

The University of Michigan
Radiation Laboratory
3228 EECS Building
Ann Arbor, MI 48109-2122
Tel: (734) 747-1792

Measured Radio Frequency Emissions
From

**TRW JR RKE Receiver
Model GQ43VT24R**

Report No. 415031-966
September 2, 1998

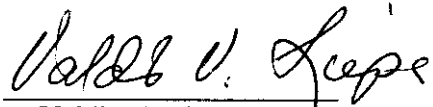
For:
TRW-TED
24175 Research Drive
Farmington Hills, MI 48335

Contact:
Daliang Shi
Tel: (248)426-3012
Fax: (248)478-7241
PO: verbal

Measurements made by:

Valdis Liepa
Scott Lukas

Tests supervised by:
Report approved by:



Valdis V. Liepa
Research Scientist

Summary

Tests for compliance with FCC Regulations subject to Part 15, Subpart B, were performed on TRW superregenerative RKE Model GQ43VT24R receiver. This device is subject to Rules and Regulations as a Receiver. As a Digital Device it is exempt, but such measurements were made to assess the receiver's overall emissions.

In testing performed on August 28- September 1, 1998, the device tested in the worst case met the specifications for radiated emissions by 12.6 dB (see p. 6), and the antenna conducted emissions by 1.4 dB (see p. 5). The line conductive emission tests do not apply, since the device is powered from an automotive 5 VDC source.

EXHIBIT *E*

Page *170* of *10*

U of Mich file 415031- *966*

1. Introduction

TRW JR RKE Receiver, Model GQ43VT24R, was tested for compliance with FCC Regulations, Part 15, adopted under Docket 87-389, April 18, 1989. The tests were performed at the University of Michigan Radiation Laboratory Willow Run Test Range following the procedures described in ANSI C63.4-1992 "Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz". The attenuation characteristics of the Open Site facility are on file with FCC Laboratory, Columbia, Maryland. (FCC file 31040/SIT)

2. Test Procedure and Equipment Used

The test equipment commonly used in our facility is listed in Table 2.1 below. The second column identifies the specific equipment used in these tests. The HP 8593E spectrum analyzer is used for primary amplitude and frequency reference.

Table 2.1. Test Equipment.

Test Instrument	Equipment Used	Manufacturer/Model	Cal. Date/By
Spectrum Analyzer (9kHz-22GHz)		Hewlett-Packard 8593A SN: 3107A01358	June 1998/HP
Spectrum Analyzer (9kHz-26GHz)	X	Hewlett-Packard 8593E SN: 3107A01131	July 1998/HP
Spectrum Analyzer (0.1-1500 MHz)	X	Hewlett-Packard 182T/8558B SN: 1529A01114/543592	August 1997/U of M Rad Lab
Preamplifier (5-1000MHz)	X	Watkins-Johnson A11 -1 plus A25-1S	May 1996/U of M Rad Lab
Preamplifier (5-4000 MHz)	X	Avantek	Nov. 1992/ U of M Rad Lab
Power Meter w/ Thermistor		Hewlett-Packard 432A	August 1989/U of M Rad Lab
Broadband Bicone (20-200 MHz)	X	Hewlett-Packard 478A	August 1989/U of M Rad Lab
Broadband Bicone (200-1000 MHz)		University of Michigan	July 1988/U of M Rad Lab
Dipole Antenna Set (25-1000 MHz)	X	University of Michigan	June 1996/U of M Rad Lab
Dipole Antenna Set (30-1000 MHz)		EMCO 3121C SN: 992	June 1996/U of M Rad Lab
Active Loop Antenna (0.090-30MHz)		EMCO 6502 SN: 2855	December 1993/ EMCO
Active Rod (30Hz-50 MHz)		EMCO 3301B SN: 3223	December 1993/EMCO
Ridge-horn Antenna (0.5-5 GHz)	X	University of Michigan	February 1991/U of M Rad Lab
LISN Box		University of Michigan	May 1994/U of M Rad Lab
Signal Cables		Assorted	January 1993/U of M Rad Lab
X-Y Plotter		Hewlett-Packard 7046A	During Use/U of M Rad Lab
Signal Generator (0.1-990 MHz)	X	Hewlett-Packard 8656A	January 1990/U of M Rad Lab
EMI/Fld Int. Meter (30-1000 MHz)		Stoddard NM-37/57A SN: 0606-80119	August 1989/U of M Rad Lab
Printer	X	Hewlett-Packard 2225A	August 1989/HP

3. Configuration and Identification of Device Under Test

The DUT is a 315.0 MHz superregenerative receiver, designed for onboard automobile security/convenience applications, and as such, it is powered from an automobile 5 VDC source. The receiver is housed in a plastic case approximately 3x2x0.75 inches, having one multipin connector for power input and digital signal output. The antenna is external (using a custom connector) and will use the rear window defroster wires. For testing, a "generic" wire harness was made up, one bundle containing control (output) signal wires and the other bundle containing a pair of power-up wires. The length of the harness was about 1.9 m and the ends of signal wires were left open. Also a special antenna connector-to-BNC adaptor was made for termination and measurement of antenna conducted emissions. In the receiver, decoding, signal processing, etc., are performed by a micro, timed by a 4.00 MHz oscillator.

The DUT was designed and manufactured by TRW-TED 24175 Research Drive Farmington Hills, MI 48335. It is identified as:

TRW JR RKE Receiver
Model: GQ43VT24R
SN:
FCC ID: GQ43VT24R
CANADA: To be provided by Industry Canada

3.1 Modifications Made

There were no modifications made to the DUT by this laboratory. However, a coaxial adaptor (BNC to special) was made for electrical access to the antenna terminal.

4. Emission Limits

The DUT tested falls under Part 15, Subpart B, "Unintentional Radiators". The pertinent test frequencies, with corresponding emission limits, are given in Tables 4.1 and 4.2 below and Section 4.3.

4.1 Radiated Emission Limits

Table 4.1. Radiated Emission Limits (Ref: 15.33, 15.35, 15.109).

Freq. (MHz)	E _{lim} (3m) μ V/m	E _{lim} dB(μ V/m)
30-88	100	40.0
88-216	150	43.5
216-960	200	46.0
960-2000	500	54.0

Note: Quasi-Peak readings apply to 1000 MHz (120 kHz BW)
Average readings apply above 1000 MHz (1 MHz BW)

4.2 Line Conducted Emission Limits

Table 4.2. Conducted Emission Limits (Ref: 15.107).

Freq. (MHz)	μV	$\text{dB}(\mu\text{V})$
0.450 - 1.705	250	48.0
1.705 - 30.0	250	48.0

Note: Quasi-Peak readings apply here

4.3 Antenna Power Conduction Limits

Ref: 15.111(a). $P_{\text{max}} = 2 \text{ nW}$; for frequency range see Table 4.1.

5. Emission Tests and Results

NOTE: Even though the FCC and/or Industry Canada specify that both the radiated and conductive emissions be measured using the Quasi-Peak and/or average detection schemes, we normally use peak detection since especially the Quasi-Peak is cumbersome to use with our instrumentation. In case the measurement fails to meet the limits, or the measurement is near the limit, it is remeasured using appropriate detection. We note, that since the peak detected signal is always higher or equal to the Quasi-Peak or average detected signal, the margin of compliance may be better, but not worse, than indicated in this report. The type of detection used is indicated in data table, Table 5.1.

5.1 Anechoic Chamber Radiated Emission Tests

To familiarize with the radiated emission behavior of the DUT, it was studied and measured in the shielded anechoic chamber. In the chamber there is a set-up similar to that of an outdoor 3-meter site, with turntable, antenna mast, and a ground plane. Instrumentation includes spectrum analyzers and other equipment as needed.

To study and test for radiated emissions, the DUT was powered by a laboratory power supply at 5.0 VDC. A 315 MHz CW signal was injected (radiated) from a nearby signal generator using a short wire antenna. The DUT was taped to a styrofoam block and placed on the test table on each of the three axis. At each orientation, the table was rotated to obtain maximum signal for vertical and horizontal emission polarizations. This sequence was repeated throughout the required frequency range.

In the chamber we studied and recorded all the emissions using a ridge-horn antenna, which covers 200 MHz to 5000 MHz, up to 2 GHz. In scanning from 30 MHz to 2.0 GHz, there were no spurious emissions observed other than the LO, the injection signal, and the LO harmonics. Figures 5.1 and 5.2 show emissions measured 0-1000 MHz and 1000-2000 MHz, respectively. These measurements are made with a ridge-horn antenna at 3m, with spectrum analyzer in peak hold mode and the receiver rotated in all orientations. The measurements up to 1000 MHz (Fig. 5.1) are used for initial evaluation only, but those above 1000 MHz (Fig. 5.2) are used in final assessment for compliance.

5.2 Open Site Radiated Emission Tests

The DUT was then moved to the 3 meter Open Field Test Site where measurements were repeated up to 1000 MHz using a small bicone, or dipoles when the measurement is near the limit. The DUT was exercised as described in Sec. 5.1 above. The measurements were made with a spectrum analyzer using 120 kHz IF bandwidth and peak detection mode, and, when appropriate, using Quasi-Peak or average detection (see 5.0). Figure 5.3 shows the DUT on the test table, and figure 5.4 shows the table oriented with respect to antenna for the worst case emissions for measurement at "fundamental".

The emissions from digital circuitry were measured on the Open Site using a standard bicone. These results are also given in Table 5.1.

5.3 Computations and Results for Radiated Emissions

To convert the dBm's measured on the spectrum analyzer to dB(μ V/m), we use expression

$$E_3(\text{dB}\mu\text{V/m}) = 107 + P_R + K_A - K_G$$

where P_R = power recorded on spectrum analyzer, dB, measured at 3m
 K_A = antenna factor, dB/m
 K_G = pre-amplifier gain, including cable loss, dB

When presenting the data, at each frequency the highest measured emission under all of the possible orientations is given. Computations and results are given in Table 5.1. There we see that the DUT meets the limit by 12.6 dB.

5.4 Conducted Emission Tests

These tests do not apply, since the DUT is powered from an automotive 5 VDC source.

6. Other Measurements

6.1 Emission Spectrum Near Fundamental

Near operating frequency the emission spectrum is measured typically over 50 MHz span with and without injection signal. These data are taken with the DUT close to antenna and, hence, amplitudes are relative. The plots are shown in Figure 6.1.

6.2 Effect of Supply Voltage Variation

The DUT has been designed to operate from 5 VDC power. Using a spectrum analyzer, relative radiated emissions were recorded at the "fundamental" (315 MHz) as voltage was varied from 2.0 to 8.0 VDC. Figure 6.2 shows the emission variation.

6.3 Operating Voltage and Current

$$\begin{aligned} V &= 5.0 \text{ VDC} \\ I &= 1.7 \text{ mADC} \end{aligned}$$

6.4 Antenna RF Power Conducted Measurements

These measurements are made by connecting a spectrum analyzer directly to the receiver antenna terminal and recording the typical regenerative receiver "finger" pattern similar to that seen in Figure 6.1, plus other emissions if measurable. Power readings of individual lines are summed up, in this case giving 1.46 nW or 1.4 dB below the 2 nW limit. The locking signal is injected in the receiver by radiation from a nearby antenna which, in turn, is connected to a signal generator.

The University of Michigan
Radiation Laboratory
3228 EECS Building
Ann Arbor, Michigan 48109-2122
(734) 647-1792

Table 5.1 Highest Emissions Measured

Radiated Emission - RF											TRW RKE Receiver; FCC
#	Freq. MHz	Ant. Used	Ant. Pol.	Pr dBm	Det. Used	Ka dB/m	Kg dB	E3 dBμV/m	E3lim dBμV/m	Pass dB	Comments
1	315.0	Dip	H	-72.6	Pk	18.9	19.9	33.4	46.0	12.6	side, *worst case
2	315.0	Dip	V	-77.2	Pk	18.9	19.9	28.8	46.0	17.2	side
3	630.0	Dip	H	-85.0	Pk	25.2	16.6	30.7	46.0	15.3	side, 30 kHz BW
4	630.0	Dip	V	-85.2	Pk	25.2	16.6	30.5	46.0	15.5	side, 30 kHz BW
5	945.0	Dip	H	-91.0	Pk	28.9	14.2	30.7	46.0	15.3	max all, noise 30 kHz BW
6	945.0	Dip	V	-91.0	Pk	28.9	14.2	30.7	46.0	15.3	max all, noise 30 kHz BW
7	1260.0	Horn	H	-68.0	Pk	20.6	28.1	31.5	54.0	22.5	max all orient., noise
8	1620.0	Horn	H	-68.0	Pk	21.5	28.2	32.3	54.0	21.7	max all orient., noise
9	1890.0	Horn	H	-66.5	Pk	22.4	28.1	34.8	54.0	19.2	max all orient., noise
10											
11											
12											
13											
14											
15											
16											
17											

Digital Emissions											
#	Freq. MHz	Ant. Used	Ant. Pol.	Pr dBm	Det. Used	Ka dB/m	Kg dB	E3 dBμV/m	E3lim dBμV/m	Pass dB	Comments
1											
2											
3	Digital emissions are more than 20 dB below the FCC Class B limit.										
4											
5											
6											

Conducted Emissions							
#	Freq. MHz	Line Side	Det. Used	Vtest dBμV	Vlim dBμV	Pass dB	Comments
	Not applicable						

Meas. 8/27/98; U of Mich.

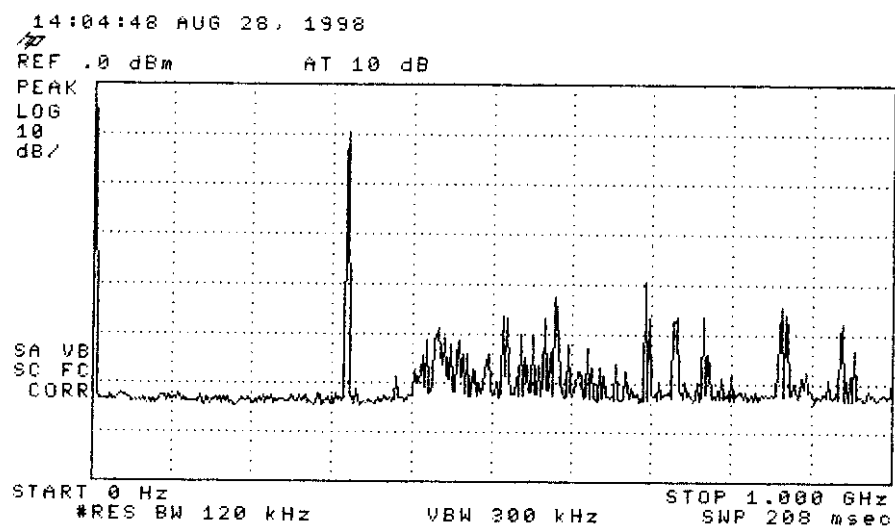
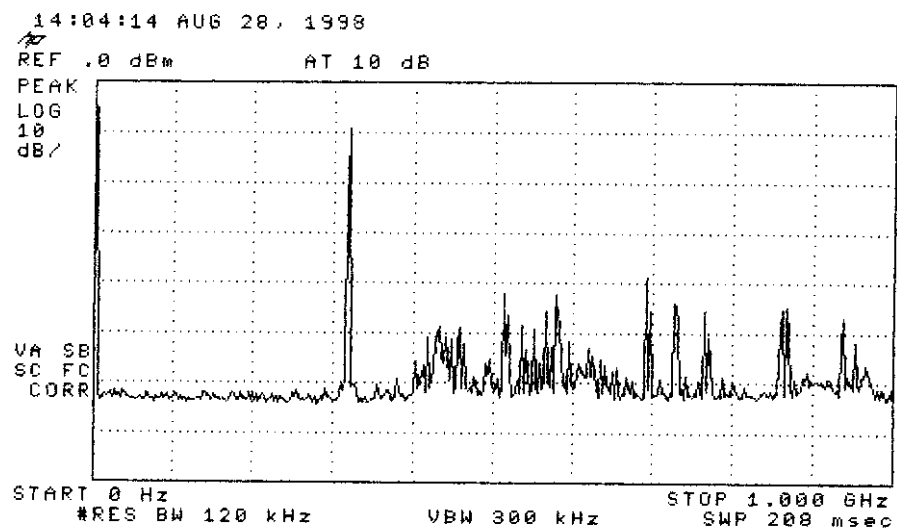


Figure 5.1. Emissions measured at 3 meters in anechoic chamber, 0-1000 MHz.
(top) Receiver plus ambient
(bottom) Ambient

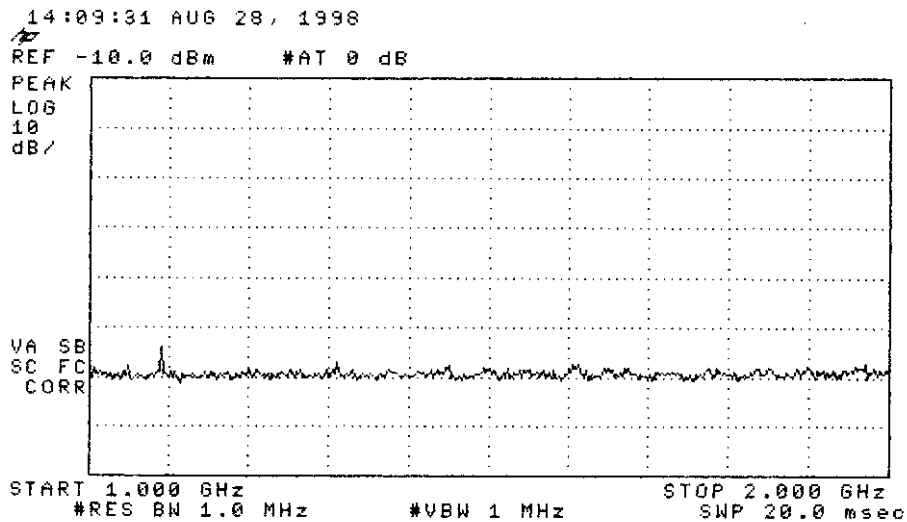
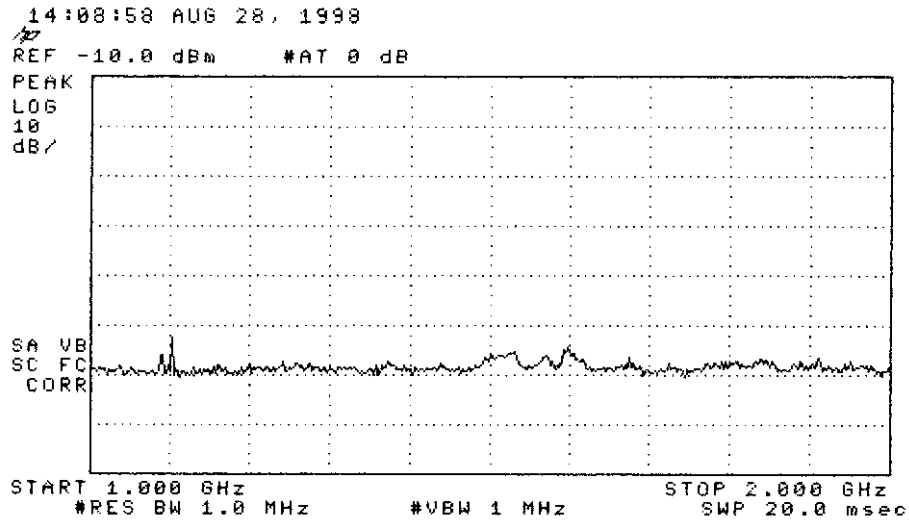


Figure 5.2. Emissions measured at 3 meters in anechoic chamber, 1000-2000 MHz.
 (top) Receiver plus ambient
 (bottom) Ambient

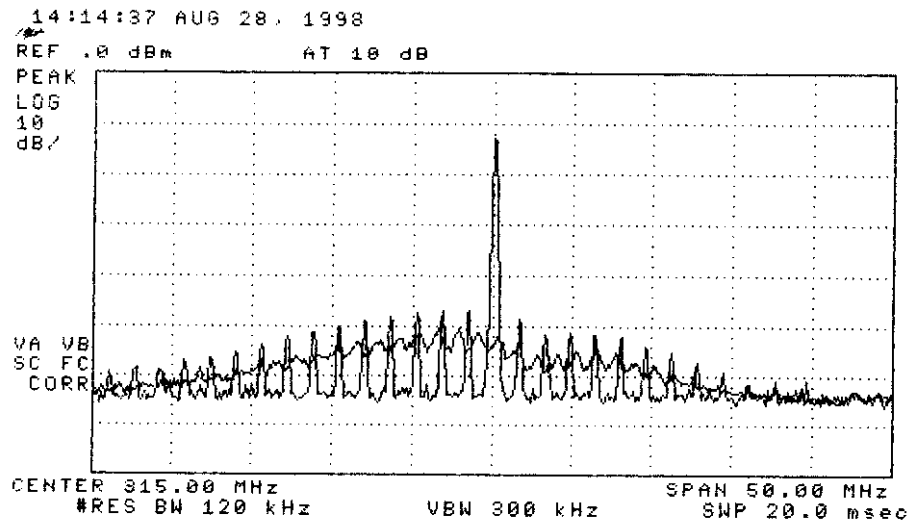


Figure 6.1. Relative receiver emissions in stand-by and "locked-in" modes. The final emission measurements were made with the receiver in "locked-in" mode.

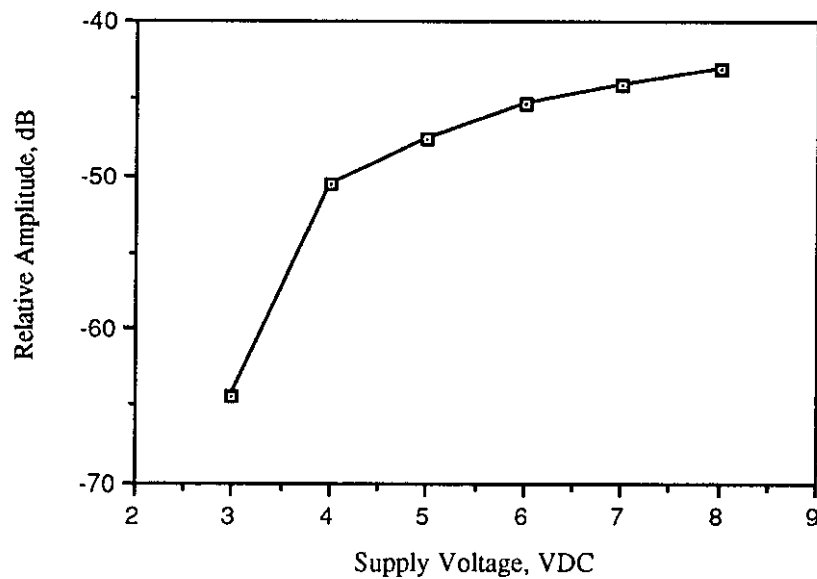


Figure 6.2. Relative emission at "fundamental" vs. supply voltage.

2001 JR/KJ RKE Receiver**General Description**

The device for which certification is being requested is a supe-regenerative receiver designed specifically for a Chrysler automobile RKE system. With its associated key fob transmitter, it can be used as a part to remotely lock and unlock the doors of the automobile in which it is installed. The receiver is installed during the assembly of the vehicle and the transmitter/receiver set is sold as an option when the vehicle is purchased. The receiver consists of one printed circuit board (PCB) housed in a 78.2 X 57.8 X 21.1 millimeter plastic case. A six pin connector on the PCB connects to the Body Control Module, (BCM). An external antenna is connected via the BCM module.

Principles of Circuit Operation

The receiver portion of the remote lock control system is incorporated into the wiring system of an automobile and is powered by the 5 Volt supply from the BCM. The receiver operates in 4 modes: sleep, active, diagnostics and program mode. Upon receipt of a valid code, the receiver leaves the sleep mode and sends a serial message to BCM to activate the desired loads (door lock motors). In the program mode, the receiver is able to learn the security code of any four Keeloq transmitters. After this, the receiver will respond only to the transmitters it is programmed to.

The R.F. portion of the receiver is super-regenerative in design and is tuned to 315MHz. The received data signal is demodulated and fed into the microprocessor, the processor will wake up when a Keeloq transmission is detected and verify the correct vehicle access code. The receiver can store up to four 32 bit transmitter vehicle access codes (VAC) into an external EEPROM integrated circuit. During receiver operation, the microprocessor compares the data to the previously stored VAC's. If a valid code is received, the microprocessor will send a serial data output transmission to the BCM to activate the appropriate outputs.

EXHIBIT FPage 1 of 1U of Mich file 415031- 964

EXHIBIT HPage 1 of 3U of Mich file 415031- 946

NORTH AMERICAN

QTY	REF	PART NO.	DESCRIPTION (BPCS)	PREC	REF DES TOP	REF DES BOT	ITEM
1	REF	203407-1	PB. CRT. JVA/JLR RAE. RCV/RS				61
1	REF	203410-1	PB. CRT. JVA/JLR RAE. RECEIVER				60
1	REF	203409	SQR. CRT. JVA/JLR RAE. RECEIVER				59
1	REF	1030817	SOLDER. TINT. BAR 63/37				58
1	REF	200563-1	PASTE. SOLDER				57
1	REF	1030569	CONFORMAL COAT. SOLVENTLESS. 9293				56
2	REF	201080-2	SCM. 1F. PK. PK. 4-14. 5mm				55
1	REF	200425	TEST. SPEC. RECT. FINAL. A1011				54
1	REF	1005887	TRANS. BCB468. 11. NPK. 50T-23. 5	S40	Q104		53
3	REF	1020585	TRANS. M985178. 11. NPK. 50T-23. 5	S40	Q101 Q102 Q103		52
1	REF	1005873	DIODE. 31G. M980914L. 70. 250MK. SM	S40	D2		51
1	REF	1027878	COIL. INDUCT. P. 1. 81. 20. 3225	S40	L103		50
1	REF	200817-2	COIL. INDUCT. F. 30K. 5. 2520	S40	L101		49
1	REF	151200-1	COIL. BEAD. P. 11. 14K. 25. 5M	S40	L1		48
1	REF	1024557	RES. CR. 0603. 3. 34K. 5. 1/16. C	S40	R115		47
1	REF	1024527	RES. CR. 0603. 180K. 5. 1/16. C	S40	R114		46
1	REF	1024561	RES. CR. 0603. 4. 74K. 5. 1/16. A	S40	R113		45
1	REF	1024885	RES. CR. 0603. 3. 3K. 5. 1/16. A	S40	R112		44
1	REF	1029732	RES. CR. 0603. 6. 04K. 1. 1/16. C	S40	R110		43
1	REF	1029688	RES. CR. 0603. 2. 1K. 1. 1/16. C	S40	R109		42
1	REF	1028772	RES. CR. 0603. 15. 8K. 1. 1/16. C	S40	R108		41
1	REF	1028737	RES. CR. 0603. 6. 81K. 1. 1/16. C	S40	R107		40
1	REF	1028792	RES. CR. 0603. 25. 5K. 1. 1/16. C	S40	R105		39
1	REF	1024468	RES. CR. 0603. 620. 5. 1/16. C	S40	R104		38
1	REF	1024468	RES. CR. 0603. 510. 5. 1/16. C	S40	R104		37
1	REF	1024499	RES. CR. 0603. 12K. 5. 1/16. C	S40	R103		36
1	REF	1024498	RES. CR. 0603. 11K. 5. 1/16. C	S40	R102		35
1	REF	1024505	RES. CR. 0603. 22K. 5. 1/16. C	S40	R101		34
1	REF	150417-3	RES. CR. 0603. 4. 7K. 5. 1/16. A	S40	R82		33
3	REF	151477-1	RES. CR. 0603. 0. 5. 1/20. C	S40	R20 R21 R125		32
3	REF	150417-5	RES. CR. 0603. 47K. 5. 1/16. A	S40	R11 R15 R111		31
1	REF	150417-4	RES. CR. 0603. 10K. 5. 1/16. A	S40	R8		30
1	REF	1024545	RES. CR. 0603. 146K. 5. 1/16. A	S40	R7		29
1	REF	150417-6	RES. CR. 0603. 100K. 5. 1/16. A	S40	R6		28
1	REF	1024777	RES. CR. 0603. 1. 5K. 5. 1/16. A	S40	R5		27
1	REF	1029561	RES. CR. 0603. 100. 1. 1/16. C	S40	R2		26
1	REF	150281-1	CAP. CERAM. 1206. 0. 22U. 10. 25	S40	C115		25
1	REF	1026281	CAP. CERAM. 1206. 0. 1U. 10. 100	S40	C2		24
1	REF	1006868	CAP. CERAM. 0805. 0. 001U. 10. 100	S40	C13		23
1	REF	1028388	CAP. CERAM. 0805. 0. 01U. 20. 100	S40	C9		22
13	REF	N/A	UNINSTALLED	S40	C125 C200 C261 C130 R10 R12 R16 R140 R141 R200 R1 Q2 R51		21
1	REF	150275-14	CAP. CERAM. 0603. 0. 22U. 80V. 20. 16	S40	C118		20
1	REF	1024567	CAP. CERAM. 0603. 100P. 5. 50	S40	C113		19
1	REF	1030273	CAP. CERAM. 0603. 1. 5P. 7. 50	S40	C111		18
1	REF	201276-25	CAP. CERAM. 0603. 3. 6P. 7. 50	S40	C110		17
1	REF	150275-15	CAP. CERAM. 0603. 220P. 5. 50	S40	C109		16
1	REF	201276-90	CAP. CERAM. 0603. 19P. 2. 50	S40	C108		15
1	REF	201276-26	CAP. CERAM. 0603. 3. 9P. 6. 50	S40	C107		14
1	REF	1030283	CAP. CERAM. 0603. 3. 3P. 10. 50	S40	C105		13
5	REF	1024676	CAP. CERAM. 0603. 0. 001U. 10. 50	S40	C104 C106 C114 C116 C117		12
1	REF	201276-96	CAP. CERAM. 0603. 27P. 2. 50	S40	C103		11
1	REF	201276-136	CAP. CERAM. 0603. 12P. 5. 50	S40	C102		10
1	REF	1030277	CAP. CERAM. 0603. 2. 0P. 5. 50	S40	C101		9
2	REF	1024760	CAP. CERAM. 0603. 0. 01U. 10. 50	S40	C5 C112		8
4	REF	150275-1	CAP. CERAM. 0603. 0. 1U. 80V. 20. 16	S40	C3 C7 C8 C120		7
1	REF	200334-1	CRYSTAL. SYN. EFG540. 4MHz. 0. 5. 5M	S40	Y1		6
1	REF	151189-1	CAP. ALIC. SM. 47U. 20. 10	S40	C15		5
1	REF	151800-1	IC. MICRO. CH. REC. RCVR. 01/02	S40	U2		4
1	REF	150379-1	IC. EPROM. 24AA01. SM. 501C. B	S40	U4		3
1	REF	151038-1	CONN. MOLEX. 44184-0006. 6. 5. PC	HM40	J1		2
1	REF	1024247	COIL. INDUCT. F. 60K. 7. 20	HM40	L102		1
-103	REF	-101					

PARTS LIST

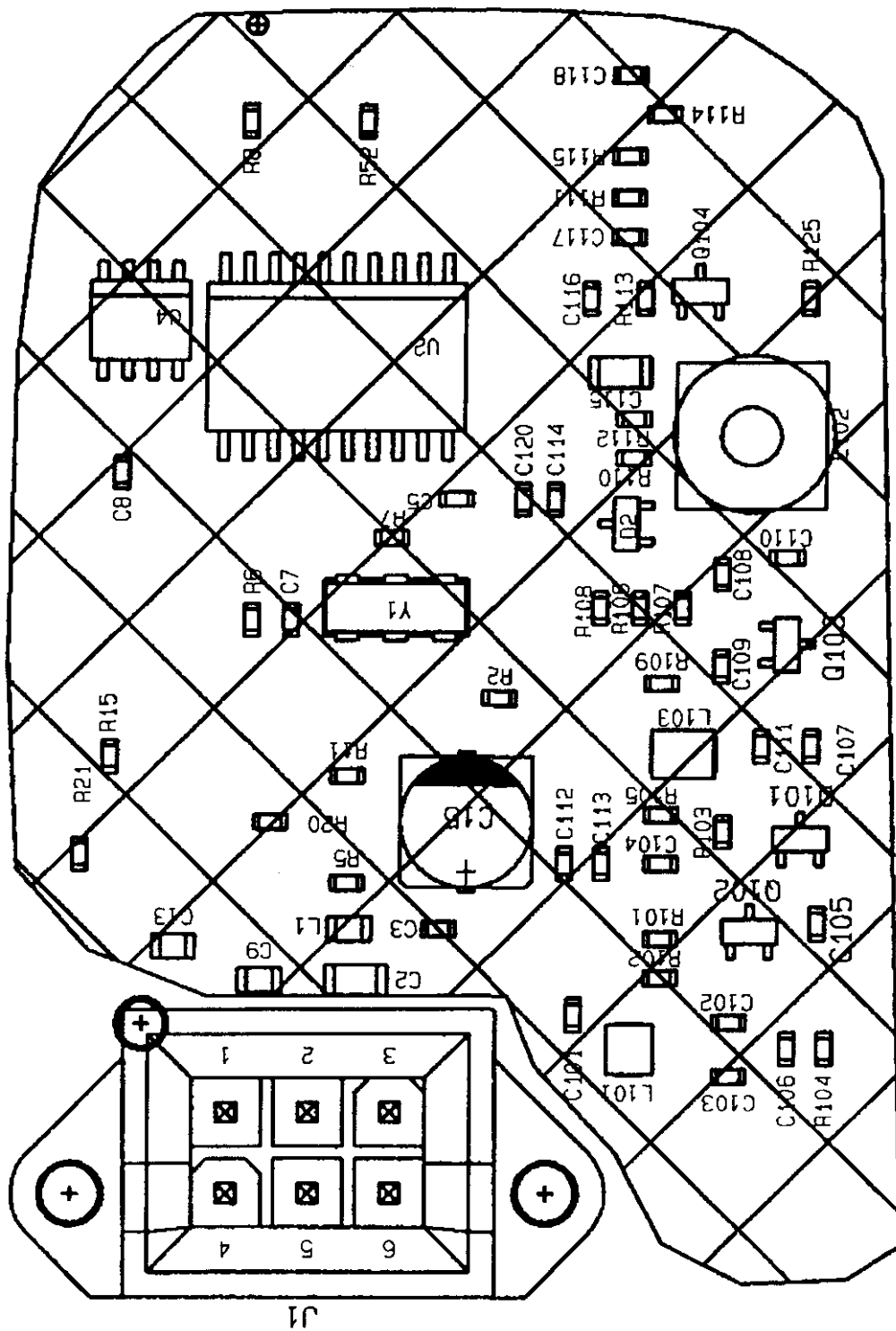


EXHIBIT H

Page 2 of 3

U of Mich file 415031- 966

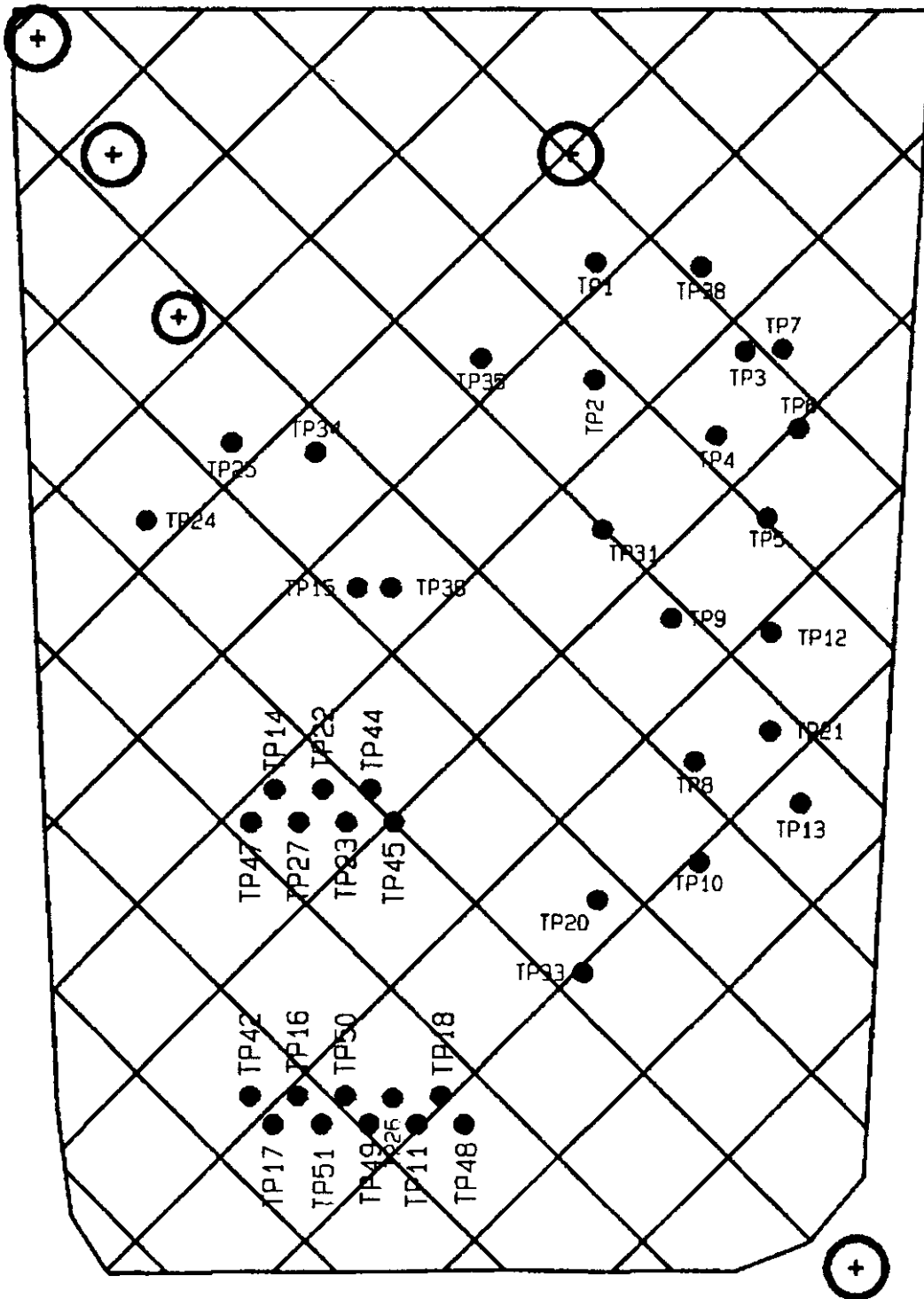


EXHIBIT 14

Page 3 of 3

U of Mich file 415031- 966