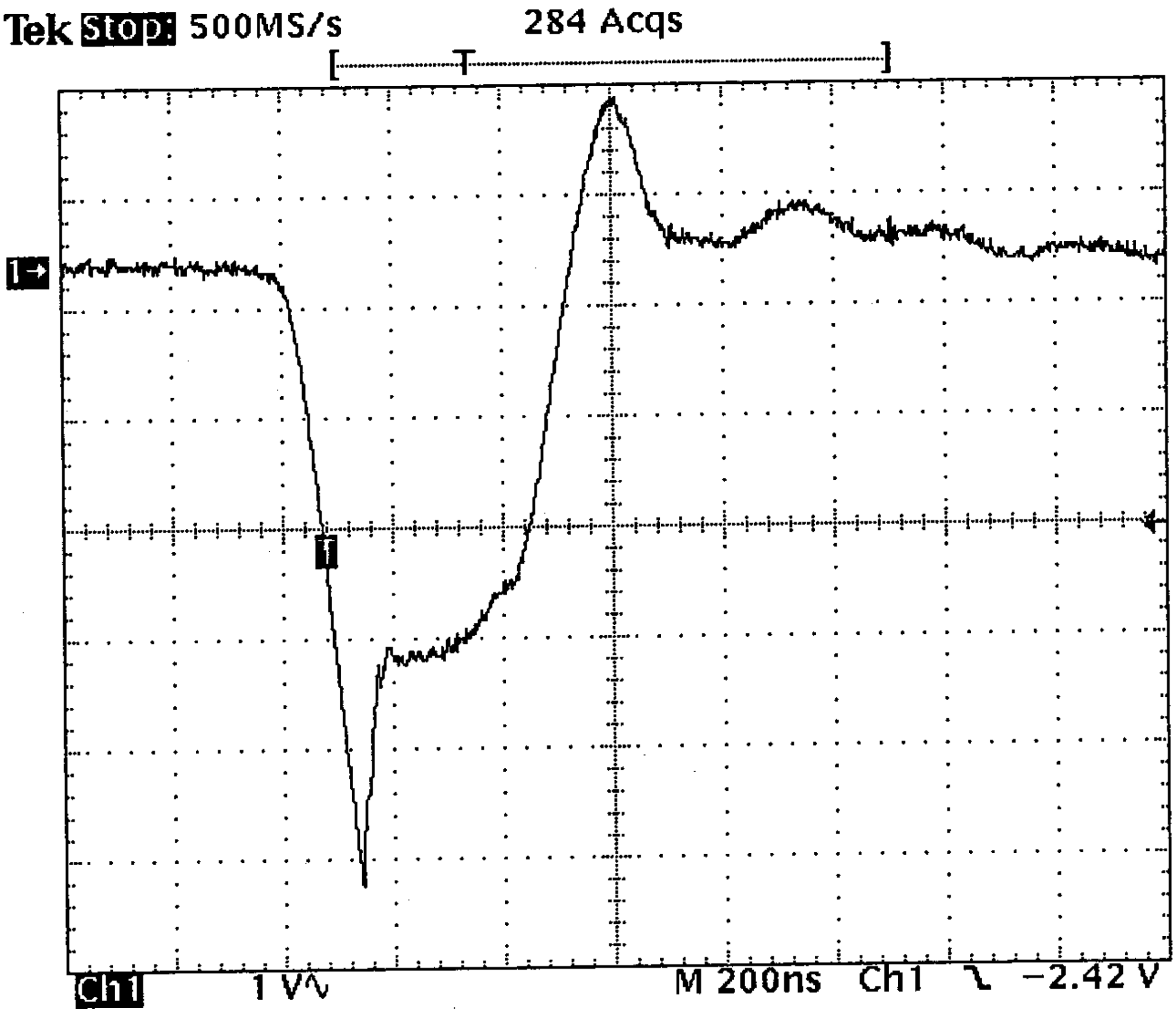
Display:

1000 V per vertical division
0.2 microseconds per horizontal division

MAGNETRON CONTROL PULSE
FCC ID: BT9BVT30

FIGURE 1a

MAGNETRON CONTROL PULSE



Nominal Pulse Width: 0.260 microseconds

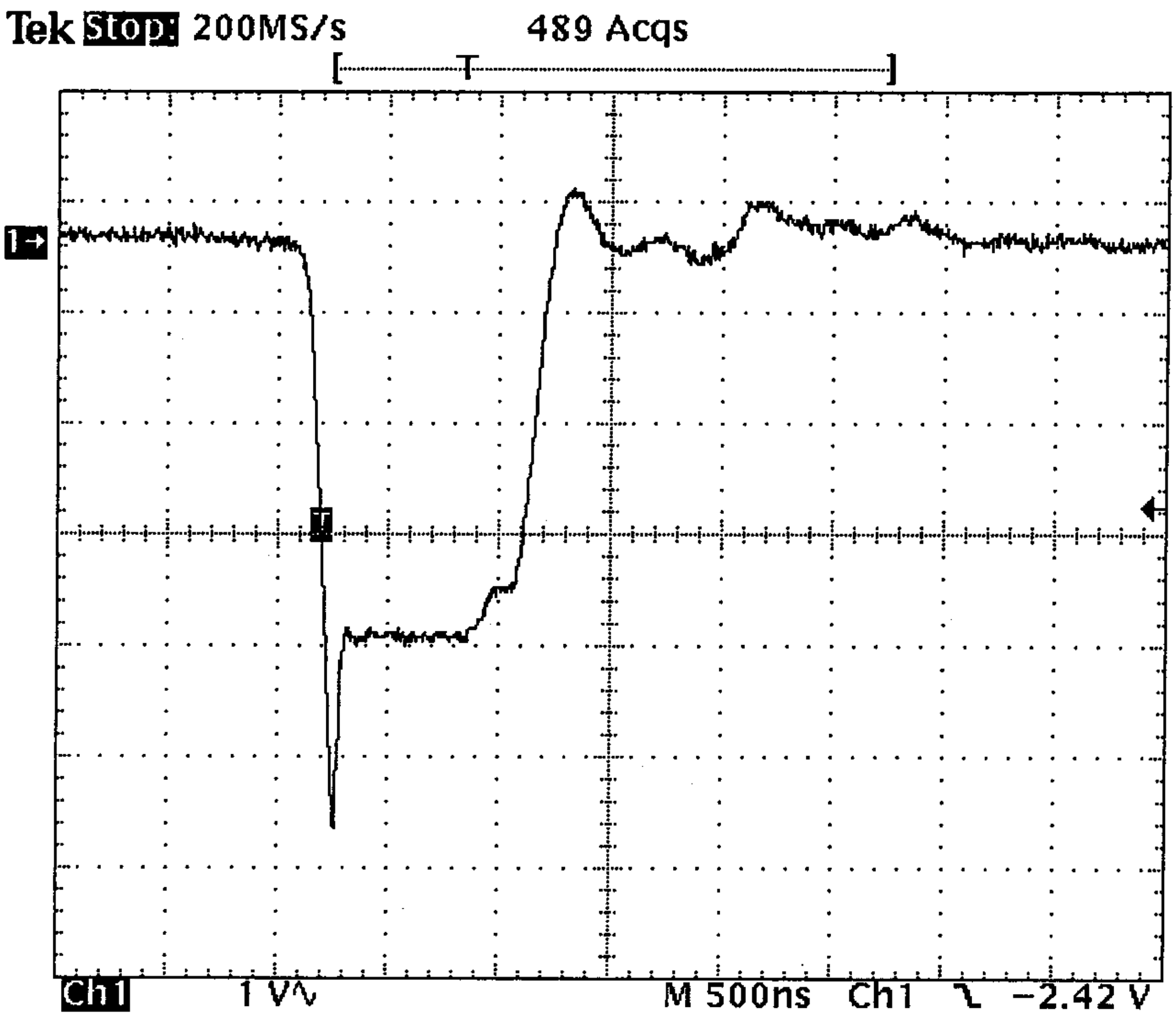
Display:

1000 V per vertical division
0.2 microseconds per horizontal division

MAGNETRON CONTROL PULSE
FCC ID: BT9BVT30

FIGURE 1b

MAGNETRON CONTROL PULSE



Nominal Pulse Width: 0.875 microseconds

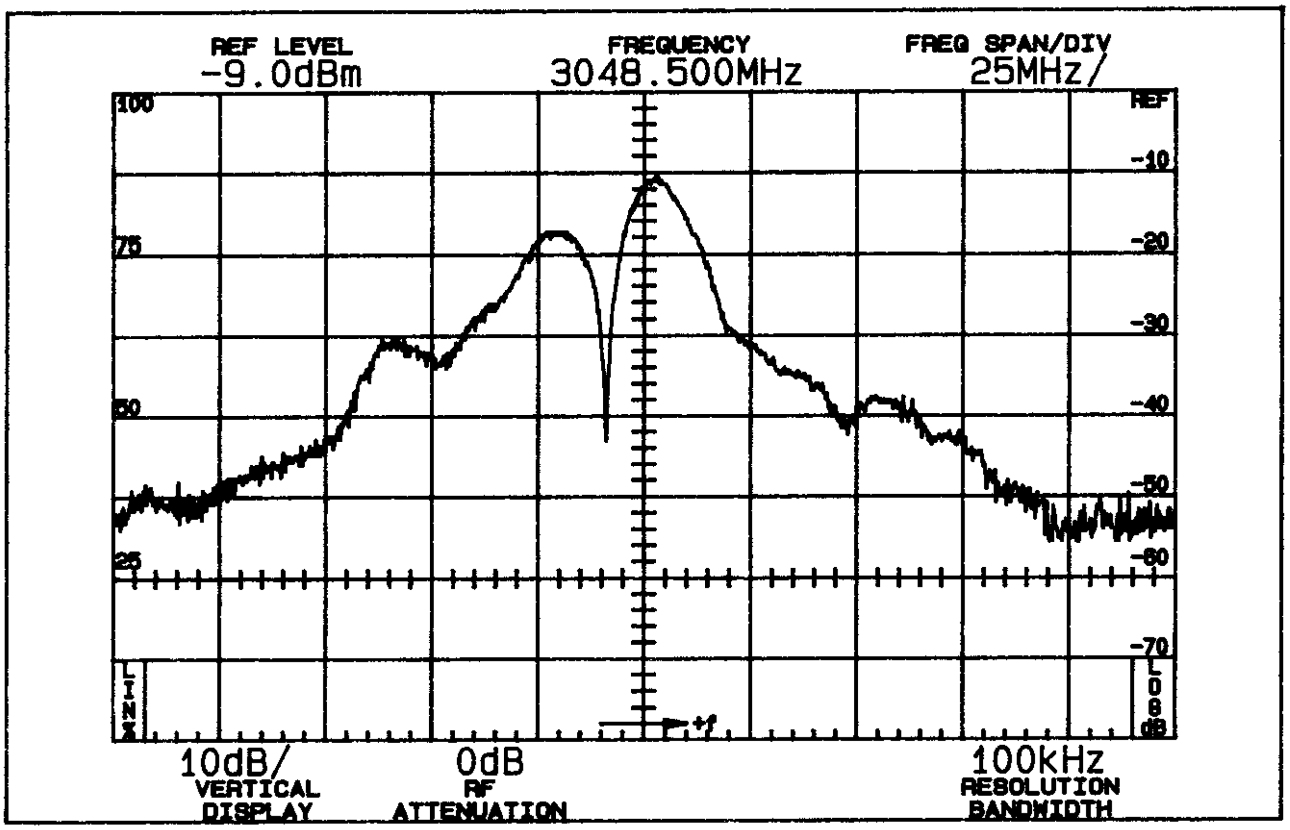
Display:

1000 V per vertical division
0.5 microseconds per horizontal division

MAGNETRON CONTROL PULSE
FCC ID: BT9BVT30

FIGURE 1c

OCCUPIED BANDWIDTH

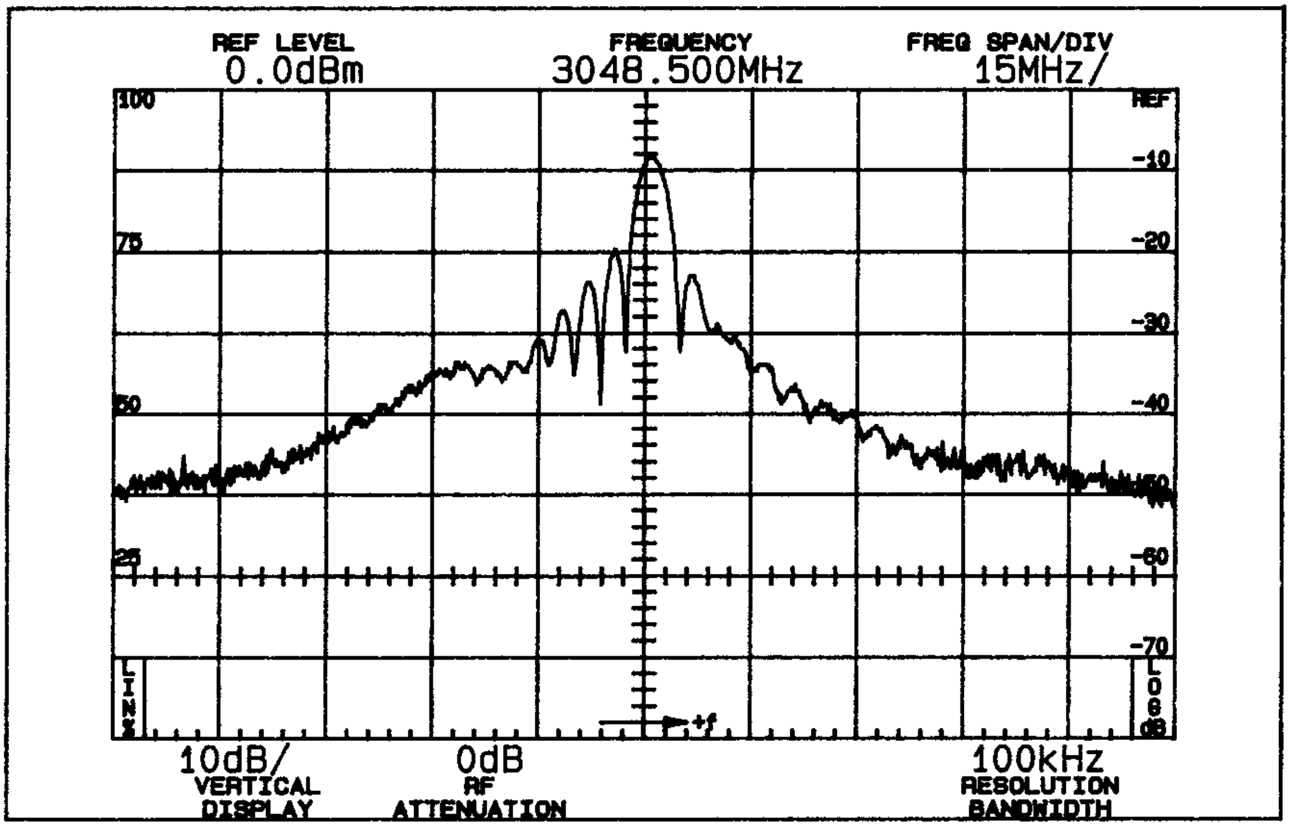


(Pulsewidth 0.054 microseconds, PRF 1730 Hz)

OCCUPIED BANDWIDTH
FCC ID: BT9BVT30

FIGURE 2a

OCCUPIED BANDWIDTH

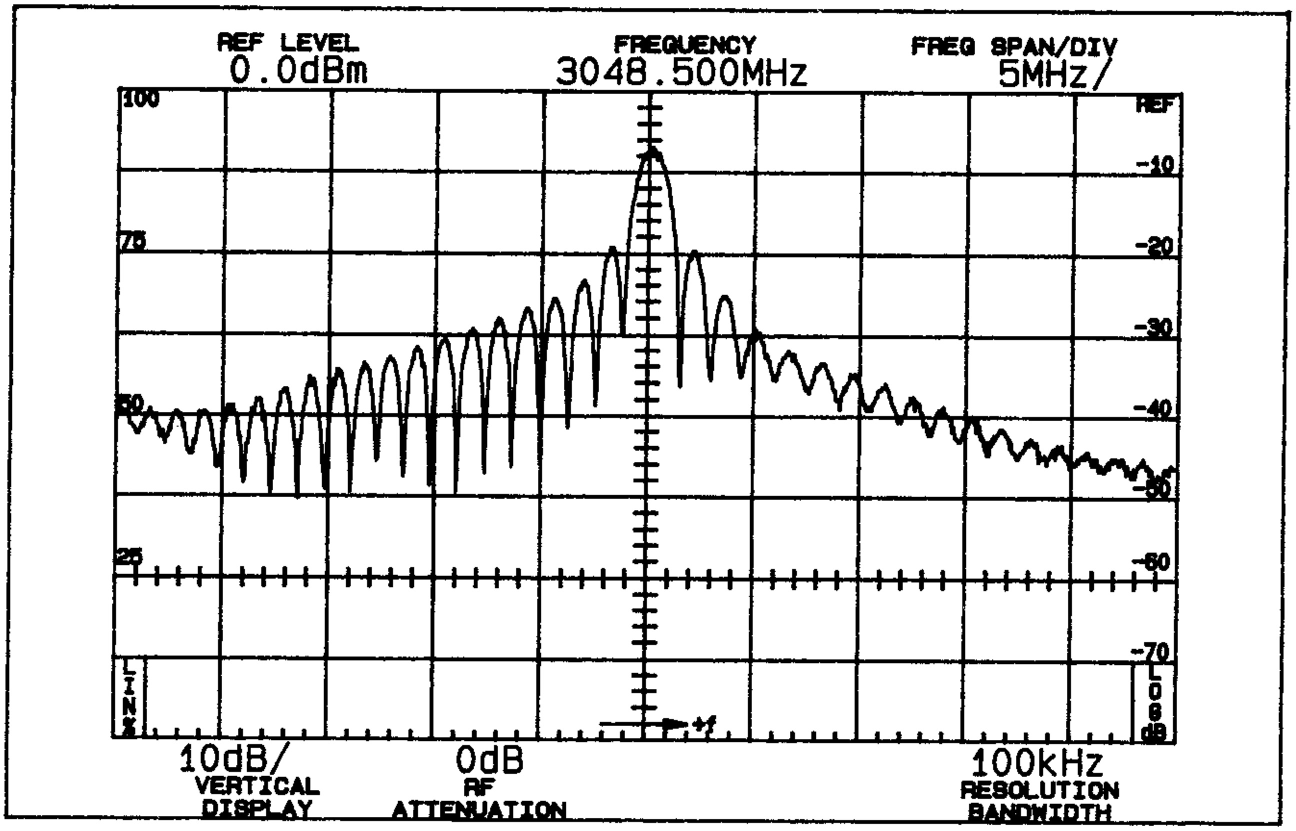


(Pulsewidth 0.260 microseconds, PRF 1730 Hz)

OCCUPIED BANDWIDTH
FCC ID: BT9BVT30

FIGURE 2b

OCCUPIED BANDWIDTH



(Pulsewidth 0.875 microseconds, PRF 791 Hz)

OCCUPIED BANDWIDTH
FCC ID: BT9BVT30

FIGURE 2c

F. SPURIOUS EMISSIONS AT THE ANTENNA TERMINALS
(Paragraph 2.991 of the Rules)

The 65831A transmitter was tested for spurious emissions while the equipment was modulated with pulsewidths of 0.054, 0.260 and 0.875 microseconds.

Measurements were made with a Tektronix 494P spectrum analyzer coupled to the transmitter output waveguide through the S-band rectional coupler. During the tests, the transmitter was terminated in a 50 ohm S-band load. Supply voltage was maintained at 117 Vac throughout the test.

Spurious emissions were measured throughout the RF spectrum from 100 MHz to 40 GHz. Any emissions that were between the required attenuation and the noise floor of the spectrum analyzer were recorded. Data are shown in Table 2.

Table 2

TRANSMITTER CONDUCTED SPURIOUS

FREQUENCY	dBc for each pulsewidth		
	0.054	0.260	0.875
100 MHz to 40 GHz	*	*	*
Average power (P) watts	2.1	12.6	19.5
	Required Attenuation:		
43+10LogP	46	54	56

*No signals were observed above analyzer noise floors:

100 kHz - 1.8 GHz	-98 dBm		5.4 GHz - 18 GHz	-80 dBm
1.7 GHz - 5.5 GHz	-93 dBm		15 GHz - 21 GHz	-75 dBm
3.0 GHz - 7.1 GHz	-93 dBm		21 GHz - 40 GHz	-60 dBm

G. FIELD STRENGTH MEASUREMENTS OF SPURIOUS RADIATION
(Paragraph 2.993(a), (b) (2) of the Rules)

Field intensity measurements of radiated spurious emissions were made with a Tektronix 494P spectrum analyzer using singer DM-105A calibrated test antennas below 1 GHz, Emco 3115 double-ridged horn from 1 to 18 GHZ, and Emco 3116 horn to 40 GHz. The transmitter and dummy load were located on a open field site 3 meters from the test antenna. The transmitter and test antennas were arranged to maximize pickup. Both vertical and horizontal test antenna polarization were employed.

G. FIELD STRENGTH MEASUREMENTS (continuued)

Reference level for the spurious radiation was taken as an ideal dipole excited by 19.5 watts, the maximum average output power of the transmitter according to the following relationship:*

$$E = \frac{(49.2P_t)^{1/2}}{R}$$

Where E = electric field intensity in volts/meter

P_t = transmitter power in watts

R = distance in meters

for the case $E = \frac{(49.2x19.5)^{1/2}}{3} = 10.3$ V/M

Since the spectrum analyzer is calibrated in decibels above one milliwatt (dBm), a conversion, for convenience, was made from dBu to dBm:

10.3 volts/meter = $10.3x10^6$ uV/m

dBu/m = $20Log_{10}(10.3x10^6)$

= 140 dBu/m

Since 1 uV/m = -107 dBm, the reference becomes:

140 - 107 = 33 dBm

The measurement system was capable of detecting signals 50 dB or more below the reference level. Measurements were made from 100 MHz to 40 GHz.

All spurious emissions were below applicable limit of 56 dBc. (See noise floors, Table 2, Page 10.)

*Reference Data for Radio Engineers, Fourth Edition, International Telephone and Telegraph Corporation, p. 676

H. FREQUENCY STABILITY AS A FUNCTION OF TEMPERATURE (Paragraph 2.995 (2) of the Rules)

Measurement of frequency stability versus temperature was made at temperatures from -30°C to 50°C. At each temperature, the frequency determining circuitry of the transmitter was exposed to ambient a minimum of 30 minutes after indicated temperature had stabilized to within ±3° of the desired test temperature. Following the soak at each temperature, the unit was turned on, keyed and frequency measured within 2 minutes.

The transmitter output stage was terminated with a dummy load. Primary supply was 117 Vac. Frequency was measured with the spectrum analyzer in the frequency counter mode.

Data are shown in Table 3.

TABLE 3

Frequency vs Temperature

Nominal Temperature, °C	Frequency, GHz
-30	3.0487
-20	3.0485
-10	3.0486
0	3.0485
10	3.0485
20	3.0484
30	3.0484
40	3.0483
50	3.0483

These data are within the limits of FCC Rule 80.209(b) which specifies 1.5/T MHz to upper and lower limits of the authorized frequency band, where "T" is pulse duration in microseconds.

For the equipment tested, the authorized frequency band is 2900-3100 MHz, and worst-case 1.5/T is 30 MHz (0.054 microsecond pulse duration on the minimum range position).

I. FREQUENCY STABILITY AS A FUNCTION OF SUPPLY VOLTAGE (Paragraph 2.995(d)(1) of the Rules)

Oscillator frequency as a function of power supply voltage was measured with the Tektronix 494P spectrum analyzer as supply voltage was varied ±15% from the nominal 117 Vac volt rating. A Keithley 177 digital voltmeter was used to measure supply voltage at transmitter primary input terminals. Measurements were made at 20°C ambient.

I. FREQUENCY STABILITY AS A FUNCTION OF SUPPLY VOLTAGE (Continued)

TABLE 4

Frequency vs Supply Voltage

Supply Voltage, Vac	Frequency, GHz
134.6	3.0485
128.7	3.0485
122.9	3.0485
117.0	3.0485
111.2	3.0485
105.3	3.0485
99.5	3.0485

The equipment met applicable limits.

APPENDIX A

POWER-BANDWIDTH DETERMINATION

The bandwidth within which 99% of the emission power density occurs was determined by area integration.

The Tektronix 494P spectrum analyzer digitizes the screen into 1000 x 250 data points as Y-axis (frequency) and X-axis (log amplitude) respectively.

To determine the 99% power density, the digitized spectrum plot, Figure 2a, was normalized to the noise baseline and the anti-log taken of each resulting X-axis value. This value, now a linear function, was multiplied by the corresponding Y-axis increment and the successive results summed over the 1000 increment total, resulting in an area value.

Additional summations were made in which successive approximations of less than the full 1000 increment Y-axis (frequency) width were included in the integrated area and the result compared to the original area computation.

When a ratio of 0.99 was detected, the successive approximations were halted and the resulting Y-axis value noted. This value was then scaled back into frequency by using the frequency/division calibration of the plot.

Using this method, 99% power bandwidth was 109.6 MHz.