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Measured Radio Frequency Emissions
From

TRW JR RKE Receiver
Model GQ43VT24R

Report No. 415031-966
September 2, 1998

For:
TRW-TED
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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.

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		Hewlett-Packard 432A	August 1989/U of M Rad Lab
w/ Thermistor		Hewlett-Packard 478A	August 1989/U of M Rad Lab
Broadband Bicone (20-200 MHz)	X	University of Michigan	July 1988/U of M Rad Lab
Broadband Bicone (200-1000 MHz)		University of Michigan	June 1996/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 automotbile 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) μV/m	E_{lim} dB(μV/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	dB(μV)
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). Pmax = 2 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 syrofoam 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 excersized 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(μV/m), we use expression

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

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

V = 5.0 VDC
I = 1.7 mADC

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.

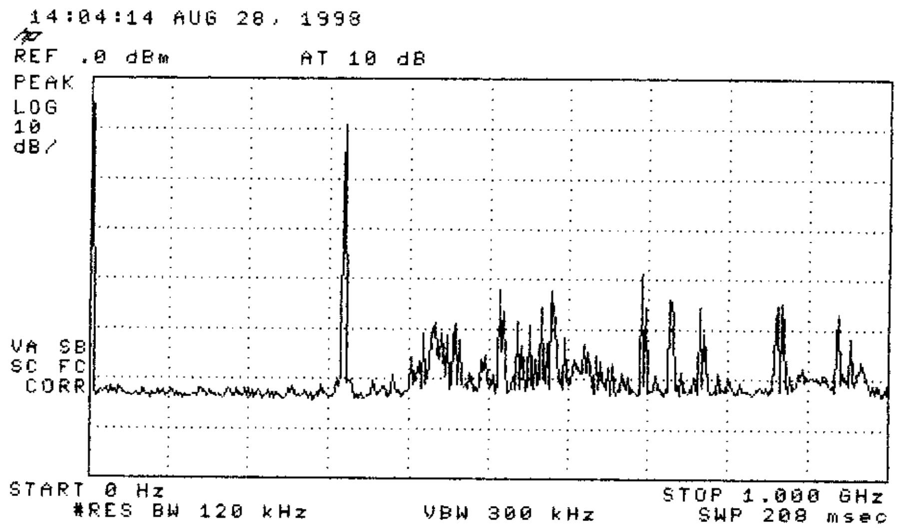
Table 5.1 Highest Emissions Measured

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.



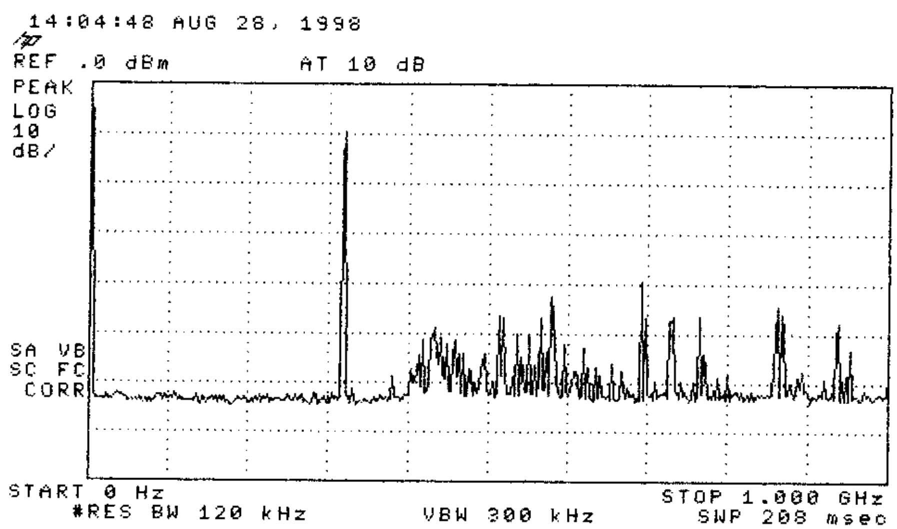
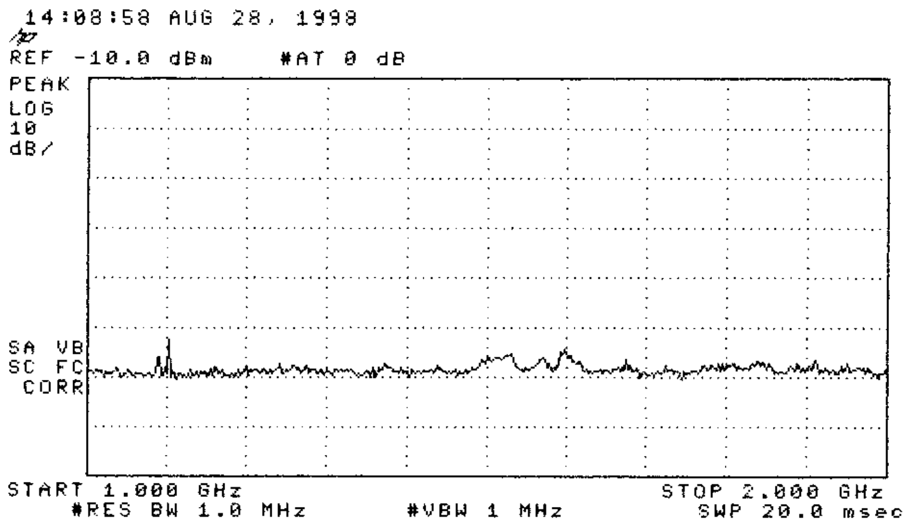


Figure 5.1. Emissions measured at 3 meters in anechoic chamber, 0-1000 MHz.
(top) Receiver plus ambient
(bottom) Ambient



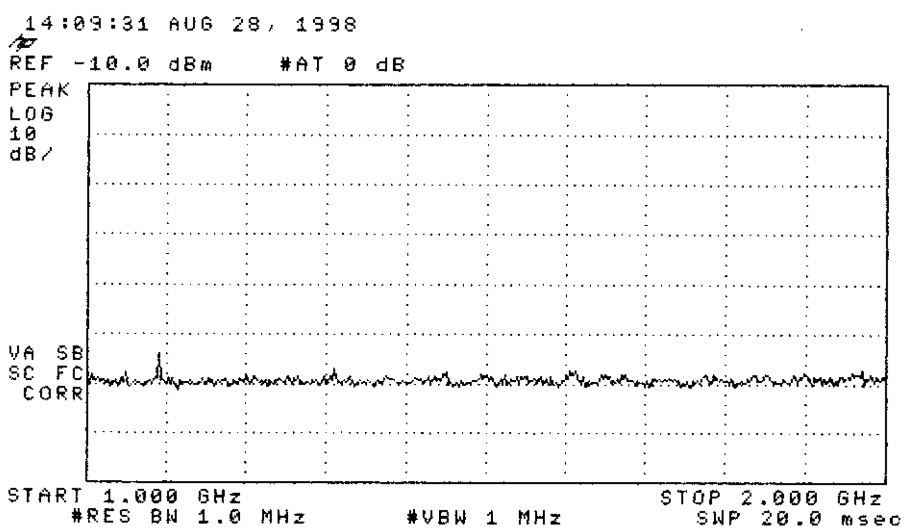


Figure 5.2. Emissions measured at 3 meters in anechoic chamber, 1000-2000 MHz.
(top) Receiver plus ambient
(bottom) Ambient

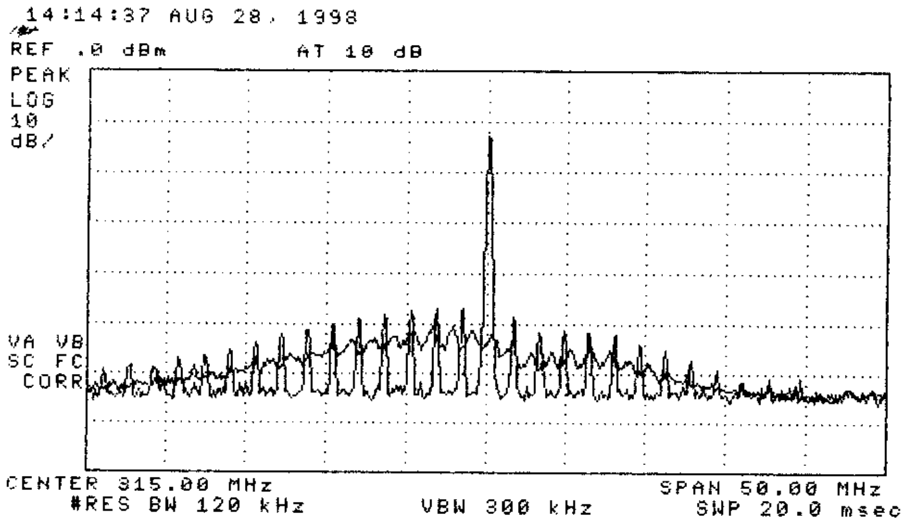


Figure 6.1. Relative receiver emissions in stand-by and "locked-in" modes. The final emission measurements were made with the receiver in "locked-in" mode.

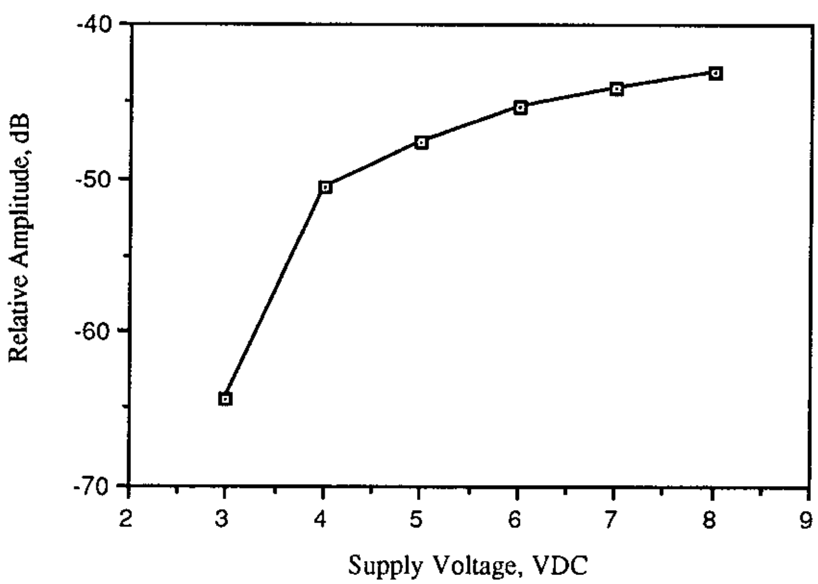


Figure 6.2. Relative emission at "fundamental" vs. supply voltage.

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.

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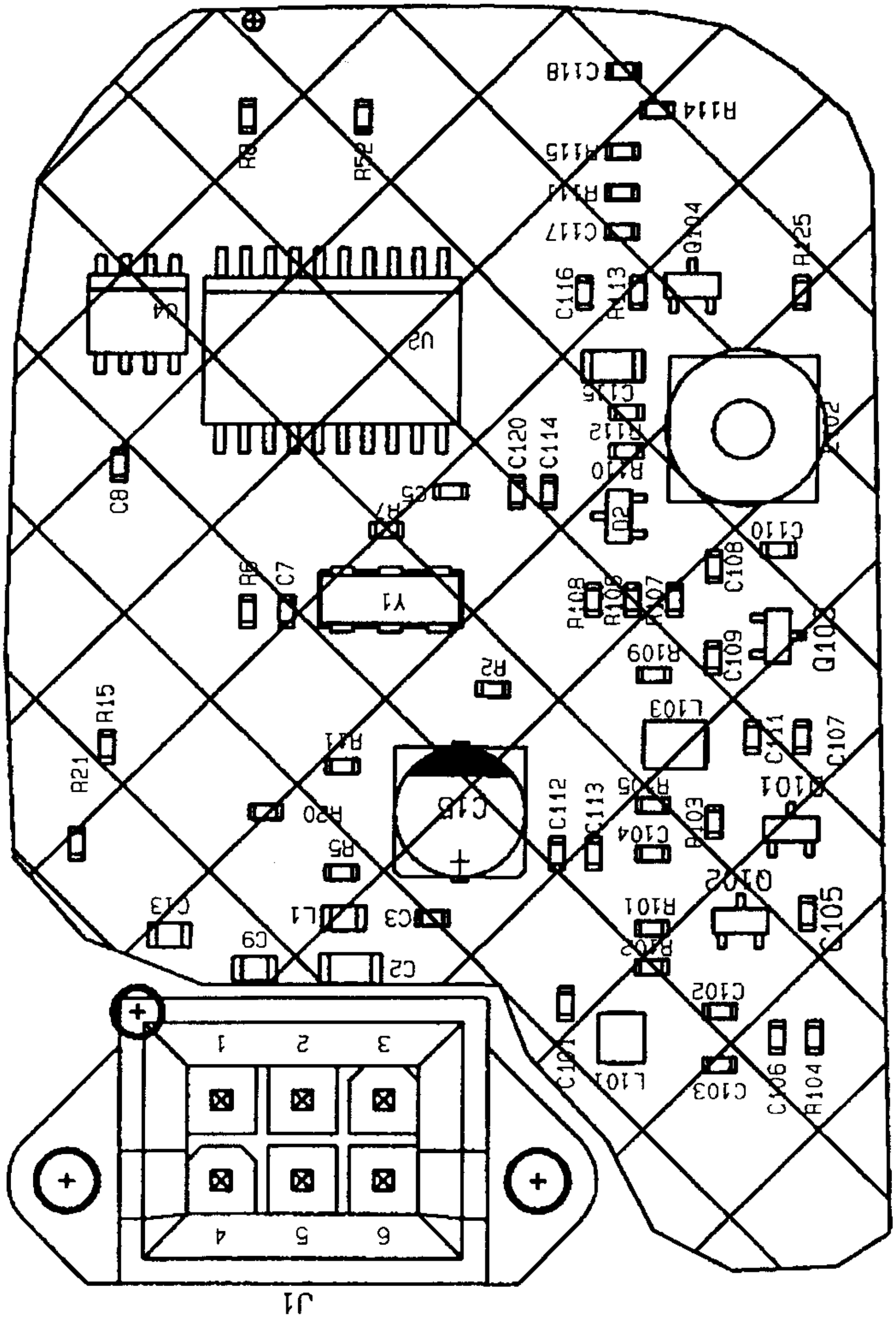
NORTH AMERICAN

QTY REQ PER BOARD PER NEXT ASSEMBLY	-103	-101	PART NO.	DESCRIPTION (BPCS)	PRCS	REF DES TOP	REF DES BOT	ITEM
	1		205387-1	PCB; CHRY; JR/KJ/LH; RKE; RCVR/SG				61
		1	203410-1	PCB; CHRY; JR/KJ/LH; RKE; RECEIVER				60
	REF	REF	203409	SCH; CHRY; JR/KJ/LH; RKE; RECEIVER				59
	REF	REF	1030817	SOLDER; TINT; BAR; 63/37				58
	REF	REF	200583-1	PASTE; SOLDER				57
	REF	REF	1030569	CONFORMAL COAT; SOLVENTLESS; 5293				56
	2	2	201080-2	SCW; TF; PN; PH; 4-14; 5mm				55
	REF	REF	205425	TEST; SPEC; RECVR; FINAL AUDIT				54
	1	1	1005887	TRANS; BC846BLT1; NPN; SOT-23; S	SMD	Q104		53
	3	3	1025095	TRANS; MMBR5179LT1; NPN; SOT-23; S	SMD	Q101 Q102 Q103		52
	1	1	1005973	DIODE; SIG; MMBD914L; 70; 225MW; SM	SMD	D2		51
	1	1	1027879	COIL; INDUC; P; 1.8U; 20; 3225	SMD	L103		50
	1	1	200817-2	COIL; INDUC; F; 39N; 5; 2520	SMD	L101		49
	1	1	151200-1	COIL; BEAD; F; 11.14N; 25; SM	SMD	L1		48
	1	1	1024557	RES; CR; 0603; 3.3MEG; 5; 1/16; C	SMD	R115		47
	1	1	1024527	RES; CR; 0603; 180K; 5; 1/16; C	SMD	R114		46
	1	1	1024561	RES; CR; 0603; 4.7MEG; 5; 1/16; A	SMD	R113		45
	1	1	1024485	RES; CR; 0603; 3.3K; 5; 1/16; A	SMD	R112		44
	1	1	1029732	RES; CR; 0603; 6.04K; 1; 1/16; C	SMD	R110		43
	1	1	1029688	RES; CR; 0603; 2.1K; 1; 1/16; C	SMD	R109		42
	1	1	1029772	RES; CR; 0603; 15.8K; 1; 1/16; C	SMD	R108		41
	1	1	1029737	RES; CR; 0603; 6.81K; 1; 1/16; C	SMD	R107		40
	1	1	1029792	RES; CR; 0603; 25.5K; 1; 1/16; C	SMD	R106		39
	1	1	1024468	RES; CR; 0603; 620; 5; 1/16; C	SMD	R105		38
	1	1	1024466	RES; CR; 0603; 510; 5; 1/16; C	SMD	R104		37
	1	1	1024499	RES; CR; 0603; 12K; 5; 1/16; C	SMD	R103		36
	1	1	1024498	RES; CR; 0603; 11K; 5; 1/16; C	SMD	R102		35
	1	1	1024505	RES; CR; 0603; 22K; 5; 1/16; C	SMD	R101		34
	1	1	150417-3	RES; CR; 0603; 4.7K; 5; 1/16; A	SMD	R52		33
	3	3	151477-1	RES; CR; 0603; 0; 5; 1/20; C	SMD	R20 R21 R125		32
	3	3	150417-5	RES; CR; 0603; 47K; 5; 1/16; A	SMD	R11 R15 R111		31
	1	1	150417-4	RES; CR; 0603; 10K; 5; 1/16; A	SMD	R8		30
	1	1	1024545	RES; CR; 0603; 1MEG; 5; 1/16; A	SMD	R7		29
	1	1	150417-6	RES; CR; 0603; 100K; 5; 1/16; A	SMD	R6		28
	1	1	1024477	RES; CR; 0603; 1.5K; 5; 1/16; A	SMD	R5		27
	1	1	1029561	RES; CR; 0603; 100; 1; 1/16; C	SMD	R2		26
	1	1	150291-1	CAP; CERM; 1206; 0.22U; 10; 25	SMD	C115		25
	1	1	1028281	CAP; CERM; 1206; 0.1U; 10; 100	SMD	C2		24
	1	1	1006868	CAP; CERM; 0805; 0.001U; 10; 100	SMD	C13		23
	1	1	1028389	CAP; CERM; 0805; 0.01U; 20; 100	SMD	C9		22
	13	13	N/A	UNINSTALLED	SMD	C125 C200 C201 C130 R10 R12 R16 R140 R141 R200 Q1 Q2 R51		21
	1	1	150275-14	CAP; CERM; 0603; 0.22U; 80/-20; 16	SMD	C118		20
	1	1	1024567	CAP; CERM; 0603; 100P; 5; 50	SMD	C113		19
	1	1	1030273	CAP; CERM; 0603; 1.5P; 7; 50	SMD	C111		18
	1	1	201276-25	CAP; CERM; 0603; 3.6P; 7; 50	SMD	C110		17
	1	1	150275-15	CAP; CERM; 0603; 220P; 5; 50	SMD	C109		16
	1	1	201276-90	CAP; CERM; 0603; 15P; 2; 50	SMD	C108		15
	1	1	201276-26	CAP; CERM; 0603; 3.9P; 6; 50	SMD	C107		14
	1	1	1030283	CAP; CERM; 0603; 3.3P; 10; 50	SMD	C105		13
	5	5	1024676	CAP; CERM; 0603; 0.001U; 10; 50	SMD	C104 C106 C114 C116 C117		12
	1	1	201276-96	CAP; CERM; 0603; 27P; 2; 50	SMD	C103		11
	1	1	201276-136	CAP; CERM; 0603; 12P; 5; 50	SMD	C102		10
	1	1	1030277	CAP; CERM; 0603; 2.0P; 5; 50	SMD	C101		9
	2	2	1024760	CAP; CERM; 0603; 0.01U; 10; 50	SMD	C5 C112		8
	4	4	150275-1	CAP; CERM; 0603; 0.1U; 80/-20; 16	SMD	C3 C7 C8 C120		7
	1	1	200334-1	CRYSTAL; SYN; EFOS40; 4MHZ; 0.5; SM	SMD	Y1		6
	1	1	151189-1	CAP; ALIC; SM; 47U; 20; 10	SMD	C15		5
	1	1	151800-1	IC; MICRO; CH; RKE_RCVR_01/02	SMD	U2		4
	1	1	150319-1	IC; EEPROM; 24AA01-SN; SOIC; 8	SMD	U4		3
	1	1	151038-1	CONN; MOLEX; 44184-0006; 6_S; PC	HAND	J1		2
	1	1	1024247	COIL; INDUC; F; 60N; 7; RD	HAND	L102		1

PARTS LIST



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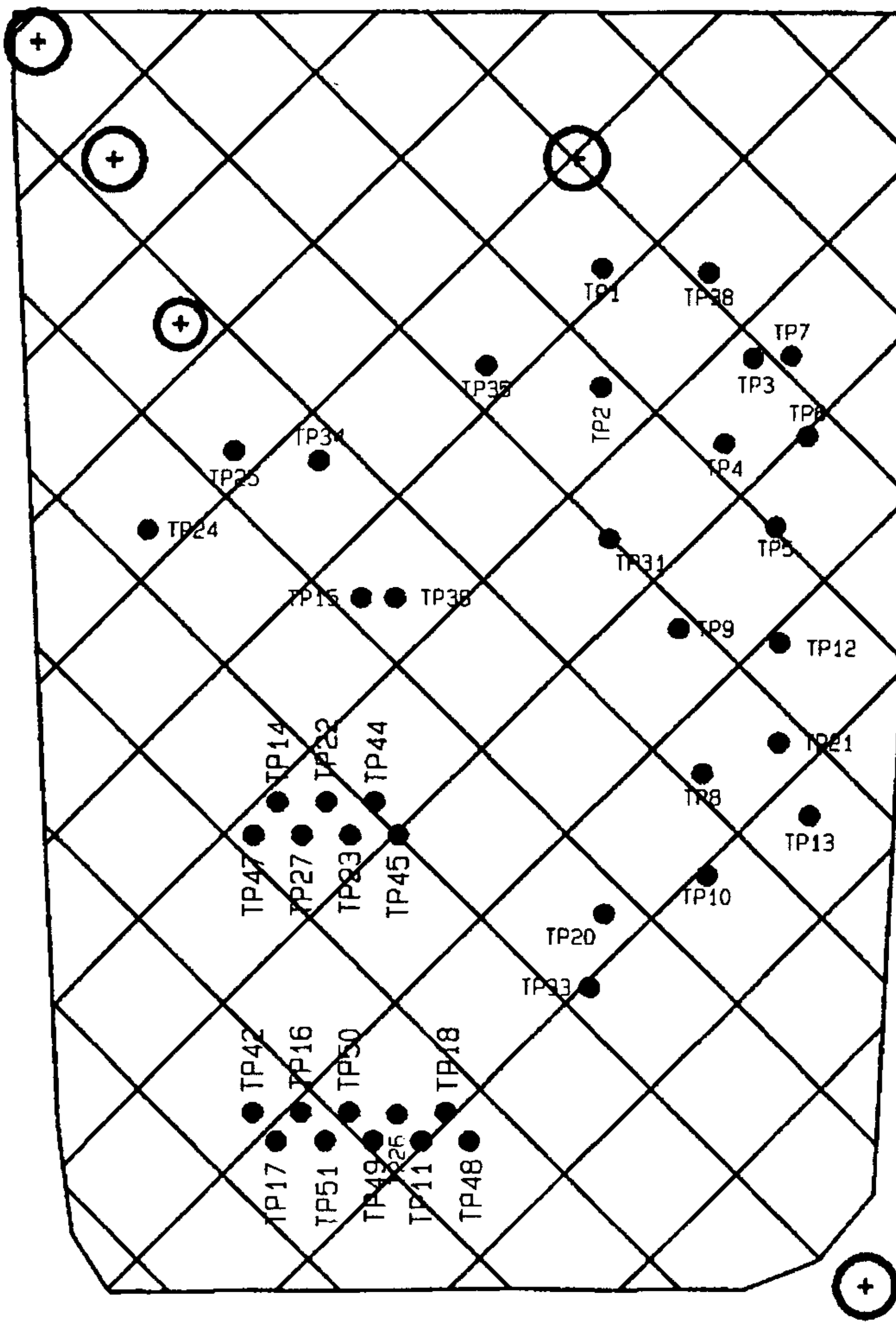

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