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ENGINEERING STATEMENT

For Type Certification of

LITTON MARINE SYSTEMS B.V.

Type No. 65820600

FCC ID: BT9BME25

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, B.V., to make Type Certification measurements on the Type No. 65820600 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 Certification are included in this report. It is submitted that the above mentioned device meets FCC requirements and Type Certification is requested.

Rowland S. Johnson

Dated: February 22, 1999

A. INTRODUCTION

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

The Type No. 65820600 is a "X" band marine radar transmitter typically used with model E-180/E-250/E-340 display units for marine radar applications.

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

1. Name of applicant: Litton Marine Sustems, B.V.

2. Identification of equipment: FCC ID: BT9BME25

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

3. Quantity production is planned.

4. Technical description:

   a. 100M2P0N emission (see Appendix A for procedure)
   b. Frequency range: 9300 - 9500 MHz
   c. Rated operating power of the transmitter is 25 kW
   d. The Type No. 65820600 complies with the power limitation of Part 80.
   e. The nominal dc voltage and dc currents at magnetron:

<u>dc voltage</u> (peak)	<u>dc current</u> (peak)
8 kilovolts	8 amperes

   f. Function of each active semi-conductor device: See Appendix 3.
   g. Circuit diagram is included in Appendix 4.
   h. A draft instruction book is submitted as Appendix 5.
   i. The transmitter tune-up procedure is included in Appendix 6.
   j. A description of circuits for stabilizing frequency is included in Appendix 7.
   k. A description of circuits and devices employed for suppression of spurious radiation and for limiting modulation is included in Appendix 8.
   l. (Not applicable)

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

5. Data for 2.985 through 2.997 follow this section B.

6. (Not applicable)
7. (Not applicable)

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

RF power output into a dummy load was measured with a HP X752D directional coupler, HP X382A variable attenuator, and HP432A power meter with HP478A thermocouple sensor.

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

Table 1
RF Power Output

Pulse Setting	Short	Medium	Long	
Measured PRF	1792	1818	833	PPS
Pulse Length (microseconds)	0.052	0.256	0.730	uS
Average Power	2.2	10.5	12.9	W
Duty Cycle (PRF x Pulse Length)	93.1	465.4	608.0	($x10^{-6}$)
Peak Power (Ave. PWR/Duty Cycle)	24.0	22.5	21.2	kW

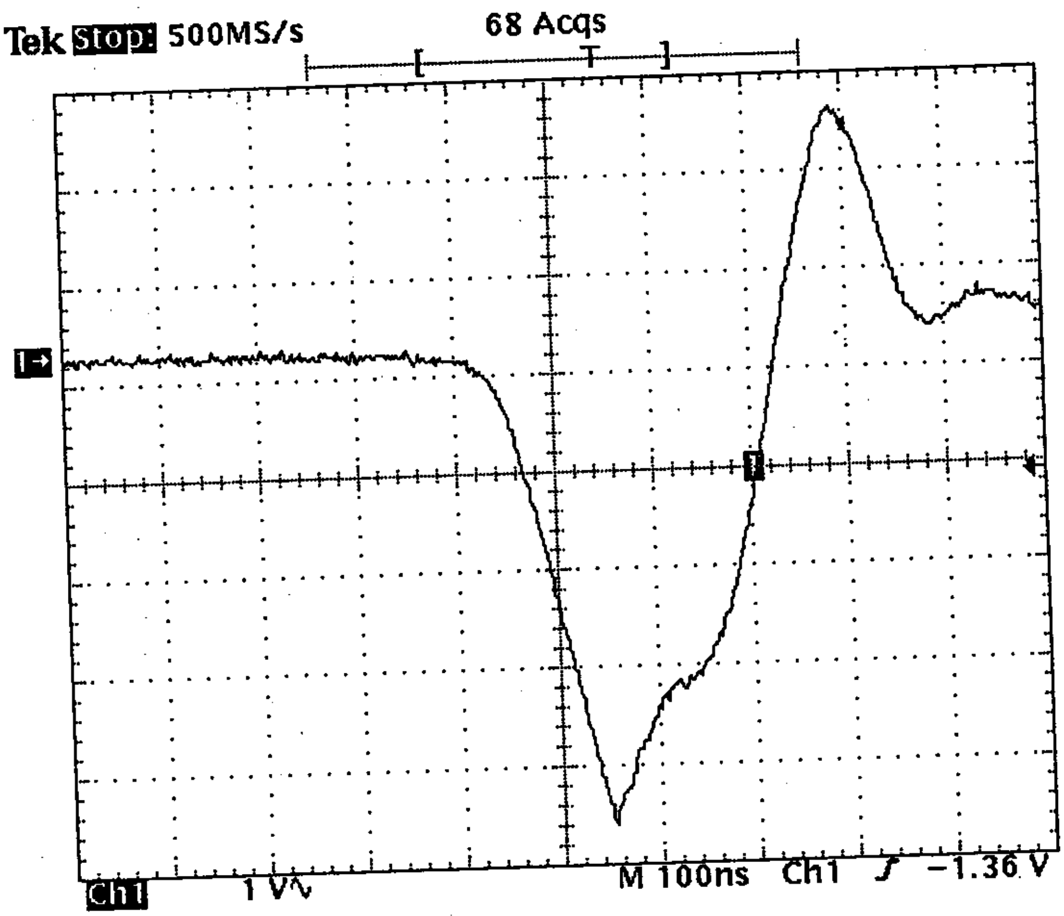
D. MODULATION CHARACTERISTICS (Paragraph 2.987 of the Rules)

1. Magnetron pulse input was measured with a Tektronix TDS360 digital storage oscilloscope and 6015 high voltage probe, and plotted with a HP 7550 plotter. Oscilloscope display for each pulse width are included as Figures 1a, 1b, and 1c for nominal pulse widths of 0.052, 0.256, and 0.730 microseconds respectively.

2. Graphs of occupied bandwidth for nominal pulse widths of 0.052, 0.256, and 0.730 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 the allowed bandwidth as required by Section 2.989. (See Appendix A.)

MAGNETRON CONTROL PULSE



Nominal Pulse Width: 0.052 microseconds

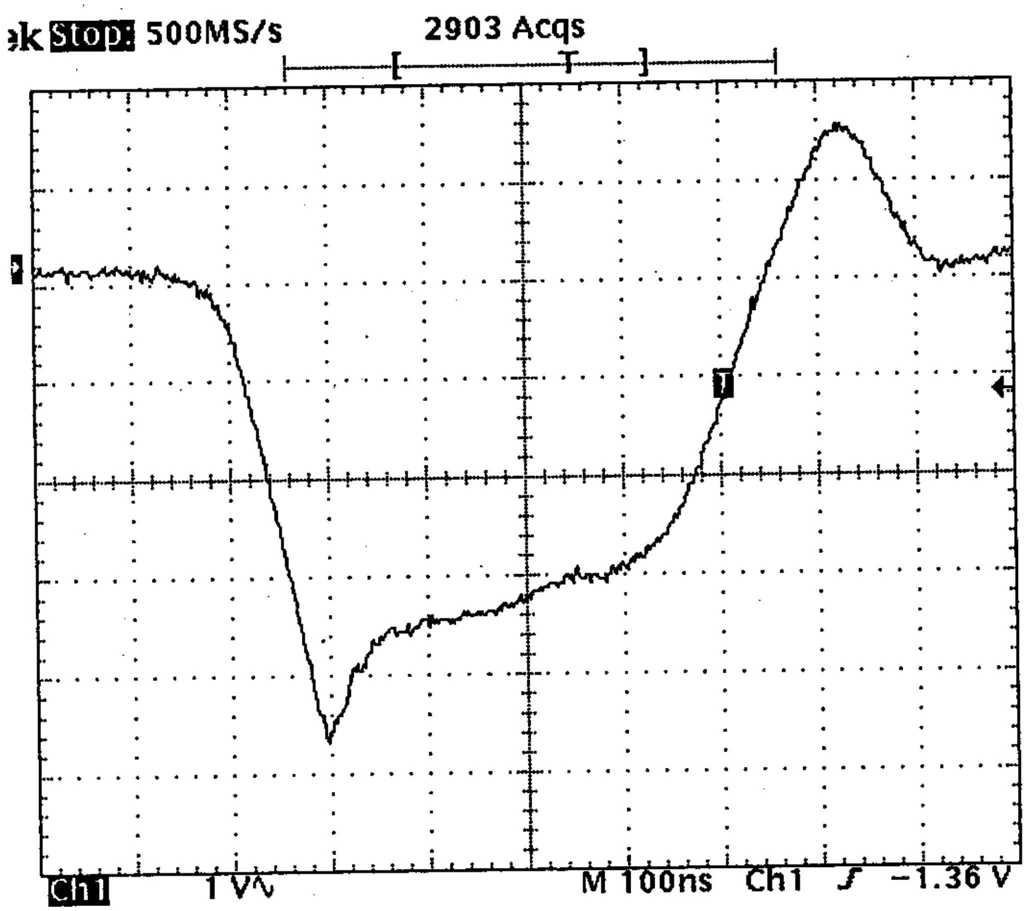
Display:

1000 V per vertical division
100 nanoseconds per horizontal division

MAGNETRON CONTROL PULSE
FCC ID: BT9BME25

FIGURE 1a

MAGNETRON CONTROL PULSE



Nominal Pulse Width: 0.256 microseconds

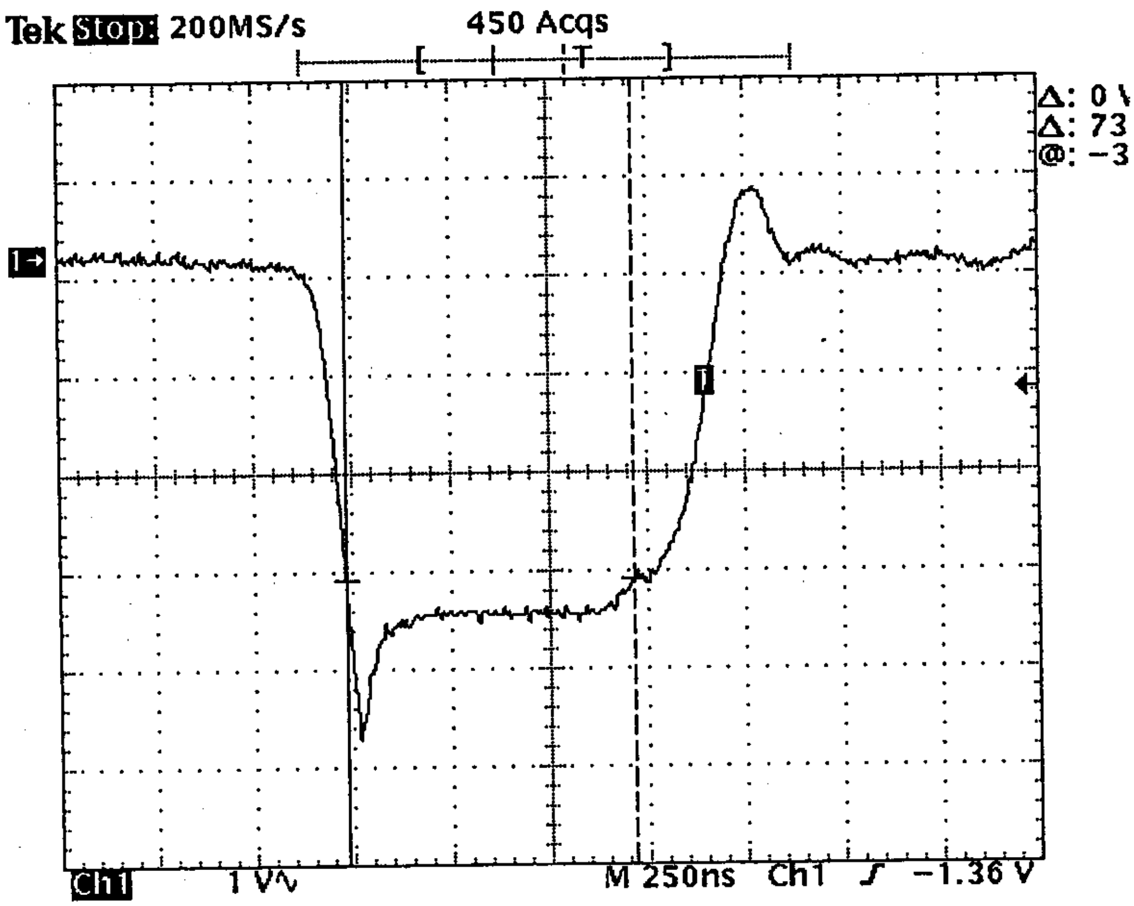
Display:

1000 V per vertical division
100 nanoseconds per horizontal division

MAGNETRON CONTROL PULSE
FCC ID: BT9BME25

FIGURE 1b

MAGNETRON CONTROL PULSE



Nominal Pulse Width: 0.730 microseconds

Display:

1000 V per vertical division
250 nanoseconds per horizontal division

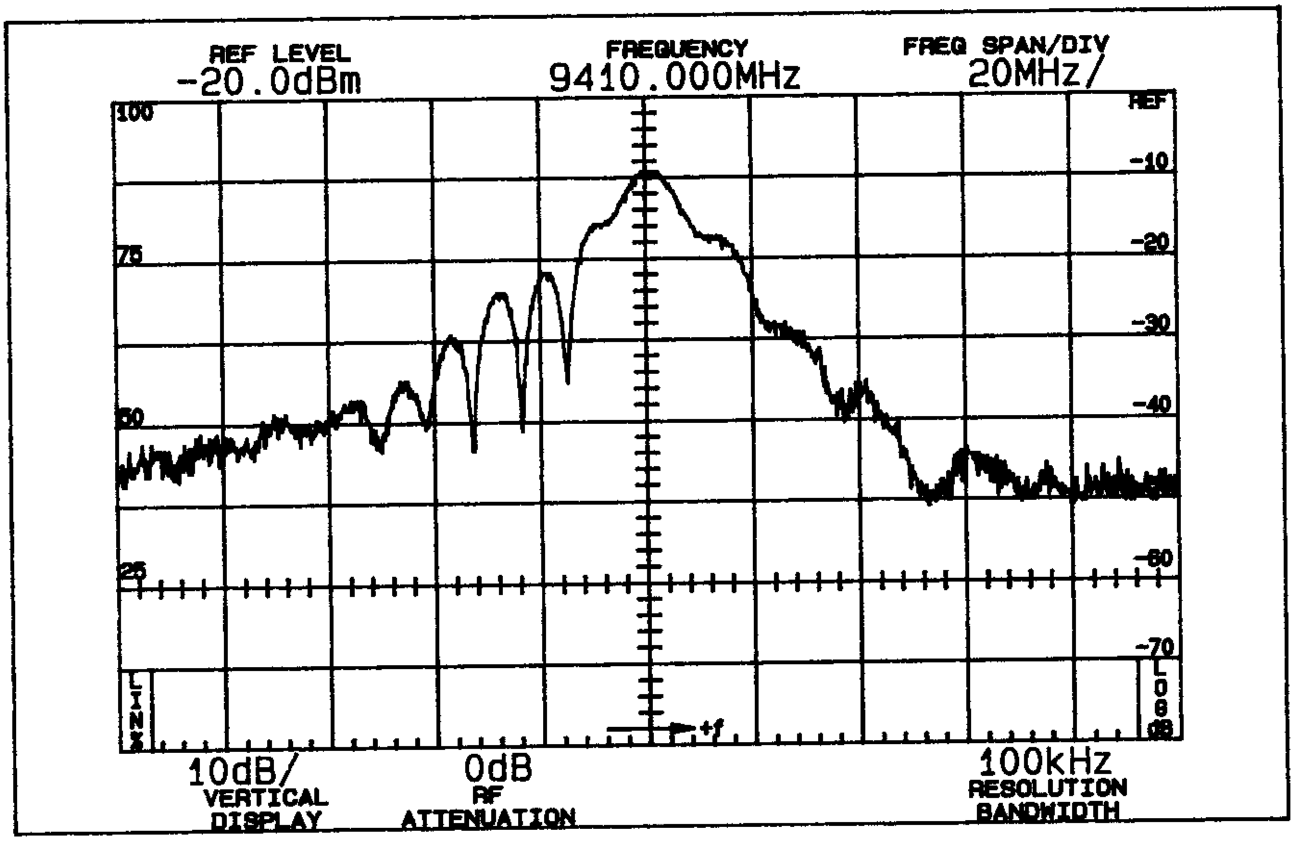
MAGNETRON CONTROL PULSE
FCC ID: BT9BME25

FIGURE 1c

A:\L... .OBW

FIGURE 2a

OCCUPIED BANDWIDTH



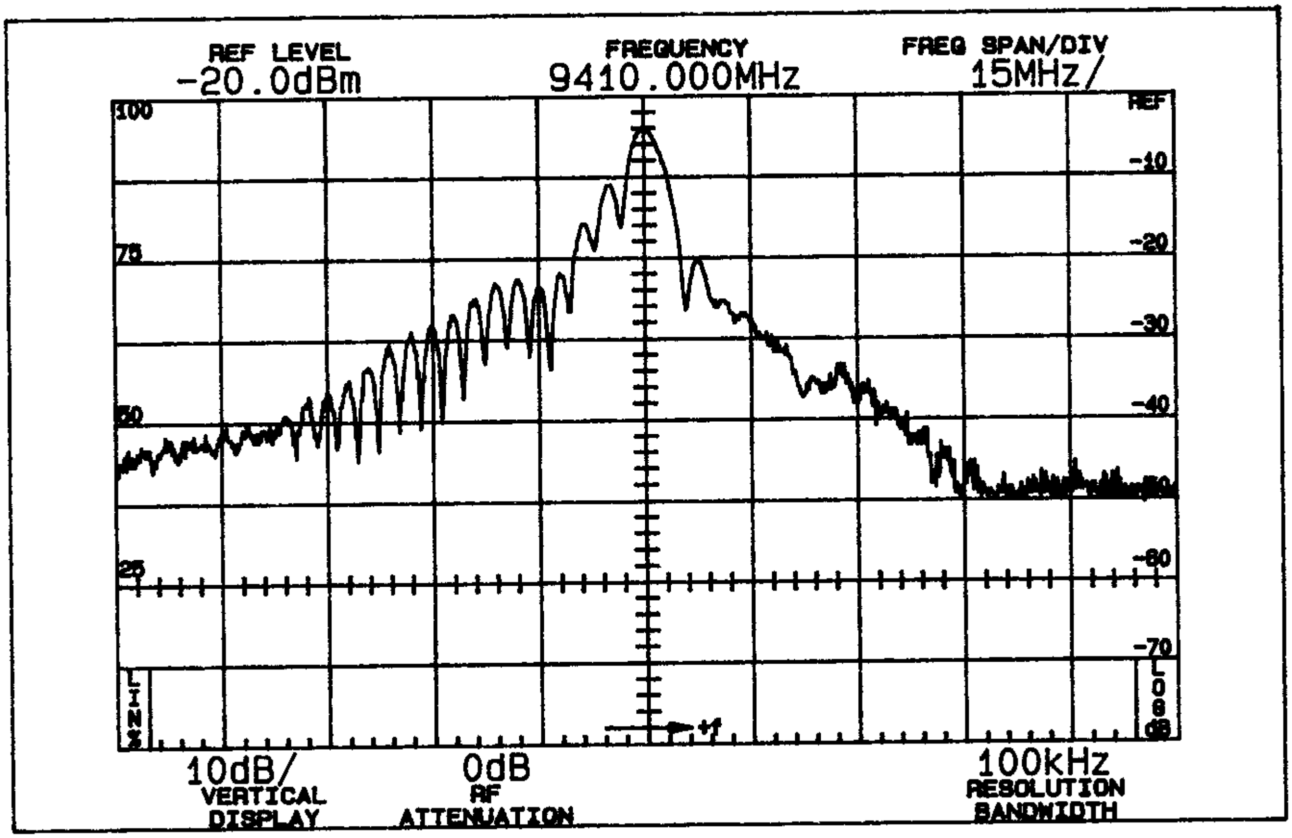
Nominal Pulse Width: 0.052 microseconds; PRF: 1792 Hz

OCCUPIED BANDWIDTH
FCC ID: BT9BME25

FIGURE 2a

TABLE 2b

OCCUPIED BANDWIDTH



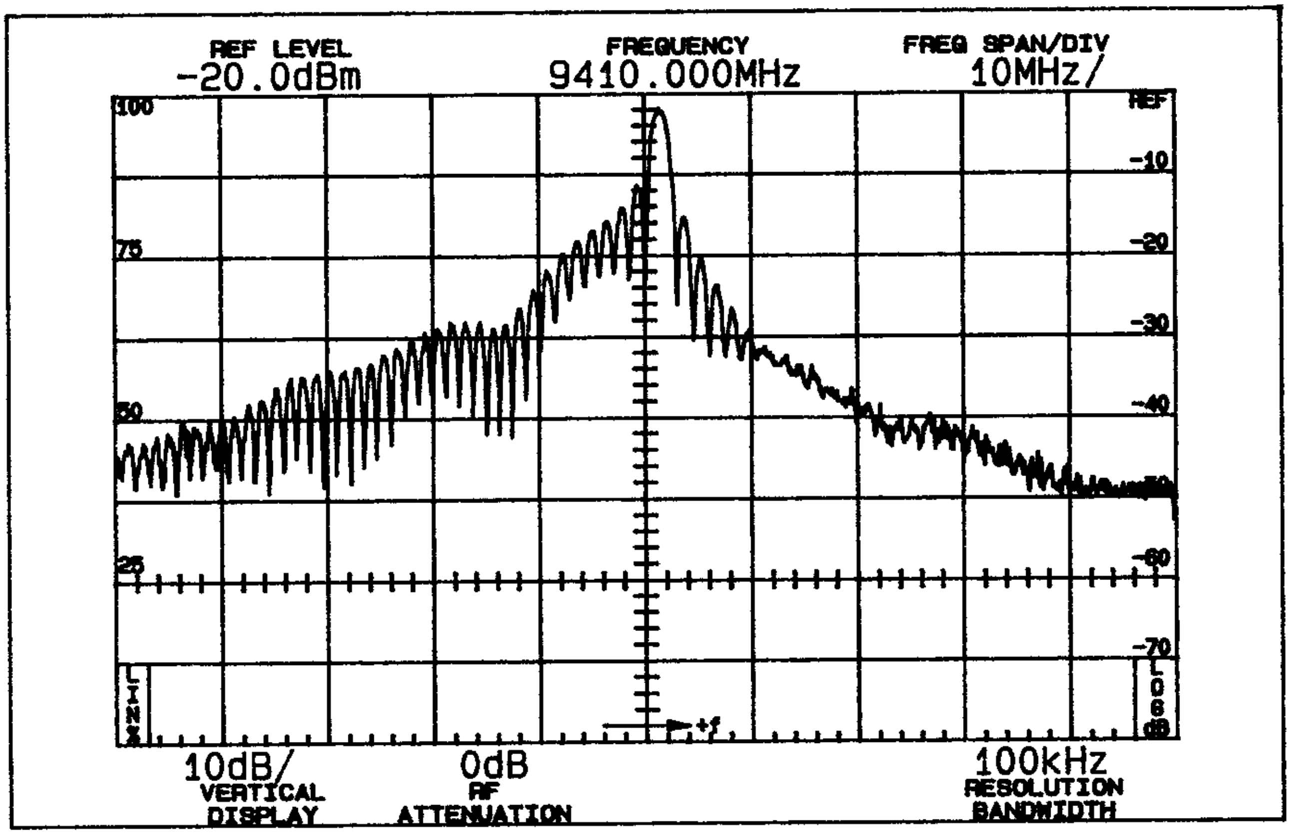
Nominal Pulse Width: 0.256 microseconds; PRF: 1818 Hz

OCCUPIED BANDWIDTH
FCC ID: BT9BME25

FIGURE 2b

TABLE 2c

OCCUPIED BANDWIDTH



Nominal Pulse Width: 0.730 microseconds; PRF: 833 Hz

OCCUPIED BANDWIDTH
FCC ID: BT9BME25

FIGURE 2c

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

The Type No. 65820600 transmitter was tested for spurious emissions while the equipment was modulated with nominal pulse-widths of 0.052, 0.256 and 0.730 microseconds.

Measurements were made with a Tektronix 494P spectrum analyzer coupled to the transmitter output waveguide through a directional coupler. During the tests, the transmitter was terminated in a 50 ohm X-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 nominal pulsewidth			
	0.052	0.256	0.730	(uS)
100 MHz to 40 GHz	*	*	*	
Average power (P)	2.2	10.5	12.9	(W)
Required Attenuation				
43 + 10LogP	47	53	54	(dB)

*No signals were observed above analyzer noise floors: (100 kHz RBW to 1 GHz, then 1 MHz RBW)

100 KHz	-	1.8 GHz	-98 dBm	5.4 GHz	-	18 GHz	-70 dBm
1.7 GHz	-	5.5 GHz	-83 dBm	15 GHz	-	21 GHz	-65 dBm
3.0 GHz	-	7.1 GHz	-83 dBm	21 GH	-	40 GHz	-56 dBm

E. 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, Polarad CA-L Horn from 1 to 2.4 GHz, EMCO 3115 double-ridged horn from 2 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 (continued)

Reference level for the spurious radiation was taken as an ideal dipole excited by 12.9 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 $E = \frac{(49.2x12.9)^{1/2}}{3} = 5.2$ V/M

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

5.2 volts/meter = $5.2x10^6$ uV/m

dBu/m = 20 $Log_{10}(5.2x10^6)$

= 134 dBu/m

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

134 - 107 = 27 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.

No spurious emissions were observed.

*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 -20°C to 50 °C. At each temperature, the frequency determining circuitry of the transmitter was exposed to test chamber ambient a minimum of 60 minutes after indicated chamber temperature ambient had stabilized to within ±2° of the desired test temperature. Following the 1 hour 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

Temperature, °C	Output Frequency, GHz
-20.1	9.4069
-10.6	9.4092
- 0.1	9.4096
10.9	9.4104
22.3	9.4100
30.9	9.4096
42.2	9.4098
50.4	9.4109

Maximum excursion of the transmitter was 9.4069 and 9.4109 GHz for the temperature extremes. FCC Rule 80.209(b) 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 9300-9500 MHz, and worst-case 1.5 T is 29 MHz (0.052 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

Supply Voltage	Frequency, GHz
134.55	9.4100
128.70	9.4100
122.85	9.4100
117.00	9.4100
111.15	9.4100
105.3	9.4100

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 100.2 MHz.