SCS Corporation
10905 Technology Place
San Diego, CA 92127
Phone: 619.485.9196
Fax: 619.485.0561

DATE:

Federal Communications Commission: MKRS556-EP
Equipment Approval Services
P.O. Box 358315
Pittsburgh, PA 15251-5315

Attention: Authorization & Evaluation Division
Applicant: Single Chip Systems Corporation
Equipment: FCC ID: MKRS556-EP
FCC Rules: 90.35

Gentlemen:

Enclosed please find the 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,

Gary Bann, RF Engineer
Single Chip Systems Corporation
PH: (858) 485-9196 x129
FX: (858) 485-0561
E-mail: garyb@scs-corp.com

TEST REPORT FOR TYPE ACCEPTANCE

of

TRANSCEIVER MODEL S556-EP

FCC ID MKRS556-EP

to

FEDERAL COMMUNICATIONS COMMISSION

Date of Report:

December 29, 2000

TABLE OF CONTENTS

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 12 antennae. The number of antennae is user configurable depending on the application requirements. The scanner connects to pairs of antennae using 2 flexible coaxial cables. Single Chip Systems intends to sell 2 types of antennae that 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 MKRS556-EP.

3. Installation and Operating Instructions
   The operation manual for the MKRS556-EP is in the process of being written. Enclosed, as an attachment, is a draft copy of the manual.

4. Type of Emission
   The MKRS556-EP 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 MKRS556-EP 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.

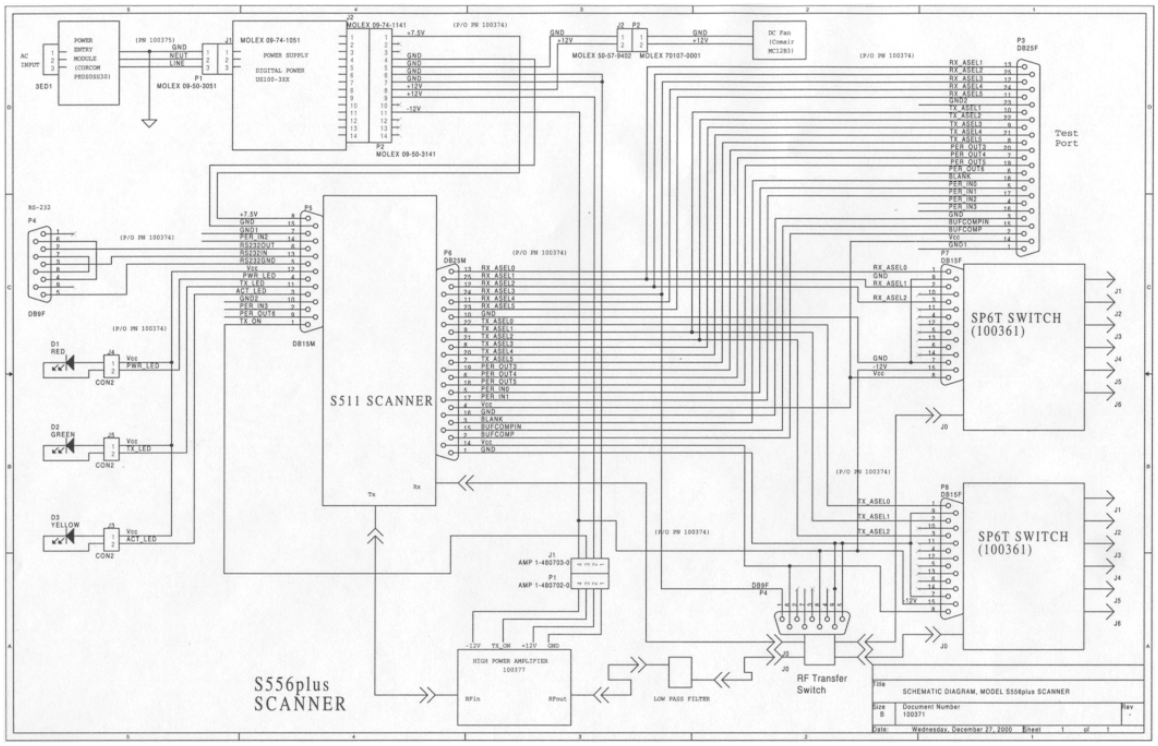


Figure 1. MKRS556-EP Top Level Schematic Diagram

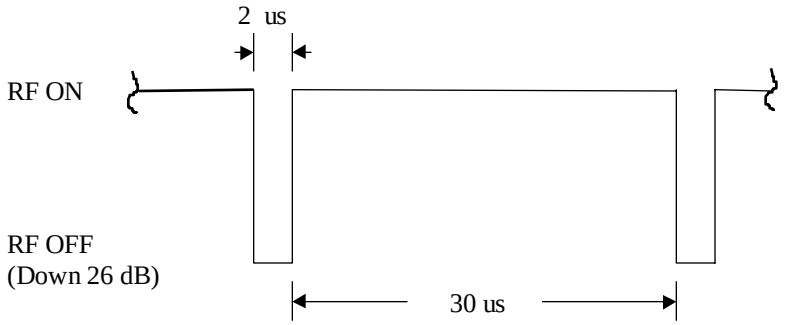
A. Description of frequency determining circuitry
   The RF frequency is generated using a phase locked loop (PLL) circuit. The licensed frequency data is burned into flash memory. At startup the microprocessor sends the PLL integrated circuit (National Semiconductor's LMX2325TM) the serial information 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 MKRS556-EP 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. A 3 section, low-pass filter located at the output of the final RF amplifier limits harmonic emissions. 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.

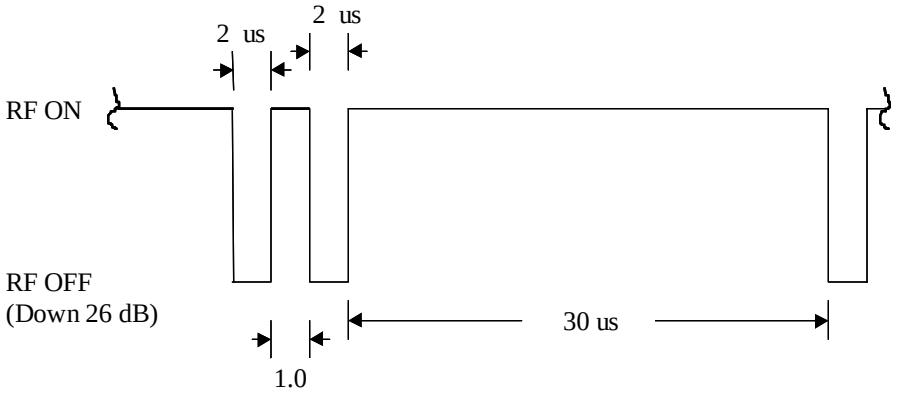
C. Description of Modulation technique and circuitry
The MKRS556-EP Transceiver uses an RF on/off modulation scheme. The RF signal powers the ID tag in the field, and then communicates with the tag by briefly turning off the RF power at the proper time. The waveform timing and duty cycle depend on the transmitted symbol. There are 3 transmitter waveforms. In the alternative, the transceiver sends a clock, a logic "0", or a logic "1". Figure 1 shows the timing for each of these waveforms. 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 (un-modulated) 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 depends 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.

CLOCK ONLY



LOGIC “0” TRANSMITTED



LOGIC “1” TRANSMITTED

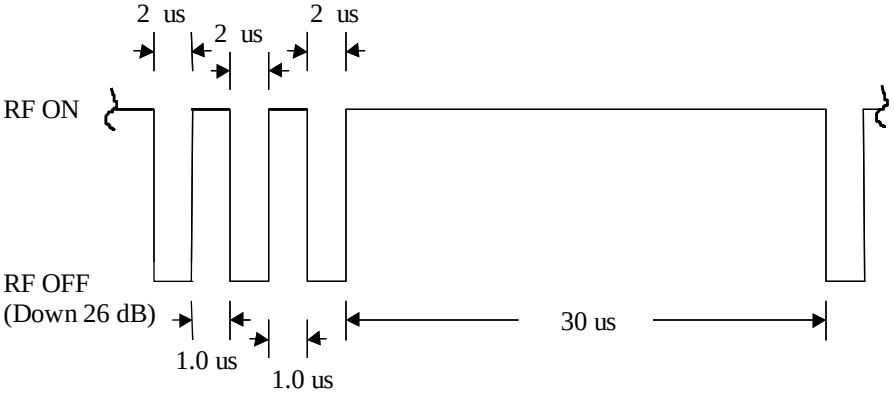


Figure 1. Modulation Modes of the MKRS556 Transceiver

11. Equipment Identification Plate

SCS Corporation
10905 Technology Pl.
San Diego, CA 92127
858.485.9196

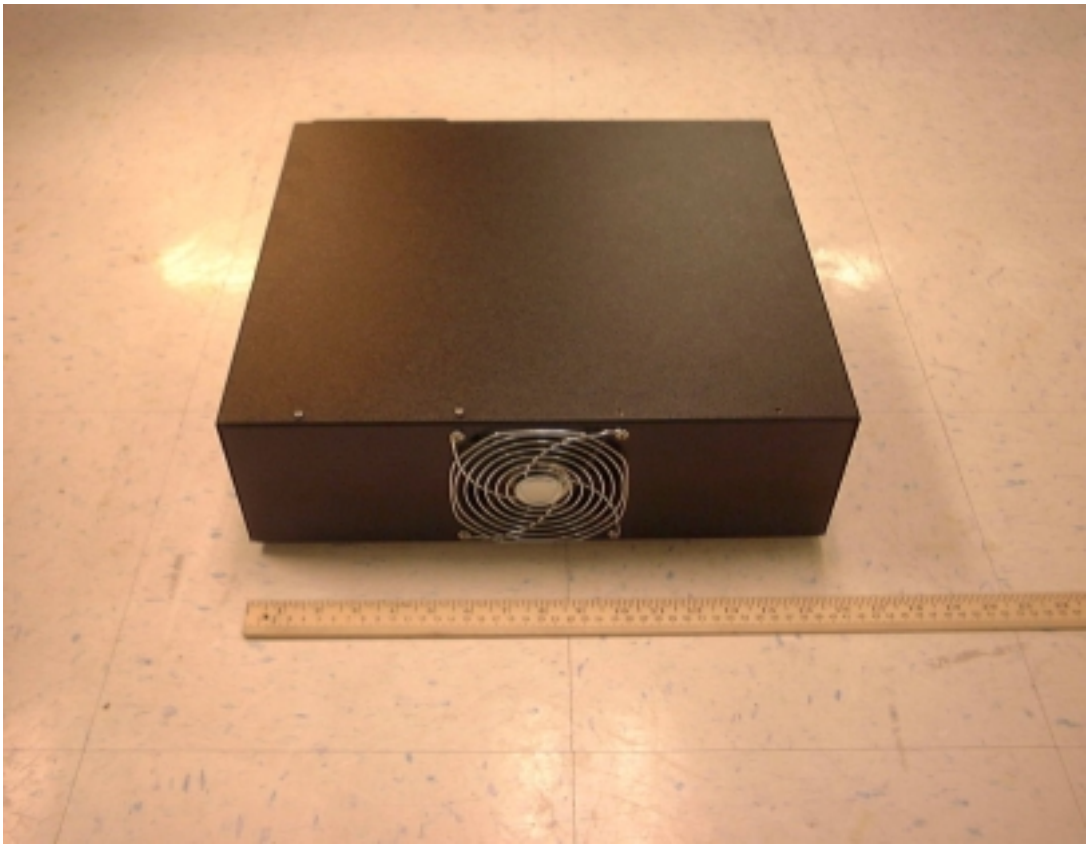
Serial No. 556EP0001
FCC ID MKRS556-EP

Country of Origin USA Patents Pending

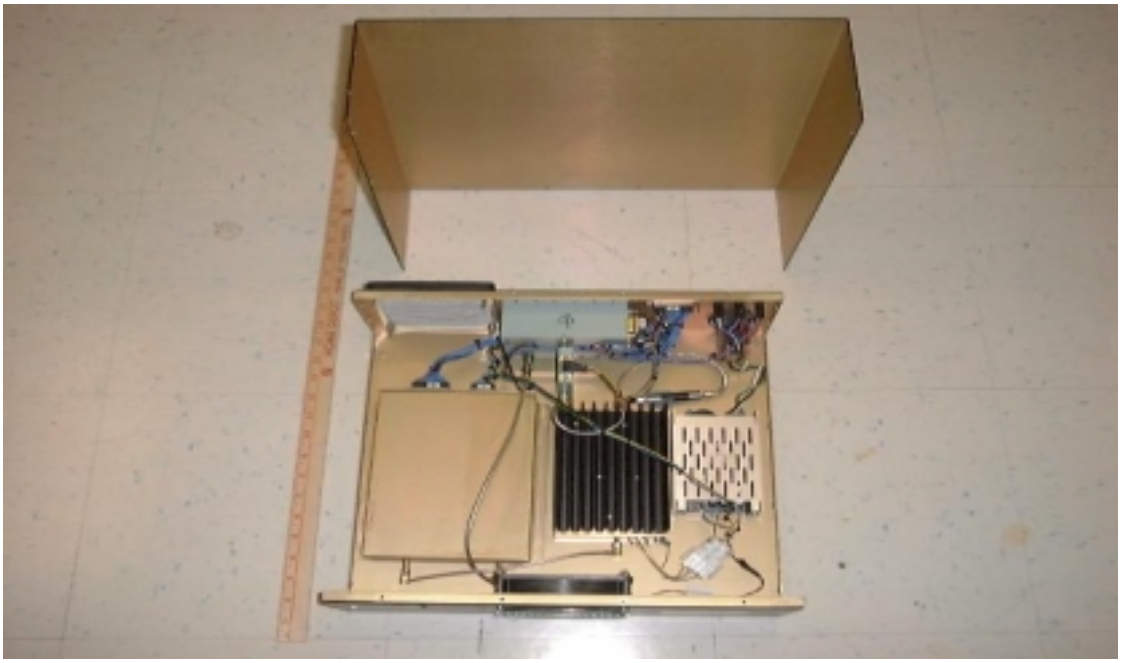
12. Photographs

Photographs showing the equipment construction and layout are shown below.

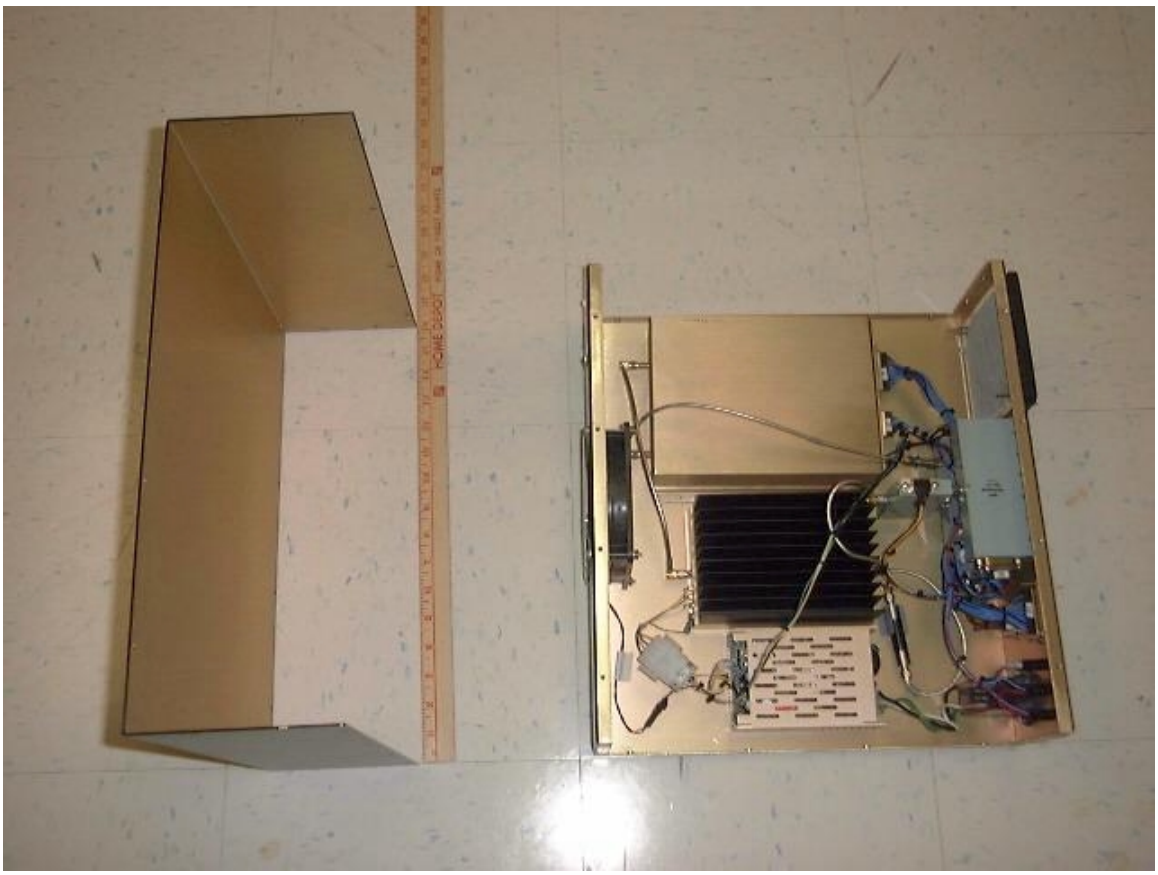
Front View of MKRS556-EP Scanner



Rear View of MKRS556-EP Scanner



Top View of MKRS556-EP Scanner



Side View of MKRS556-EP 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 un-modulated through a nominal 20 dB attenuator into a 50 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	36.4	4.37

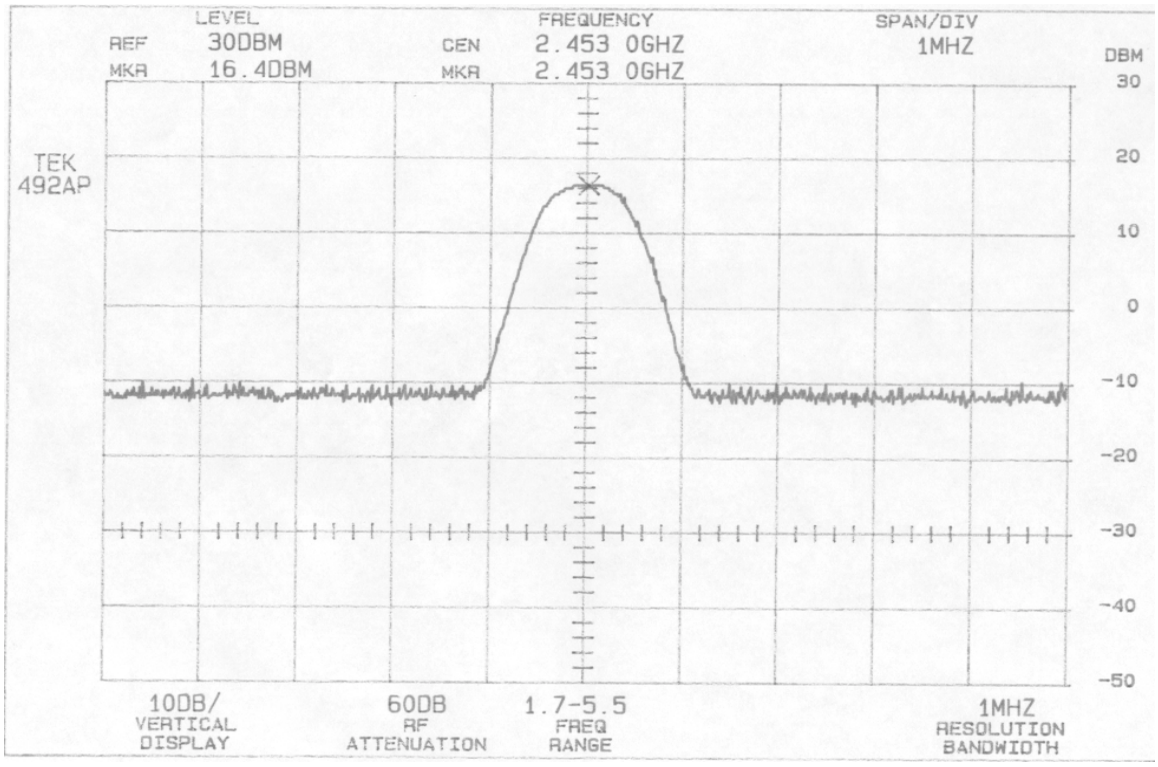


Figure 2. RF Output Power at Lowest Tuned Frequency (2.453 GHz)

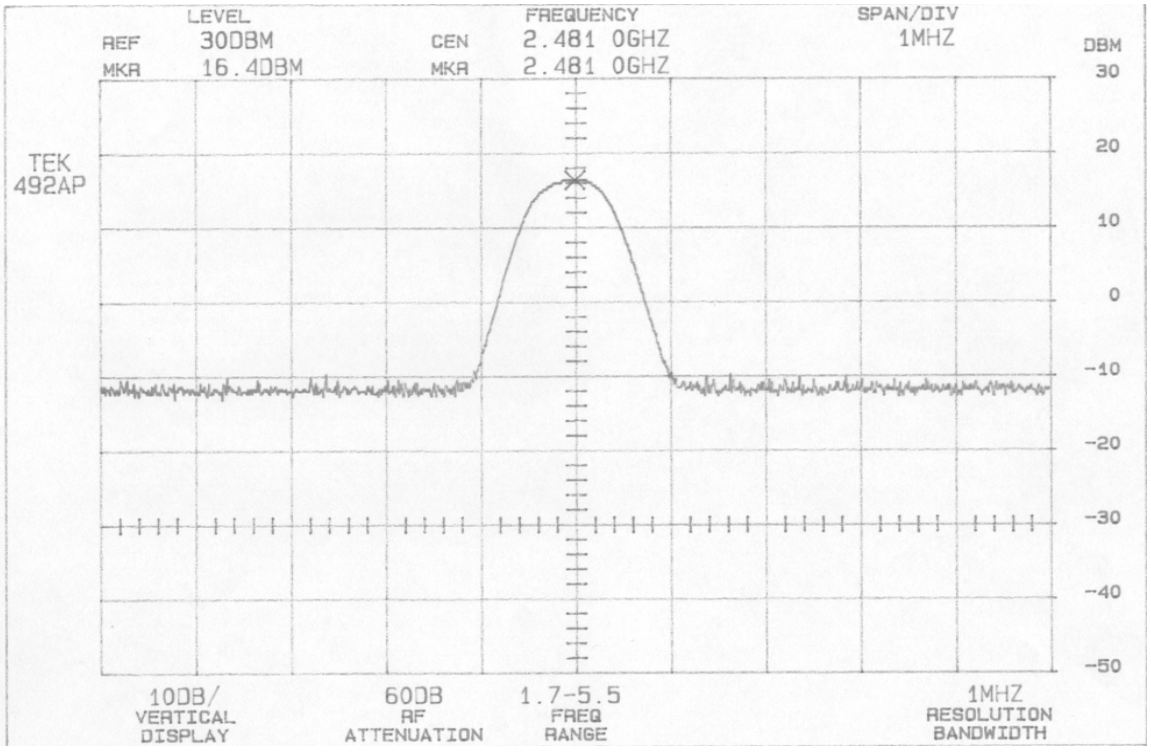


Figure 3. RF Output Power at High Frequency (2.481 GHz)

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 un-modulated 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 50dB 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 at least 50.4 dB below the peak at the band edge.

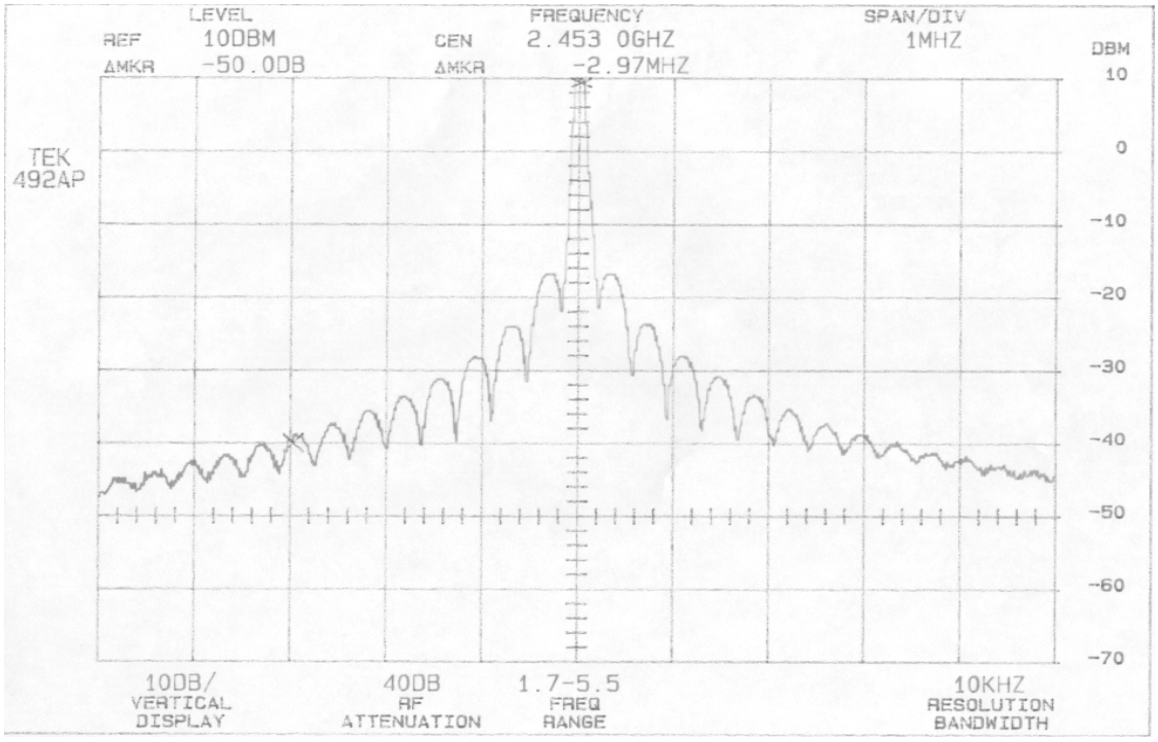


Figure 4. Modulated Bandwidth at Low Frequency Band Edge (2.450 GHz)

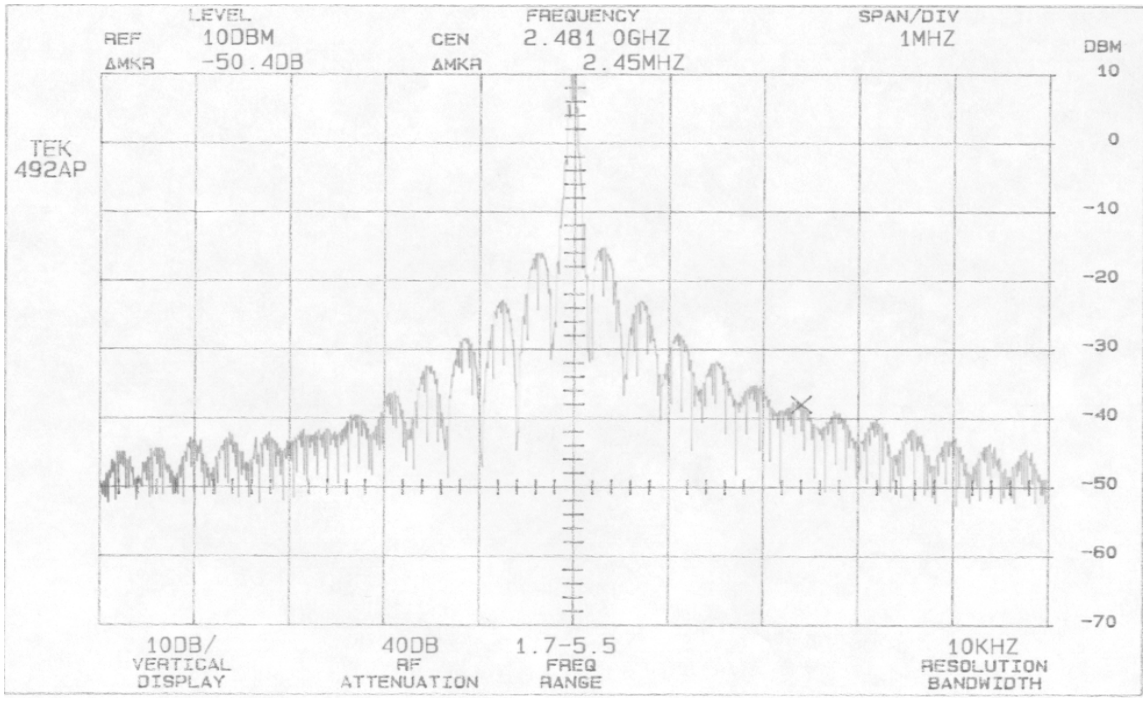


Figure 5. Modulated Bandwidth at High Frequency Band Edge (2.483 GHz)

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 un-modulated 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 un-modulated carrier and the harmonic signal:

HARMONIC	RELATIVE SIGNAL AMPLITUDE	
	LOW FREQ. (2.453 GHz)	HIGH FREQ. (2.481 GHz)
2^{ND}	56.8	52.4
3^{RD}	59.6	59.6
4^{TH} - 10^{TH}	> 70 dB	> 70 dB

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

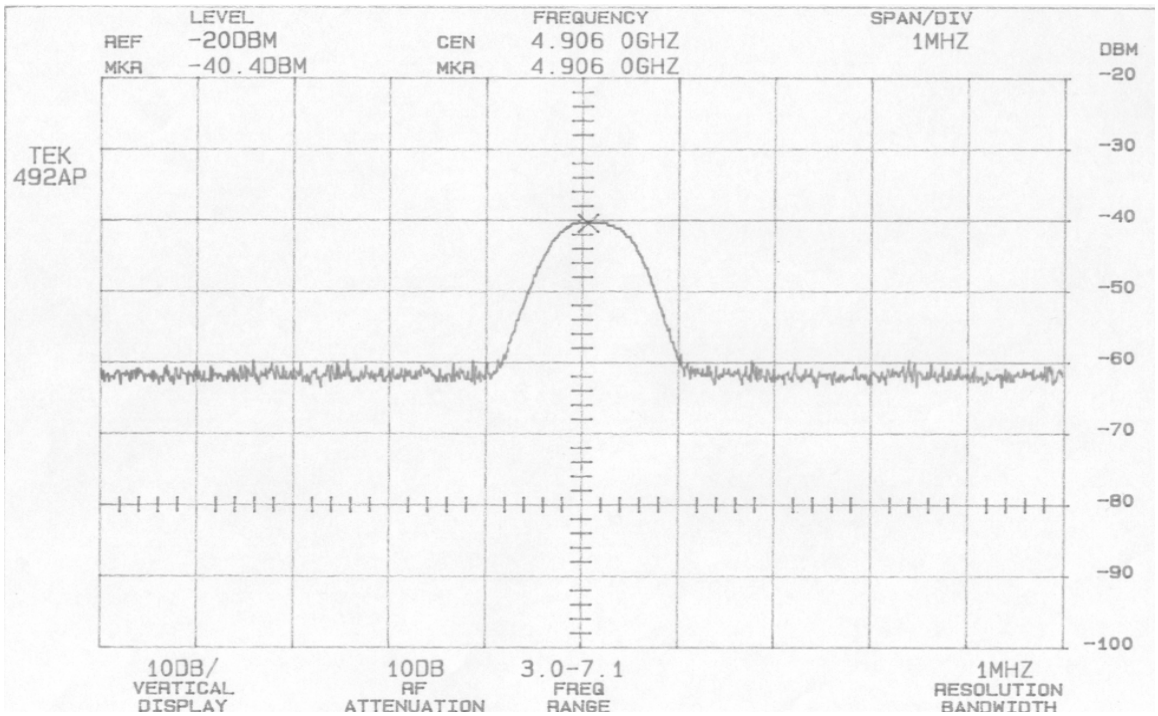


Figure 6. Conducted Second Harmonic at Low Frequency (2.453GHz)

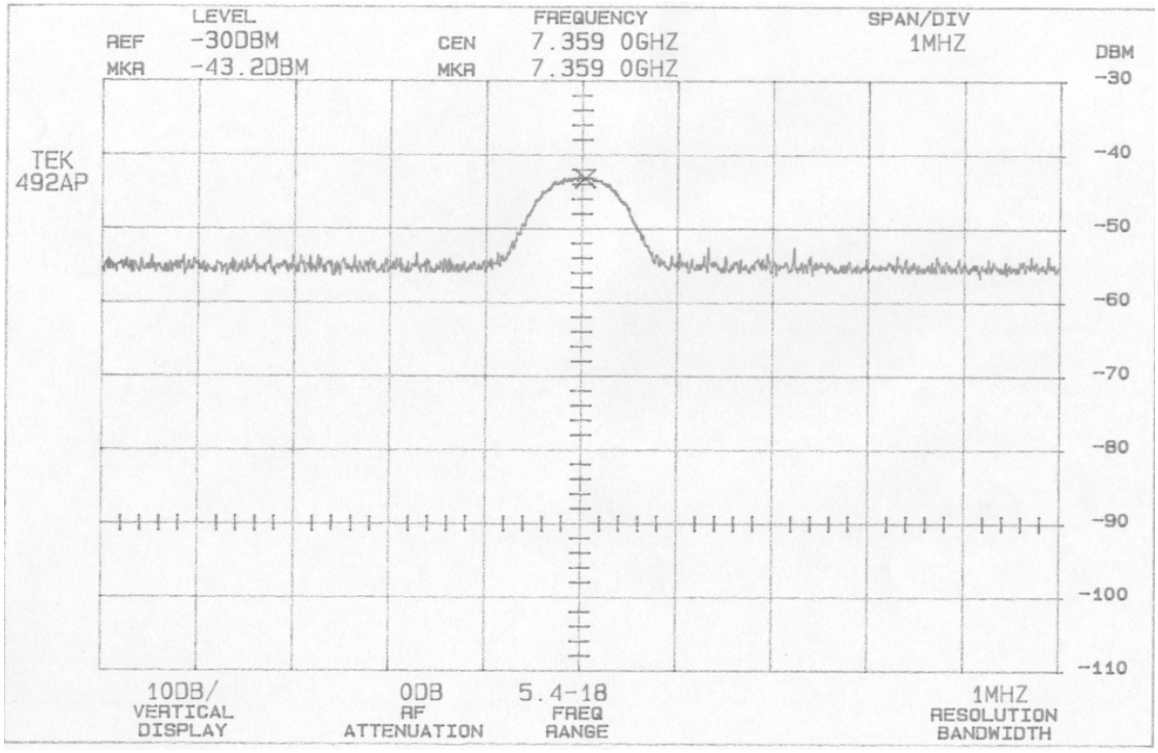


Figure 7. Conducted Third Harmonic at Low Frequency (2.453 GHz)

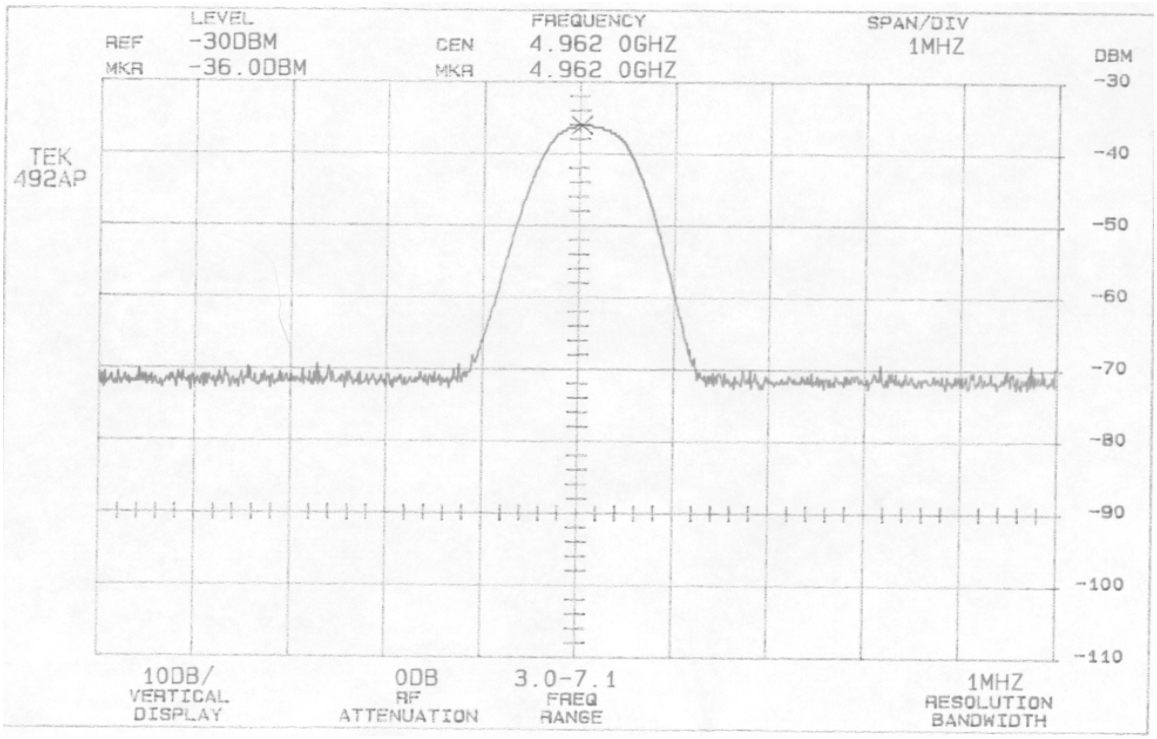


Figure 8. Conducted Second Harmonic at High Frequency (2.481 GHz)

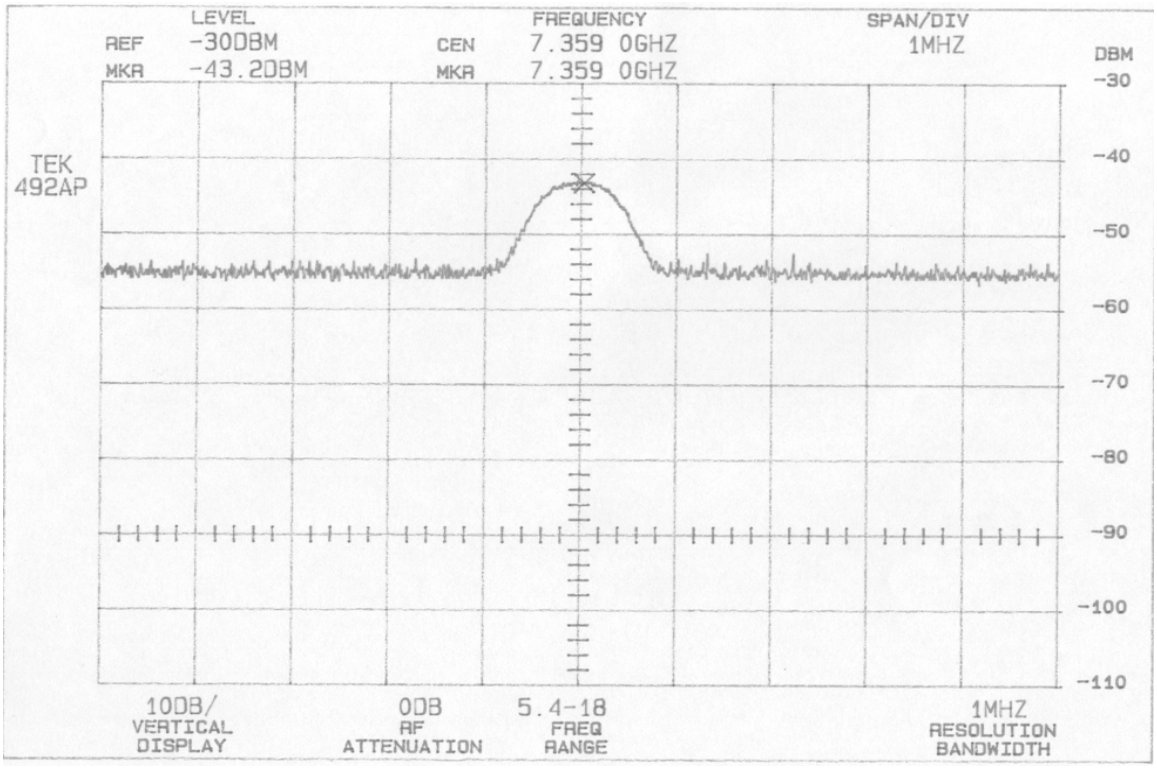


Figure 9. Conducted Third Harmonic at High Frequency (2.481 GHz)

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 10^{th} harmonic) sections. The low frequency requirement are the 47 CFR 15.209 emission limits. The high frequency requirement is that 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. Please note that the system identifier (MKR S556 +) listed in the TUV data sheets is slightly different from that submitted to the FCC in this report. This resulted from a clerical transcription error between TUV and SCS Corporation personnel. Figure 10 shows the listed results of the low frequency emissions. All emissions were within the requirements of 47 CFR 15.209.

The high frequency emissions were examined near the low and high carrier frequency settings (2.453 GHz and 2.481 GHz). Similar to the low frequency case, the configuration that exhibited the worst-case emissions was tabulated. The results are listed in Figure 11. The 2^{nd} and 3^{rd} harmonics are down by more than 50 dB from the fundamental, and all higher harmonics are below the fundamental by more than 65 dB.

REPORT No: S0496

REFERENCE ONLY

SPEC: FCC Part 15 para 15.109(b)

CUSTOMER: Single Chip Systems

TEST DIST: 10 Meters

E U T: MKRS 556 +

TEST SITE: 2

EUT MODE: Transmit 5W

BICONICAL: 739

DATE: 8-Dec-00 TESTED BY: Stephen Rackleff

LOG PERIODIC: 739

NOTES: Quasi-Peak with 120 KHz measurement bandwidth.

RCVR: 427

115Vac 60Hz

Temperature: 12 Relative Humidity: 60

EUT MARGIN -0.4 dB at 39.99 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)
39.99	19.2	12	19.4	38.6	39	-0.4	180	1
46.30	6.4	1	18.0	24.4	39	-14.6	10	1
47.48	2.8	-0.2	17.9	20.7	39	-18.3	310	1
75.42	8.3	3.6	10.0	18.3	39	-20.7	0	1
79.99	10.7	6.5	10.2	20.9	39	-18.1	150	1.5
151.98	17.4	14.8	11.3	28.7	43.5	-14.8	240	1
160.35	23.5	11.7	11.5	35.0	43.5	-8.5	230	1
239.98	15.8	14.3	16.3	32.1	46.5	-14.4	130	1
419.97	15.5	10.3	21.7	37.2	46.5	-9.3	220	1

Figure 10. Low Frequency Emissions List

Figure 11. High Frequency Radiated Emissions List

Radiated Electromagnetic Emissions

TÜV PRODUCT SERVICE

Test Report #:	**S0496 Run 1**	Test Area:	Site 3 Roof	Temperature:	18 °C
Test Method:		Test Date:	13-Dec-2000	Relative Humidity:	45 %
EUT Model #:	MKRS 556+	EUT Power:		Air Pressure:	100.1 kPa
EUT Serial #:				Page:	1 of 1
Manufacturer:	Single Chip Systems				
EUT Description:	Transmit 5 W				
Notes:					

Level Key	
Pk – Peak	Nb – Narrow Band
Qp – QuasiPeak	Bb – Broad Band
Av - Average	

FREQ (MHz)	LEVEL (dBuV)	CABLE / ANT / PREAMP (dB) (dB\m) (dB)	FINAL ()	POL / HGT / AZ (m) (DEG)	DELTA1 (dB) FCC Part 90.210	DELTA2 (dB) FCC A (> 1GHz)
Antenna: Horn PN:251 3 meters						
Attenuator: PN:657 6 ft						
2453.00	104.1 Pk	4.9 / 30.4 / -0.8	140.3	H / 1.0 / 0.0	N/A	
PreAmp: 38 dB Preamp						
4905.85	70.3 Pk	7.4 / 34.8 / 40.5	72.0	H / 1.0 / 0.0	-18.3	
4905.85	69.3 Av	7.4 / 34.8 / 40.5	71.0	H / 1.0 / 0.0	-19.3	
7358.95	69.3 Pk	8.6 / 37.8 / 36.5	79.2	H / 1.0 / 0.0	-11.1	
Ambient measurements below						
9812.00	51.1 Pk	10.6 / 39.3 / 37.1	64.0	H / 1.0 / 0.0	-26.3	
12265.0	45.7 Pk	11.4 / 41.4 / 36.8	61.8	H / 1.0 / 0.0	-28.5	
14718.0	47.2 Pk	12.4 / 41.8 / 35.8	65.6	H / 1.0 / 0.0	-24.7	
17171.0	47.2 Pk	14.6 / 41.7 / 32.9	70.6	H / 1.0 / 0.0	-19.7	
PreAmp: None						
2453.00	102.5 Pk	4.9 / 30.4 / -0.8	138.7	V / 1.0 / 0.0	N/A	
PreAmp: 38 dB Preamp						
4905.80	69.2 Pk	7.4 / 34.8 / 40.5	70.9	V / 1.0 / 0.0	-17.8	
7359.00	67.4 Pk	8.6 / 37.8 / 36.5	77.3	V / 1.0 / 0.0	-11.4	
Ambient measurements below						
9812.00	47.2 Pk	10.6 / 39.3 / 37.1	60.1	V / 1.0 / 0.0	-28.6	
12265.0	44.6 Pk	11.4 / 41.4 / 36.8	60.7	V / 1.0 / 0.0	-28.0	
14718.0	47.7 Pk	12.4 / 41.8 / 35.8	66.1	V / 1.0 / 0.0	-22.6	
PreAmp: None						
2467.00	101.1 Pk	5.0 / 30.5 / -0.8	137.3	V / 1.0 / 0.0	N/A	
PreAmp: 38 dB Preamp						
4934.00	76.2 Pk	7.4 / 34.9 / 40.5	78.0	V / 1.0 / 0.0	-9.3	
7401.00	70.1 Pk	8.6 / 37.8 / 36.5	80.1	V / 1.0 / 0.0	-7.2	
PreAmp: None						
2467.00	98.2 Pk	5.0 / 30.5 / -0.8	134.4	H / 1.0 / 0.0	N/A	
PreAmp: 38 dB Preamp						

Tested by: J Owen _____
Printed Signature

Reviewed by: _____ _____
Printed Signature

Radiated Electromagnetic Emissions

TÜV PRODUCT SERVICE

Test Report #:	**S0496 Run 1**	Test Area:	Site 3 Roof	Temperature:	18 °C
Test Method:		Test Date:	13-Dec-2000	Relative Humidity:	45 %
EUT Model #:	MKRS 556+	EUT Power:		Air Pressure:	100.1 kPa
EUT Serial #:				Page:	2 of 2
Manufacturer:	Single Chip Systems				
EUT Description:	Transmit 5 W				
Notes:					

Level Key	
Pk – Peak	Nb – Narrow Band
Qp – QuasiPeak	Bb – Broad Band
Av - Average	

FREQ	LEVEL	CABLE / ANT / PREAMP	FINAL	POL / HGT / AZ	DELTA1 (dB)	DELTA2 (dB)
(MHz)	(dBuV)	(dB) (dB\m) (dB)	()	(m) (DEG)	FCC Part 90.210	FCC A (> 1GHz)
4934.00	74.4 Pk	7.4 / 34.9 / 40.5	76.2	H / 1.0 / 0.0	-10.0	
7401.00	72.8 Pk	8.6 / 37.8 / 36.5	82.8	H / 1.0 / 0.0	-1.6	
7401.00	72.8 Av	8.6 / 37.8 / 36.5	82.8	H / 1.0 / 0.0	-1.6	
PreAmp: None						
2481.00	104.5 Pk	5.0 / 30.5 / -0.8	140.8	H / 1.0 / 0.0	N/A	
PreAmp: 38 dB Preamp						
4962.00	74.3 Pk	7.4 / 35.0 / 40.5	76.2	H / 1.0 / 0.0	-14.6	
7443.00	74.5 Pk	8.7 / 37.9 / 36.5	84.6	H / 1.0 / 0.0	-6.2	
2481.00	98.9 Pk	5.0 / 30.5 / -0.8	135.2	V / 1.0 / 0.0	N/A	
4962.00	75.4 Pk	7.4 / 35.0 / 40.5	77.3	V / 1.0 / 0.0	-7.9	
7443.00	70.9 Pk	8.7 / 37.9 / 36.5	81.0	V / 1.0 / 0.0	-4.2	

Tested by: J Owen _____
Printed Signature

Reviewed by: _____ _____
Printed Signature

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 is attributed to dual regulation on the DC voltage that 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 are available if requested, but were not included.

TEMPERATURE (°C)	FREQUENCY (GHz)	FREQUENCY DELTA FROM –30 °C (KHz)
-30	2.463987	N/A
-20	2.463987	0
-10	2.463983	-4
0	2.463983	-4
10	2.463980	-7
20	2.463977	-10
30	2.463970	-17
40	2.463973	-14
50	2.463980	-7

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.