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San Diego, CA 92127
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DATE: April 11, 2000

Federal Communications Commission
Equipment Approval Services
P.O. Box 358315
Pittsburgh, PA 15251-5315

Attention: Authorization & Evaluation Division
Applicant: Single Chip Systems Corporation
Equipment: FCC ID: MKR S556
FCC Rules: 90.35

Gentlemen:

Enclosed please find Test Data Report and all pertinent documentation, the whole for type acceptance of the referenced equipment as shown.

Should you need any further information, kindly contact the writer at Single Chip Systems Corporation.

Sincerely yours,

Eric Mikuteit, Sr. RF Engineer
Single Chip Systems Corporation
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TEST REPORT FOR TYPE ACCEPTANCE

of

TRANSCEIVER MODEL S556

FCC ID MKR S556

to

FEDERAL COMMUNICATIONS COMMISSION

Date of Report: April 11, 2000

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INTRODUCTION

The following information is formatted in accordance with the items required for FCC type acceptance as called out in 47 CFR 2.1033. This application is for a transceiver, or scanner, which is part of an RF ID system, to be used in licensed sites under 47 CFR 90.35. The scanner generates an RF signal between 2.453 and 2.481 GHz. This signal is used to power and communicate with a passive label. The scanner uses externally connected antennas to radiate and receive RF energy. The scanner can selectively multiplex between 1 to 6 antennae. The number of antennae is user configurable depending on the application requirements. The scanner connects to the antennae using 2 flexible coaxial cables. One cable connects to the transmit side of the antenna, and the other connects to the receive side. Single Chip Systems intends to sell 2 types of antennae which have either 7.5 dBi or 8.5 dBi of gain. Again, the number and type of antennae used will depend on the user's application requirements.

1. Applicant

   Single Chip Systems Corporation
   10905 Technology Place
   San Diego, CA 92127
   Ph: (858) 485-9196
   Fx: (858) 485-0561

   The applicant is the manufacturer of the equipment.

2. FCC Identifier
   The unit shall have the FCC identifier MKR S556.

3. Installation and Operating Instructions
   The operation manual for the MKR S556 is in the process of being written. Enclosed, as an attachment, is a draft copy of the manual.

4. Type of Emission
   The MKR S556 type of emission is K1D, with a necessary bandwidth of 714 K.

5. Frequency Range
   The tuned carrier frequency range is 2.453-2.481 GHz.

6. Range of Operating Power
   The output power of the MKR S556 is adjusted to 5 watts at the RF output terminals during final assembly.

7. Maximum Power Rating
   FCC part 90.205(l) permits 5 watts in the 2.450-2.4835 GHz frequency range.

8. DC Voltages and Currents
   The final amplification stage of the unit operates from 12 VDC and draws 4.0 amps of current.

9. Tuning Procedure
   During finally assembly, the site licensed frequency is burned into the unit's flash memory. With the frequency set, the RF signal amplitude will be set, at the manufacturing location, such that the output power will not exceed 5 watts at the RF output terminals over specified operating conditions. This power level will be verified, and readjusted if necessary, at the installation location.

10. Circuit Diagrams and Descriptions
    The top level circuit diagram for the entire system is shown below in Figure 1.

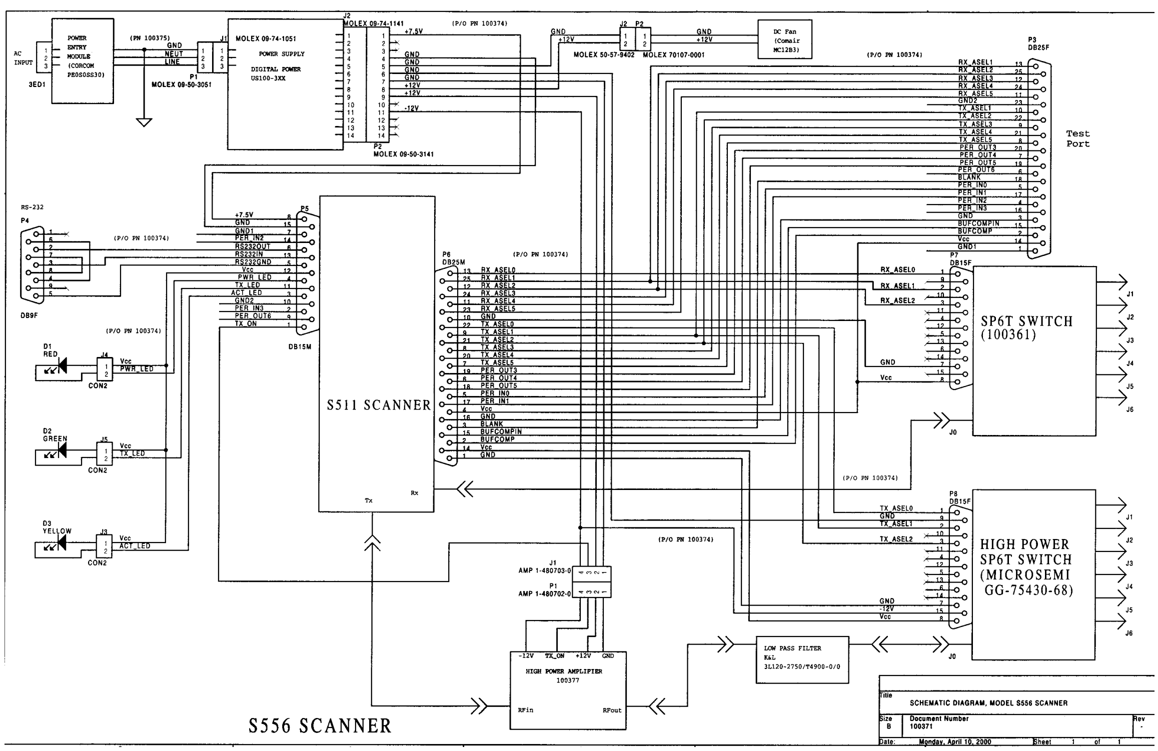


Figure 1. MKR S556 Top Level Schematic Diagram

A. Description of frequency determining circuitry
   The RF frequency is generated using a phase locked loop (PLL) circuit. The licensed frequency data is burned into flash memory. At startup the microprocessor sends the PLL integrated circuit (National Semiconductor's LMX2325TM) the serial information for the set frequency. The PLL IC uses a 20 MHz crystal oscillator as a reference frequency. The PLL IC generates a voltage for the voltage controlled oscillator (VCO). The VCO generates the RF signal, which is fed back to the PLL IC. The PLL IC divides this signal down, and

compares it to the 20 MHz reference. In the closed control loop, the PLL IC's output voltage is adjusted to precisely maintain the set frequency.

B. Description of circuitry used for spurious, modulation and power limiting
The MKR S556 RF output is on/off modulated. This modulation is accomplished using the analog gain control pin of an RF amplifier (RF Micro Devices RF2126). This gain control is set with a discrete signal from the field programmable gate array (FPGA). An RC filter on this line provides transmission bandwidth limiting. Spurious emissions are limited by a 3 section, low-pass filter located at the output of the final RF amplifier. The RF output power level is set using an analog control voltage in the amplification stage prior to the final amplifier. During final assembly, a digital potentiometer is adjusted to provide a desired output power at the RF output port. The digital potentiometer value that corresponds to the desired output power is then burned into flash memory.

C. Description of Modulation technique and circuitry
The MKR S556 Transceiver uses an RF on/off modulation scheme. The RF signal powers the ID tag in the field, and then communicates with the tag by briefly turning off the RF power at the proper time. The waveform timing and duty cycle depend on the transmitted symbol. There are 3 transmitter waveforms. The transceiver is either sending just a clock, sending a logic "0", or sending a logic "1". Figure 1 shows the timing for each of these waveforms. The range of time for the next frame of data or clock varies as a function of the interrupt latency of the microprocessor. The modulation either has the RF at full strength in the "on" state, or attenuated by at least 20 dB in the off state. Any time the scanner is normally operating, the RF signal is continuously being modulated. The system is operating CW (unmodulated) only when the transceiver is instructed to operate as such, via operator command. The sequence of clock, logic "0" and logic "1" information being transmitted is completely dependent on the commands issued by the processor, and by the tag responses.

The modulation of the signal is controlled with a digital pulse sequence from the FPGA. This signal is RC filtered to limit the transmission bandwidth, and then is sent to the analog gain control of an RF amplifier. The RF amplifier attenuates the RF signal by a minimum of 20 dB when in the "off" state.

11. Equipment Identification Plate

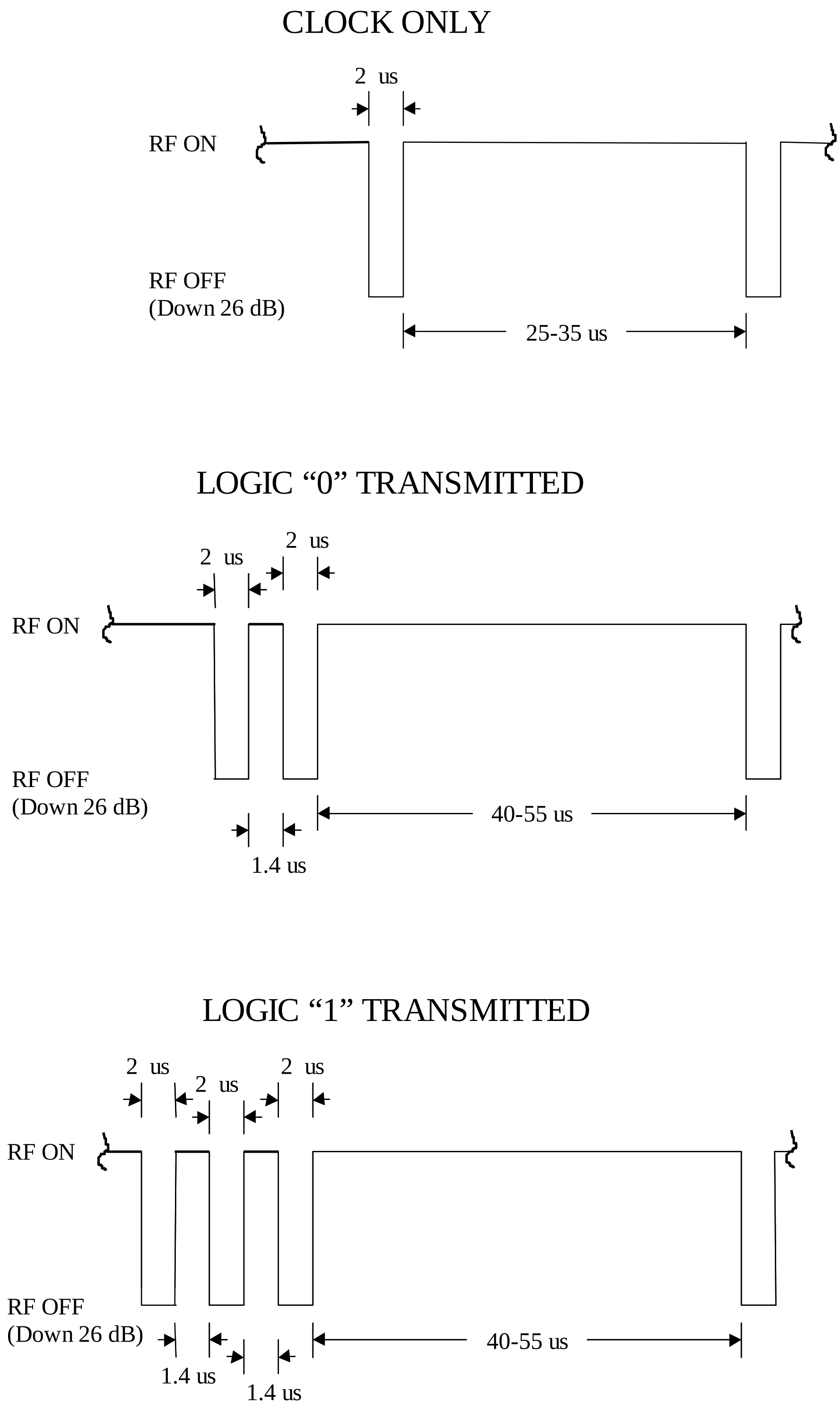
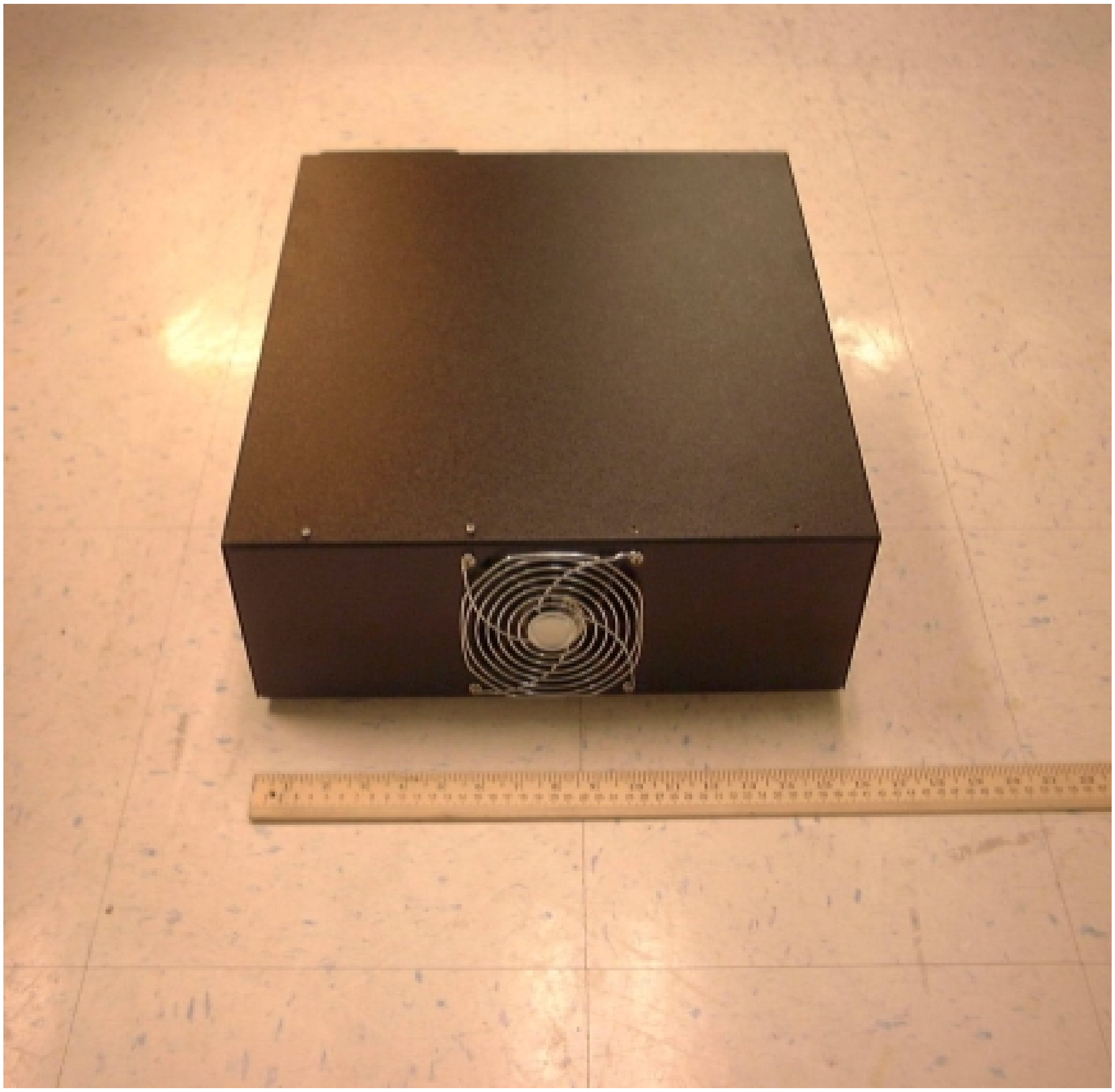


Figure 1. Modulation Modes of the MKRS556 Transceiver

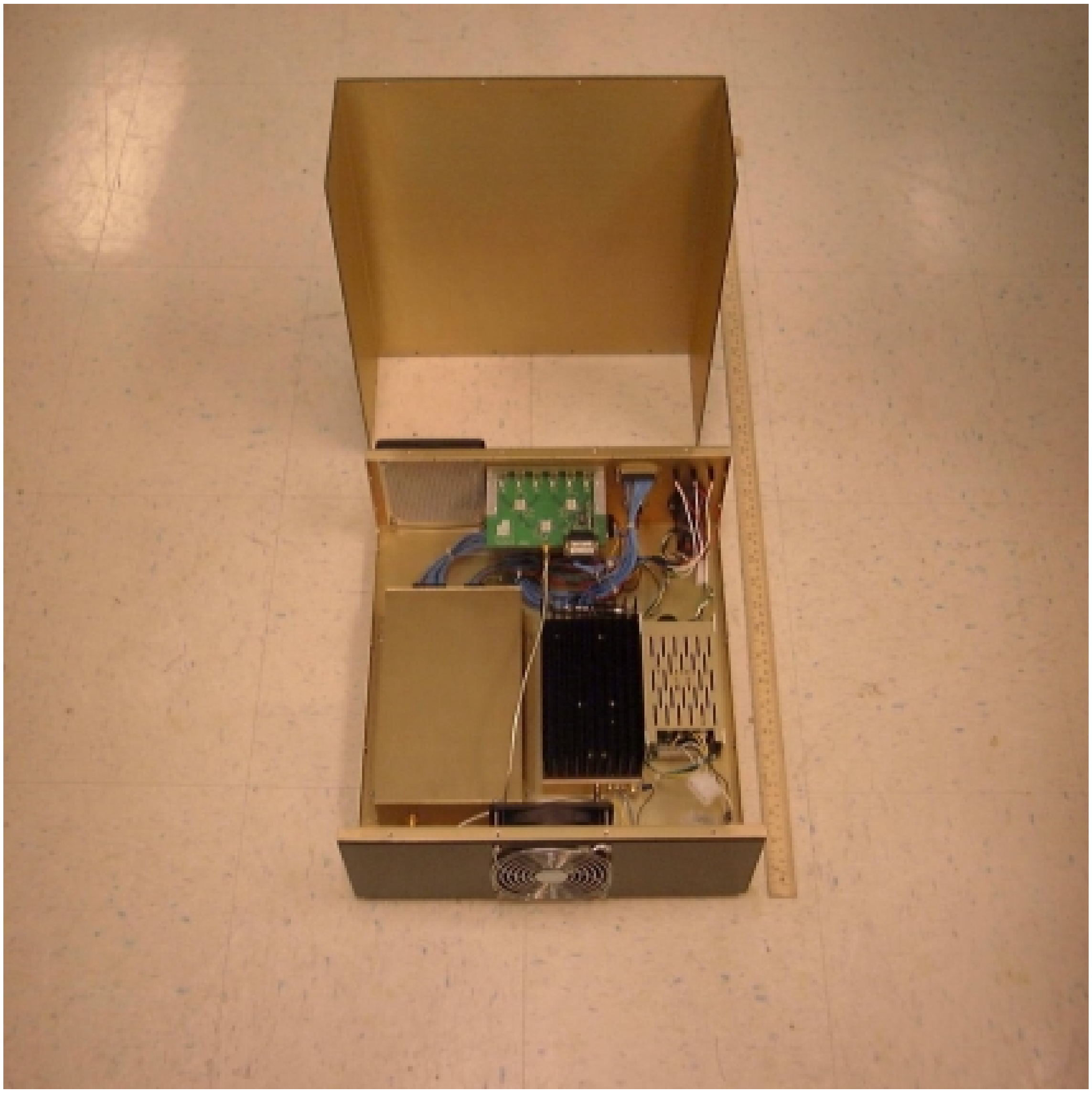
12. Photographs

Photographs showing the equipment construction and layout are shown below.

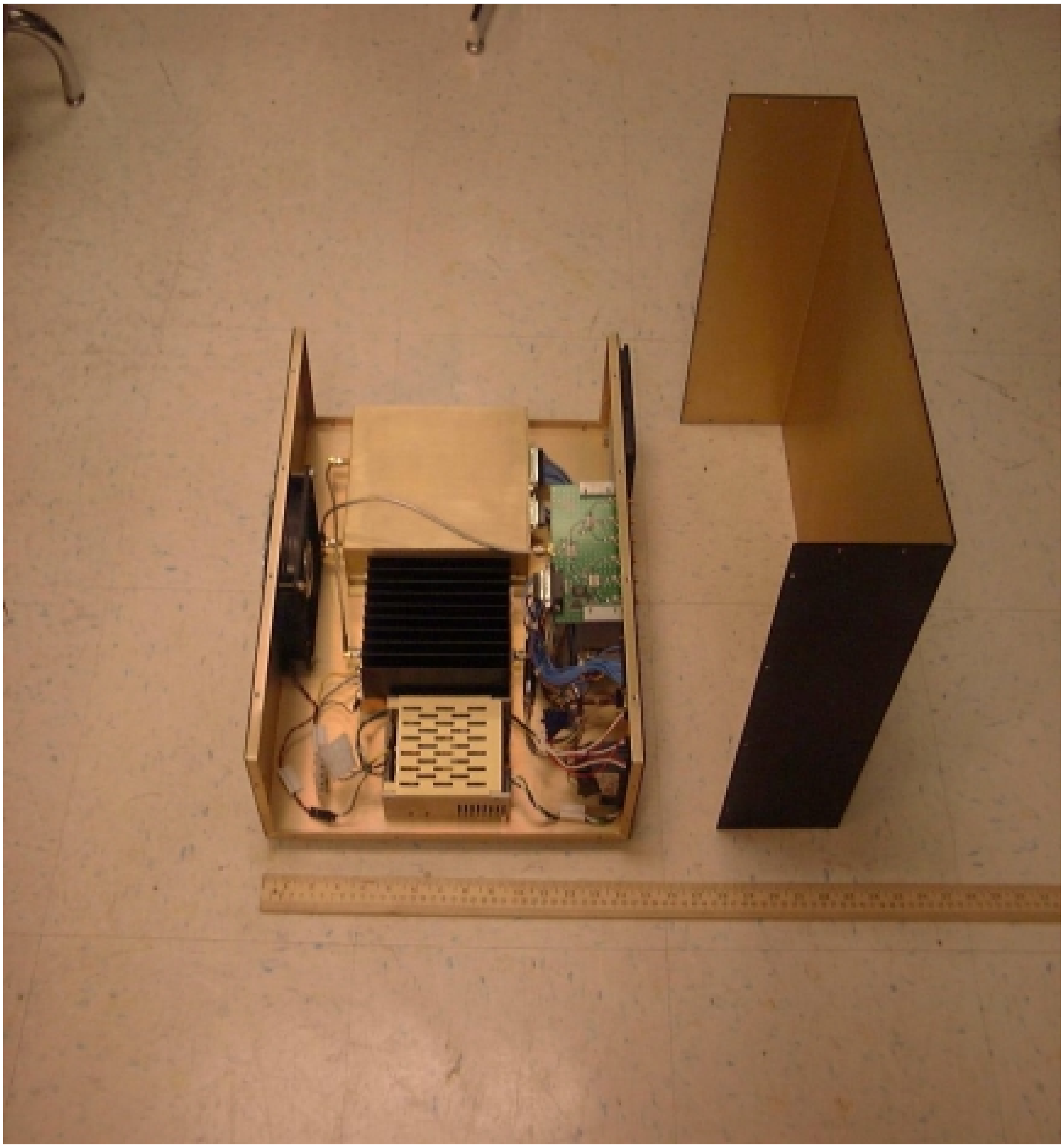
Front View of MKR S556 Scanner



Rear View of MKR S556 Scanner



Top View of MKR S556 Scanner



Side View of MKR S556 Scanner

13. N/A

14. Testing Data

A. RF Output Power (47 CFR 2.1046)

The requirement for RF output power is listed in 47 CFR 90.205(l) as 5 watts maximum, measured at the RF output terminals. Data was taken at the RF output terminals at 2 frequencies (low and high) with the carrier unmodulated into a 5 ohm load. The spectrum analyzer plots are shown in Figures 2, and 3. The results are tabulated below:

FREQUENCY (GHz)	OUTPUT POWER (dBm)	OUTPUT POWER (W)
2.453	36.4	4.37
2.481	36.8	4.79

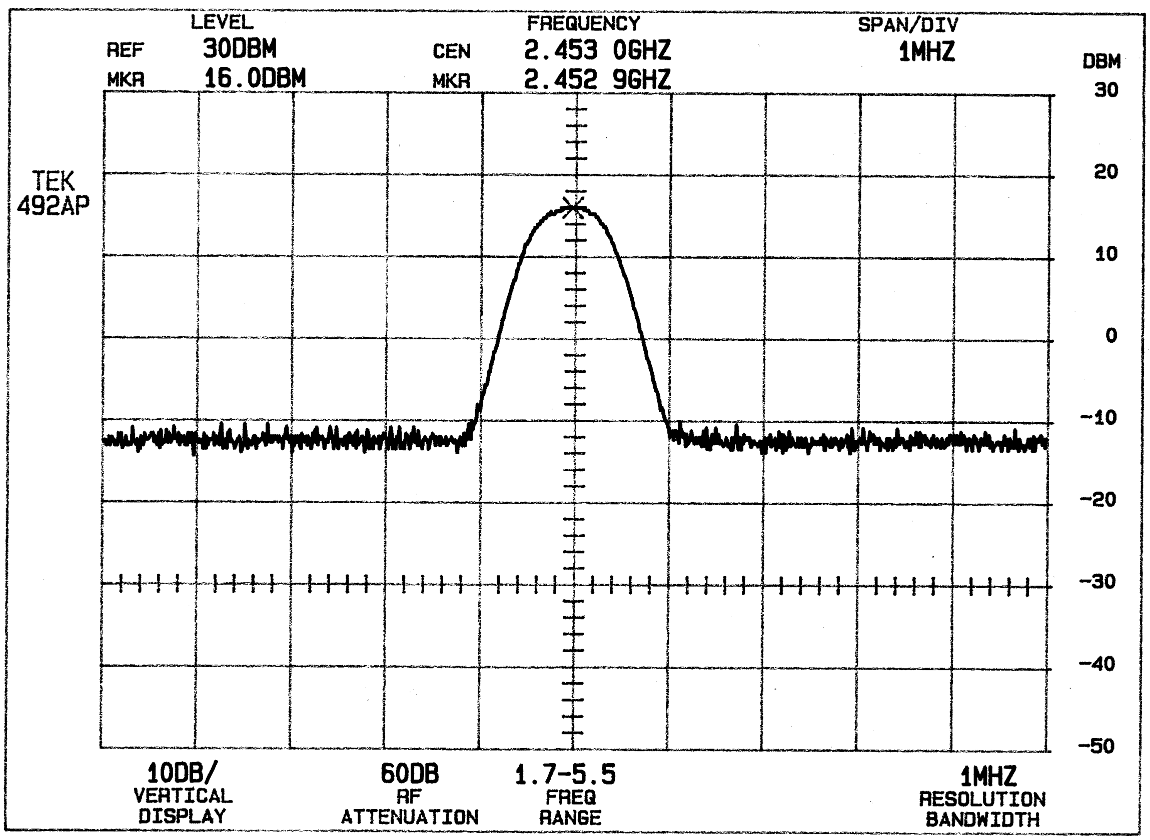


Figure 2. RF Output Power at Lowest Tuned Frequency (2.453 GHz)

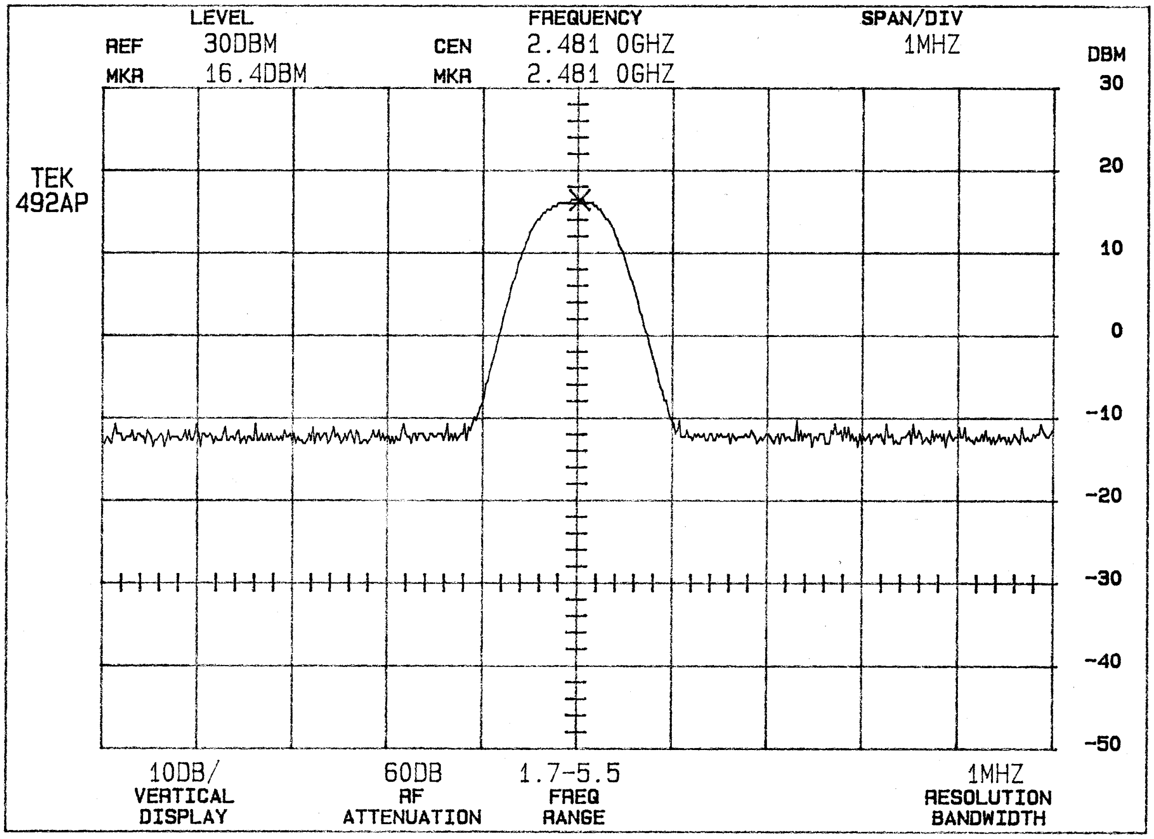


Figure 3. RF Output Power at High Frequency (2.481 GHz)

B. Occupied Bandwidth (47 CFR 2.1049)

Since 47 CFR 90.209(a)(5) has no authorized bandwidth designated for the 2.450 to 2.483 GHz range, the requirement for the occupied bandwidth is that the signal be down by 43+10*log(power) from the unmodulated carrier at the band edges. For a 5 W output, the requirement is for the sidebands to be 50 dB lower than the peak at the band edges. Data was taken at the band edges with the carrier located at the low and high extreme frequencies. Figure 4 shows the spectrum analyzer plot with the carrier at the lowest frequency location. The marker shows the signal is 50.4 dB below the peak at the band edge. Figure 5 shows the spectrum analyzer plot with the carrier at the highest frequency location. The marker amplitude at the band edge is 50 dB below the peak at the band edge.

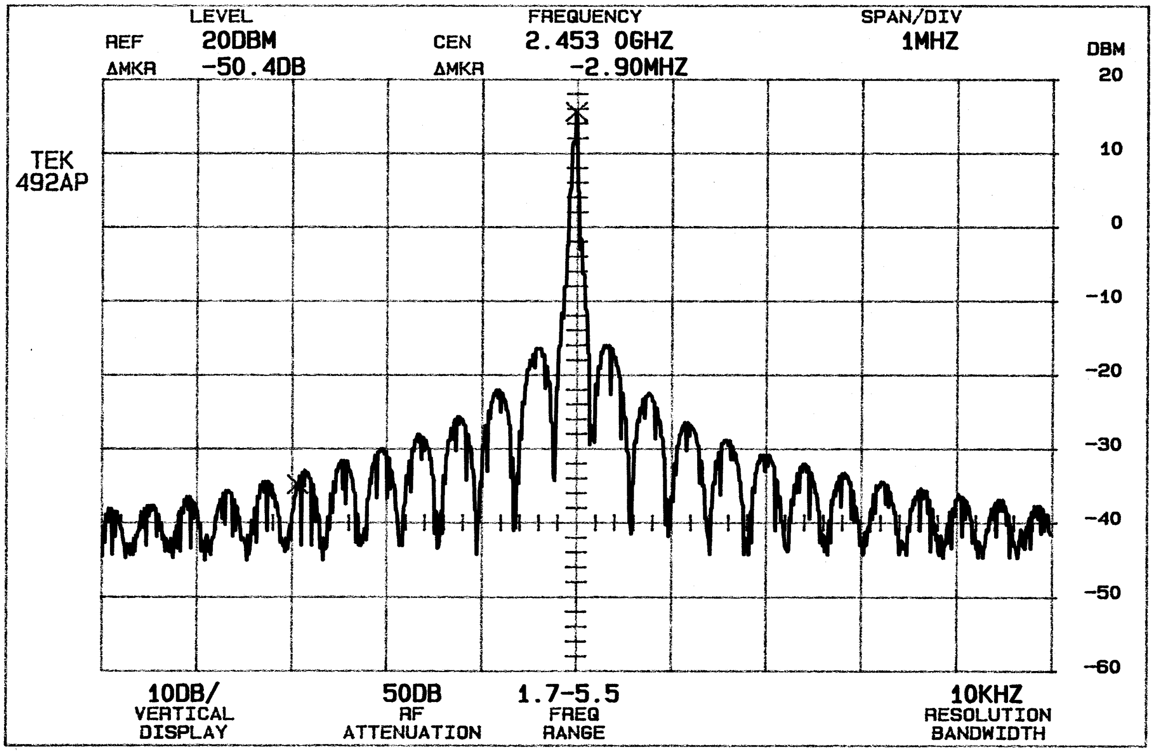


Figure 4. Modulated Bandwidth at Low Frequency Band Edge (2.450 GHz)

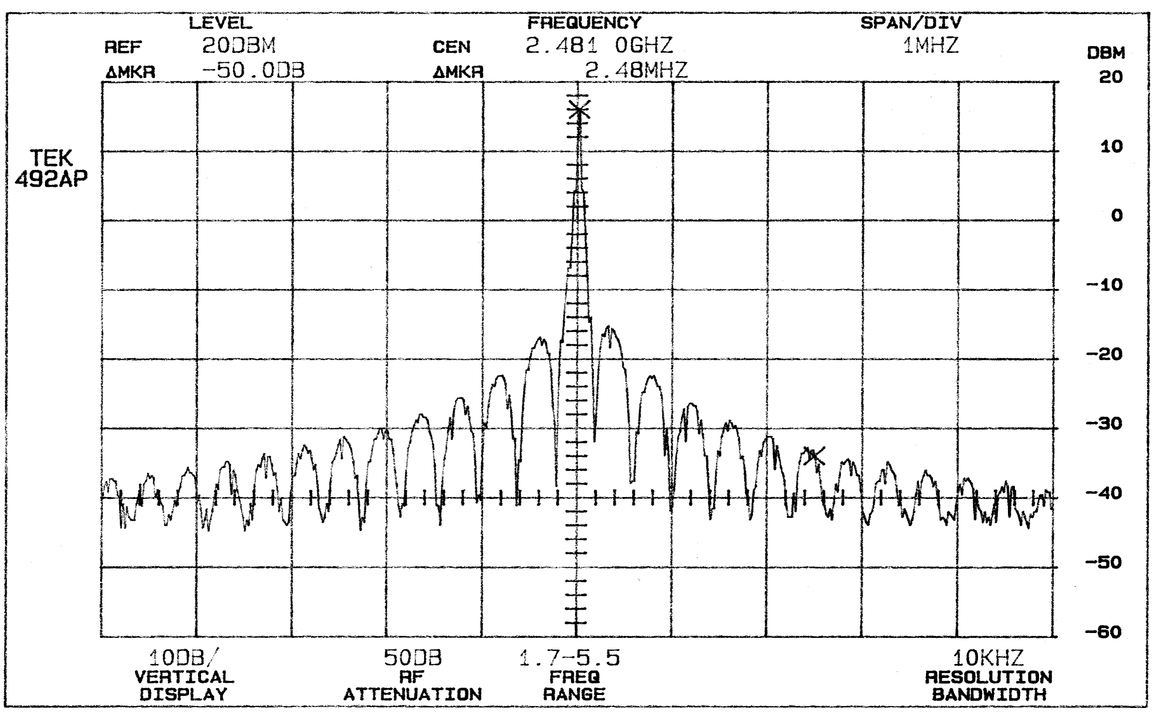


Figure 5. Modulated Bandwidth at High Frequency Band Edge (2.483 GHz)

C. Conducted Spurious Emissions (47 CFR 2.1051)

47 CFR 90.210(c)(3) states that requirement for spurious emissions is the signal be down by 43+10*log(power) from the unmodulated carrier. The data was taken at the RF output terminals for this test. The only spurious emissions seen were the harmonics of the carrier. The results are shown in the following table, with the amplitude as the delta between the unmodulated carrier and the harmonic signal:

HARMONIC	RELATIVE SIGNAL AMPLITUDE	
	LOW FREQ. (2.453 GHz)	HIGH FREQ. (2.481 GHz)
2^{ND}	57.2	58.0
3^{RD}	59.6	59.6
4^{TH} - 10^{TH}	> 80 dB	> 80 dB

The spectrum analyzer plots for the 2^{nd} and 3^{rd} harmonics are included in Figures 6 to 9.

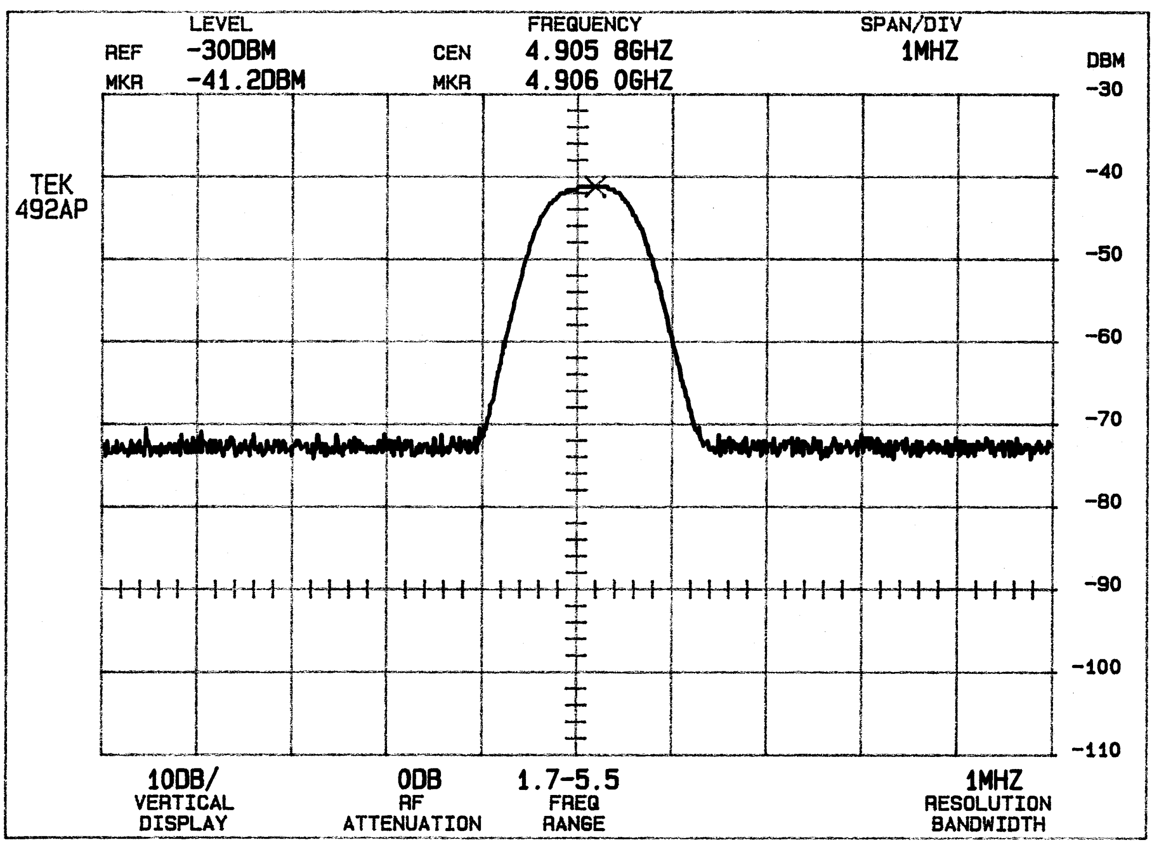


Figure 6. Conducted Second Harmonic at Low Frequency (2.453 GHz)

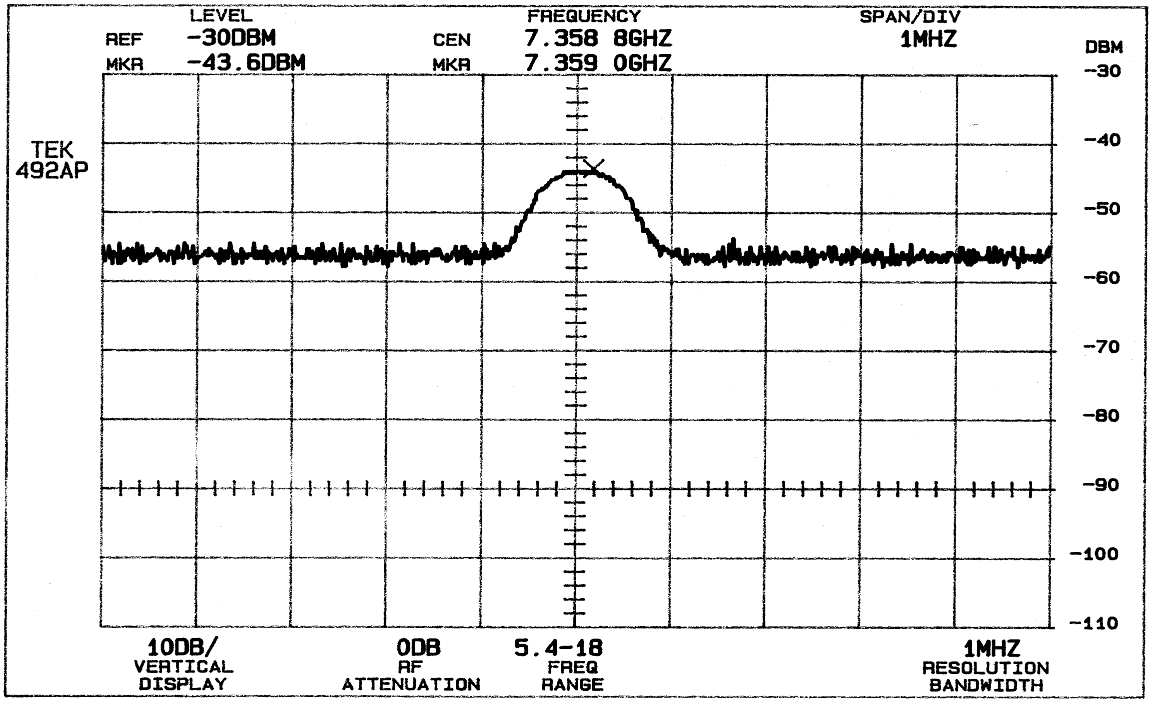


Figure 7. Conducted Third Harmonic at Low Frequency (2.453 GHz)

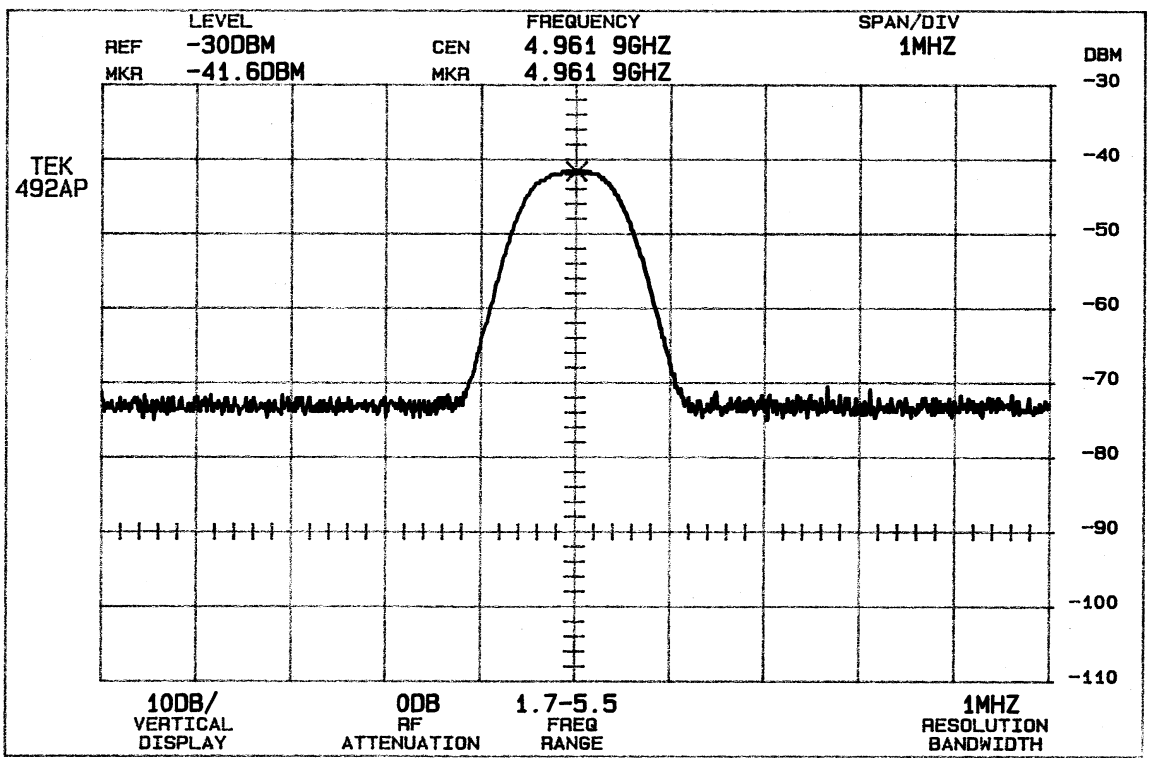


Figure 8. Conducted Second Harmonic at High Frequency (2.481 GHz)

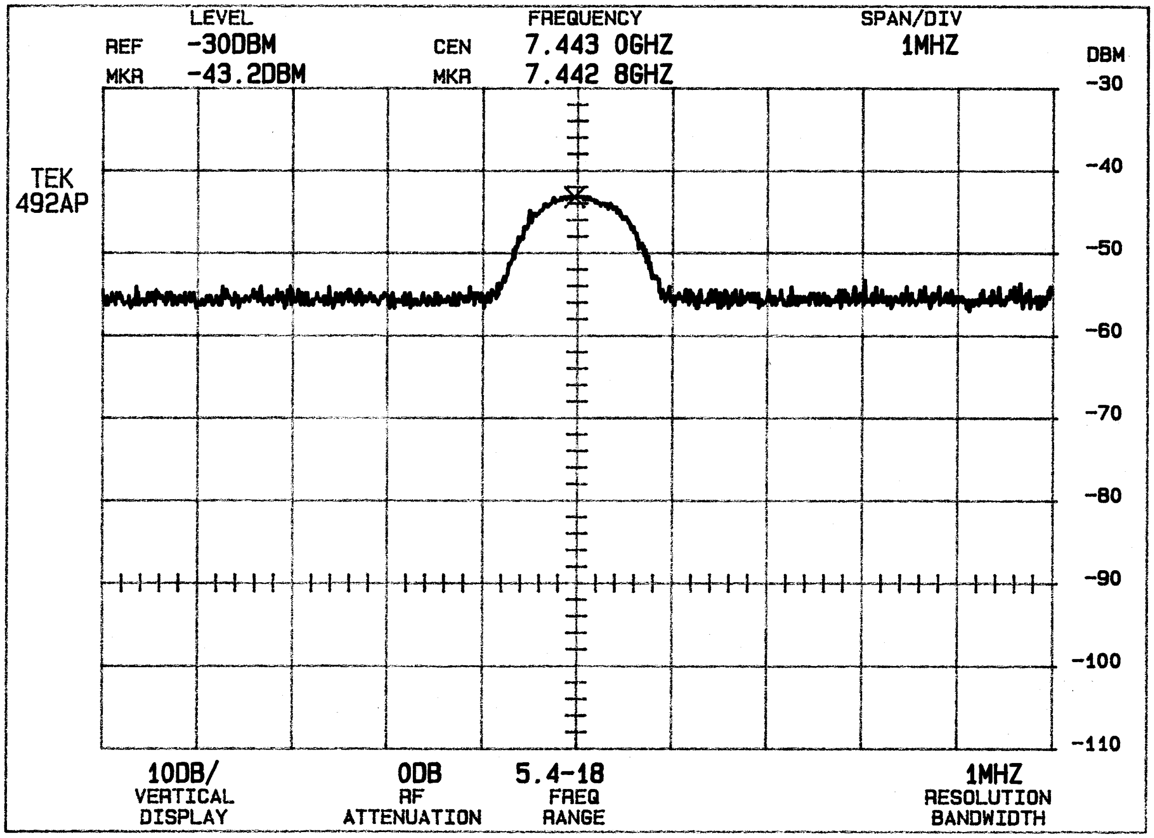


Figure 9. Conducted Third Harmonic at High Frequency (2.481 GHz)

D. Field Strength of Spurious Emissions (47 CFR 2.1053)

The field strength requirements for the radiated emissions are broken into low frequency (below 1 GHz) and high frequency (from the carrier to 10th harmonic) sections. The low frequency requirement is 47 CFR 15.209 emission limits. The high frequency requirement is for emissions be down by 43+10*log(power) from the carrier.

The field strength measurements were taken on an FCC certified outdoor open area test site at TUV's San Diego facility using the worst case configuration. Figure 10 shows the listed results of the low frequency emissions. All emissions had at least 2.7 dB of margin.

The high frequency emissions were examined near the low and high carrier frequency settings (2.452 GHz and 2.480 GHz). Similar to the low frequency case, the worst case emissions configuration used. The tabulated results are shown in Figure 11. Similar to the conducted case, the 2nd and 3rd harmonics are down by more than 50 dB from the fundamental with a minimum of 9.39 dB of margin, and all higher harmonics are below the fundamental by more than 80 dB.

REPORT No: S0135 SPEC: FCC Part 15 para 15.109(b)

CUSTOMER: Single Chip Systems TEST DIST: 10 Meters

E U T: MKRS 556 TEST SITE: 1

EUT MODE: Transmit 5W into dummy load BICONICAL: 738

DATE: 31-Mar-00 TESTED BY: J Owen LOG PERIODIC: 738

NOTES: Quasi-Peak with 120 KHz measurement bandwidth. RCVR: 466

Temperature: Relative Humidity:

EUT MARGIN -2.7 dB at 47.48 MHz ver 1.8

FREQUENCY (MHz)	VERTICAL measured (dBuv)	HORIZONTAL measured (dBuV)	CORRECTION FACTOR (dB/m)	MAXIMUM CORRECTED (dBuV/m)	SPECIFIED LIMIT (dBuV/m)	EUT MARGIN (dB)	EUT ROTATION (degrees)	ANTENNA HEIGHT (meters)
46.30	16.9	9.5	18.0	**34.9**	39	-4.1	300	1
47.48	18.5	9.1	17.8	**36.3**	39	-2.7		
75.48	23.2	16.8	9.9	**33.1**	39	-5.9		
145.18	15.1	16.9	11.4	**28.3**	43.5	-15.2	300	1
182.98	17.6	21.3	12.7	**34.0**	43.5	-9.5		

Figure 10. Low Frequency Emissions List

REPORT No: S0135 TESTED BY: J Owen

SPEC:

CUSTOMER: Single Chp Systems

TEST DIST: 3 Meters

E U T: MKRS 556

TEST SITE: 3

EUT MODE: Transmit 5W

BICONICAL: N/A

DATE: 31-Mar-00

LOG: N/A

NOTES: Duty Cycle=

OTHER: 251

XMT to ant.

RBW + VBW = 1MHz

v.beta

FREQ (MHz)	VERTICAL (dBuv)		HORIZONTAL (dBuv)		CORRECTION FACTOR (dB/m)	MAX LEVEL (dBuV/m)		SPEC LIMIT (dBuV/m)		MARGIN (dB)		EUT Rotation	Antenna Height
	pk	av	pk	av		pk	av	pk	av	pk	av		
2452	101.8		107.8		33.6	**141.4**				141.4			
4904	39.6		37.1		42.4	**82.0**		91.4		-9.39			
7356	29.2		27.7		47.2	**76.4**		91.4		-15			
9808	14.4		14.7		49.8	**64.5**		91.4		-26.9			
2466	104.6		108.2		36.2	**144.4**				144.4			
4932	32.9		32.4		42.5	**75.4**		94.4		-19			
7398	27.2		29.4		47.3	**76.7**		94.4		-17.7			
9864	17.2		16		49.9	**67.1**		94.4		-27.3			
2480	103.7		109.1		36.3	**145.4**				145.4			
4960	36.9		37.1		42.6	**79.7**		95.4		-15.7			
7440	29.3		28.2		47.4	**76.7**		95.4		-18.7			
9920	16.6		16.8		49.9	**66.7**		95.4		-28.7			

Figure 11. High Frequency Radiated Emissions List

E. Frequency Stability (47 CFR 2.1055)

The frequency stability of the High Power Scanner was measured from -30°C to +50 °C in 10 ° increments. At each temperature data was collected with the nominal 120 VAC, 60 Hz input voltage set 15% low and then set 15% high. The voltage variation had no effect on the frequency. This can be attributed to dual regulation on the DC voltage which feeds the frequency controlling circuits. The input voltage goes through a switching power supply to create the basic DC voltage, and then through a linear voltage regulator.

A table of the results is shown below. The spectrum analyzer plots, at each temperature and voltage level, are available if requested, but were not included.

TEMPERATURE (°C)	FREQUENCY (GHz)	FREQUENCY DELTA FROM –30 °C (KHz)
-30	2.463997	N/A
-20	2.464000	+3
-10	2.464001	+4
0	2.463998	+1
10	2.463991	-6
20	2.463986	-11
30	2.463984	-13
40	2.463987	-10
50	2.463995	-2

From the table, it can be seen that the maximum frequency variation was 17 KHz. This translates into a frequency drift of 6.9 parts per million.