



Automotive Electronics Group

Re: Certification for TRW '01 RS Transmitter
Model No.: GQ43VT18R
FCC ID: GQ43VT18R
CANADA:

TEST REPORT

See the following ten pages.

The University of Michigan
Radiation Laboratory
3228 EECS Building
Ann Arbor, MI 48109-2122
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Measured Radio Frequency Emissions
From

**TRW Chrysler RS Transmitter
Model GQ43VT18R**

Report No. 415031-992
April 20, 1999

For:
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Summary

Tests for compliance with FCC Regulations subject to Part 15, Subparts B and C, were performed on TRW Chrysler RS transmitter. This device is subject to the Rules and Regulations as a transmitter and as a digital device.

In testing performed April 6 through 19, 1999, the device tested in the worst case met the allowed specifications for radiated emissions by 9.8 dB at fundamental and by 1.1 dB at the harmonics (see p. 6). Besides harmonics, there were no other significant spurious emissions found; emissions from digital circuitry were negligible. The conductive emission tests do not apply, since the device is powered by two 3 VDC lithium cells.

1. Introduction

TRW Chrysler RS transmitter, Model GQ43VT18T, 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)		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	March 1999/U of M Rad Lab
LISN Box		University of Michigan	May 1994/U of M Rad Lab
Signal Cables	X	Assorted	January 1993/U of M Rad Lab
X-Y Plotter		Hewlett-Packard 7046A	During Use/U of M Rad Lab
Signal Generator (0.1-2.06 MHz)	X	Hewlett-Packard 8657B	January 1994/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 peanut-shaped 5-button low power RKE transmitter designed to send identification and control signals to a matching receiver in the car. It is activated by depressing any of the five buttons. The emission is a pulse-width modulated code on a 315 MHz carrier generated by a SAW stabilized oscillator. Coding is performed by a microprocessor. The DUT was designed and manufactured by TRW-TED, 24175 Research Drive, Farmington Hills, MI 48335. It is identified as:

TRW Chrysler RS Transmitter
Model: GQ43VT18T
SN: FCCTEST
FCC ID: GQ43VT18T
CANADA: to be provided by IC

Two units were provided, one standard, and one modified for CW emission. The CW unit was used for emission measurements, and the standard unit was used for duty factor and occupied bandwidth measurements.

3.1 EMI Relevant Modifications

No modifications were made by this laboratory.

4. Emission Limits

4.1 Radiated Emission Limits

The DUT tested falls under the category of an Intentional Radiators and the Digital Devices, subject to Subpart C, Section 15.231; and Subpart B, Section 15.109 (transmitter generated signals excluded); and Subpart A, Section 15.33. The applicable testing frequencies with corresponding emission limits are given in Tables 4.1 and 4.2 below. As a digital device, the DUT is considered as a Class B device.

Table 4.1. Radiated Emission Limits [Ref: 15.231(b), 15.205(a)] --Transmitter.

Frequency (MHz)	Fundamental Ave. E_{lim} (3m)		Spurious** Ave. E_{lim} (3m)	
	(μ V/m)	dB (μ V/m)	(μ V/m)	dB (μ V/m)
260.0-470.0	3750-12500*		375-1250	
322-335.4 399.9-410 608-614	Restricted Bands		200	46.0
960-1240 1300-1427 1435-1626.5 1660-1710 1718.9-1722.2 2200-2300	Restricted Bands		500	54.0

* Linear interpolation, formula: $E = -7083 + 41.67 * f$ (MHz)

** Measure up to tenth harmonic; 120 kHz BW up to 1 GHz, 1 MHz BW above 1 GHz

Table 4.2. Radiated Emission Limits (Ref: 15.33, 15.35, 15.109) -- Digital, Class B

Freq. (MHz)	E_{lim} (3m) $\mu\text{V/m}$	E_{lim} dB($\mu\text{V/m}$)
30-88	100	40.0
88-216	150	43.5
216-960	200	46.0
960-2000	500	54.0

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

4.2 Conductive Emission Limits

The conductive emission limits and tests do not apply here, since the DUT is powered by two internal 3 VDC lithium batteries.

5. Radiated Emission Tests and Results

5.1 Anechoic Chamber Measurements

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

In testing for radiated emissions, the transmitter was activated using the lock/unlock button with a special wooden clamp for repeated pulse emissions. It was placed on the test table flat, on its side, or on its end.

In the chamber we studied and recorded all the emissions using a bicone antenna up to 300 MHz and a ridged horn antenna above 200 MHz. The measurements made in the chamber below 1 GHz are used for pre-test evaluation only. The measurements made above 1 GHz are used in pre-test evaluation and in the final compliance assessment. We note that for the horn antenna, the antenna pattern is more directive and hence the measurement is essentially that of free space (no ground reflection). Consequently it is not essential to measure the DUT for both antenna polarizations, as long as the DUT is measured on all three of its major axis. In the chamber we also recorded the spectrum and modulation characteristics of the carrier. These data are presented in subsequent sections. We also note that in scanning from 30 MHz to 3.15 GHz using bicone and the ridge horn antennas, there were no other significant spurious emissions observed.

5.2 Outdoor Measurements

After the chamber measurements, the emissions were re-measured on the outdoor 3-meter site at 315, 630, and 945 MHz using tuned dipoles and/or the high frequency bicone.

Figure 5.1 shows the DUT placed flat on the open-site table.

5.3 Computations and Results

To convert the dBm measured on the spectrum analyzer to dB($\mu\text{V/m}$), we use expression

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

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
- K_E = pulse operation correction factor, dB (see 6.1)

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 1.1 dB.

6. Other Measurements and Computations

6.1 Correction For Pulse Operation

When the transmitter is activated, it transmits PWM code up to 35 seconds, as long as the button remains depressed. For momentary operation, the transmission time of about 200 ms. The transmission consists of a wake-up word (50ms) followed by identification/command words (27.1 ms) repeating every 74.5ms. A identification/command word consists of 10 narrow (210μs) synch pulses followed by 34 command pulses which, in the worst case, could all be wide (420μs). See Figure 6.1. These repeating words give the worst case, resulting in

$$K_E = (10 * 0.210\text{ms} + 32 * 0.420\text{ms}) / 74.5\text{ms} = 0.220 \text{ or } -13.2 \text{ dB.}$$

6.2 Emission Spectrum

Using the ridge-horn antenna and DUT placed in its aperture, emission spectrum was recorded and is shown in Figure 6.2.

6.3 Bandwidth of the Emission Spectrum

The measured spectrum of the signal is shown in Figure 6.3. The allowed (-20 dB) bandwidth is 0.25% of 315 MHz, or 787.25 KHz. From the plot we see that the -20 dB bandwidth is 68 kHz, and the center frequency is 315.0 MHz.

6.4 Effect of Supply Voltage Variation

The DUT has been designed to be powered by two 3 VDC batteries. For this test, the batteries were drained and a laboratory variable power supply was attached to their poles. Relative power radiated was measured at the fundamental as the voltage was varied from 2.2 to 3.5 volts. The emission variation is shown in Figure 6.4.

6.5 Input Voltage at Battery Terminals

Batteries:	before testing	$V_{oc} = 3.13 \text{ V}$
	after testing	$V_{oc} = 2.97 \text{ V}$
Ave. current from batteries	$I = 6.4 \text{ mA}$	(CW mode)

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Table 5.1 Highest Emissions Measured

Radiated Emission - RF											TRW Chrysler RS TX; FCC/IC
#	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	-25.1	Pk	18.9	21.8	65.8	75.6	9.8	flat *worst case
2	315.0	Dip	V	-27.1	Pk	18.9	21.8	63.8	75.6	11.8	end
3	630.0	Dip	H	-54.4	Pk	25.2	18.5	46.2	55.6	9.4	flat
4	630.0	Dip	V	-54.8	Pk	25.2	18.5	45.8	55.6	9.8	end
5	945.0	Dip	H	-68.7	Pk	28.9	16.1	37.9	55.6	17.7	flat
6	945.0	Dip	V	-68.9	Pk	28.9	16.1	37.7	55.6	17.9	end
7	1260.0	Horn	H	-34.3	Pk	20.4	28.1	51.8	55.6	3.8	flat
8	1575.0	Horn	H	-42.1	Pk	21.4	28.2	44.9	54.0	9.1	side
9	1890.0	Horn	H	-33.3	Pk	22.1	28.1	54.5	55.6	1.1	flat
10	2205.0	Horn	H	-42.3	Pk	22.9	27.0	47.4	54.0	6.6	flat
11	2520.0	Horn	H	-42.0	Pk	24.0	26.6	49.2	55.6	6.4	flat
12	2835.0	Horn	H	-55.0	Pk	24.9	25.4	38.3	55.6	17.3	flat
13	3150.0	Horn	H	-55.7	Pk	25.2	24.8	38.5	55.6	17.1	end
14											
15											
16											
17											
18											
17											

All transmitter orientations were measured; above are the major emissions.

*includes -13.2 dB duty factor

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
22											
23											
24											
25											

Digital emissions are more than 20 dB below FCC Class B limit

Conducted Emissions							
#	Freq. MHz	Line Side	Det. Used	Vtest dBμV	Vlim dBμV	Pass dB	Comments
1							
2							
3							
4							
5							
6							
7							

Not applicable

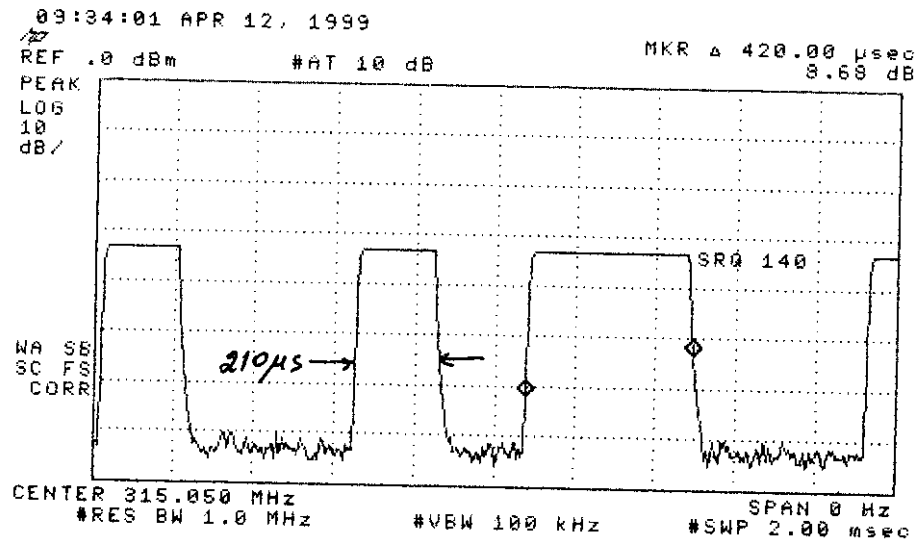
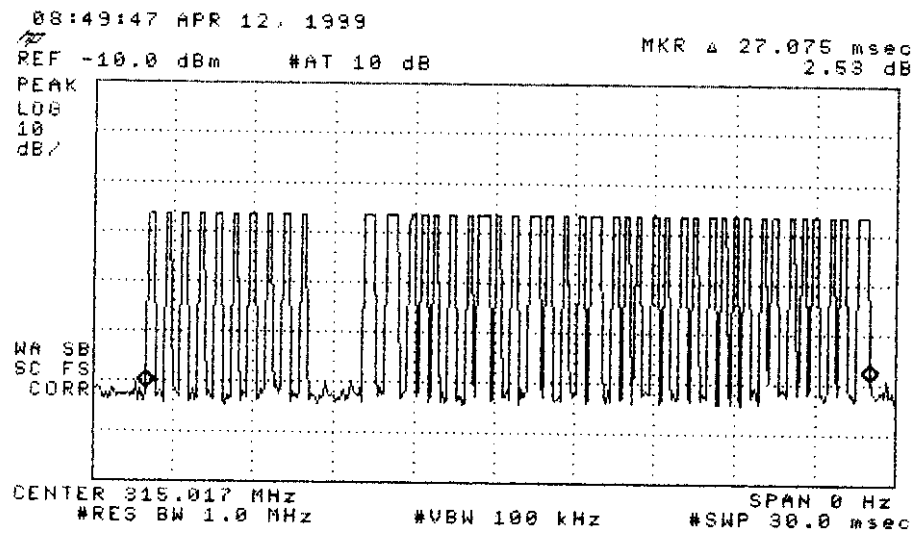
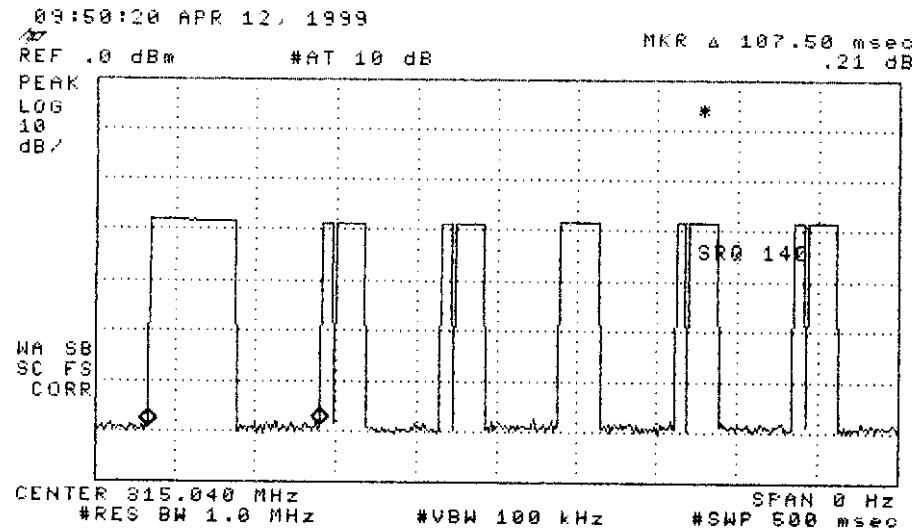


Figure 6.1. Transmissions modulation characteristics: (top) complete transmission, (center) expanded word, (bottom) expanded bits.

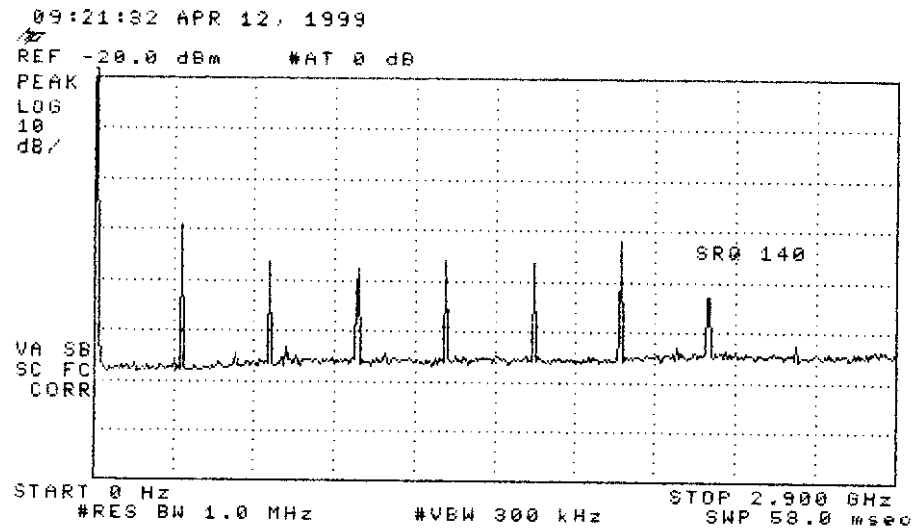


Figure 6.2. Emission spectrum of the DUT (pulsed emission).
 The amplitudes are only indicative (not calibrated).

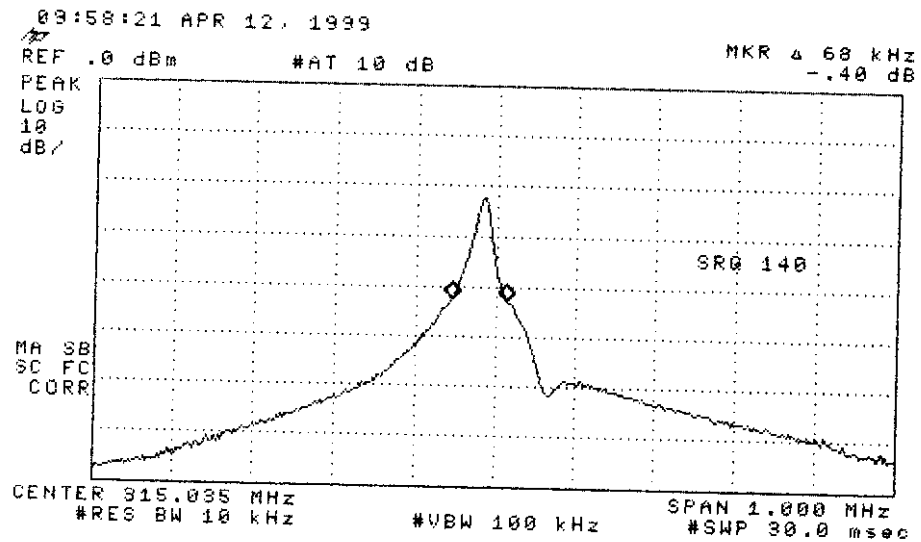


Figure 6.3. Measured bandwidth of the DUT (pulsed emission).

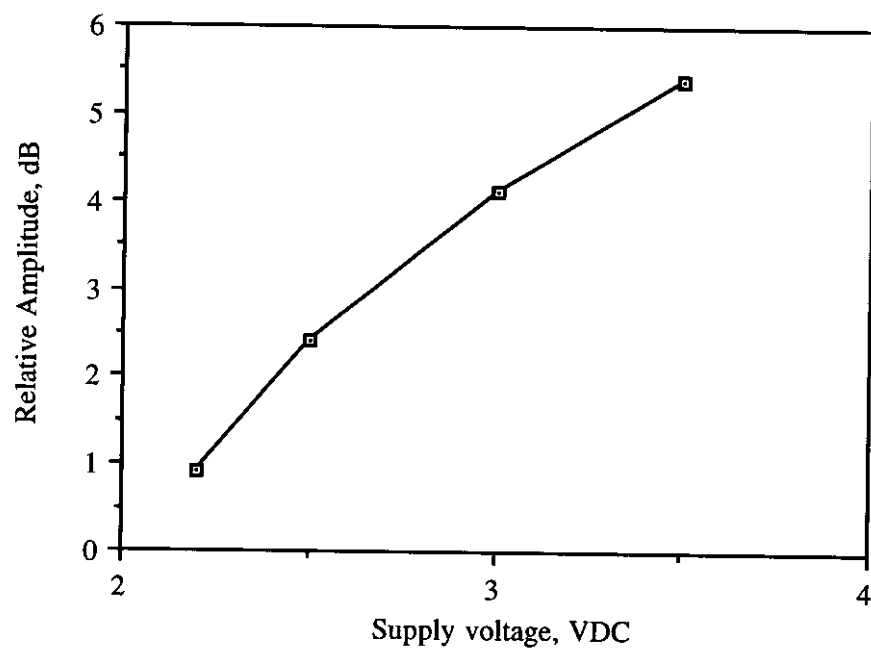


Figure 6.4. Relative emission at 315.0 MHz vs. supply voltage (pulsed emission).



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Model No.: GQ43VT18R
FCC ID: GQ43VT18R
CANADA:

PRINCIPLES OF CIRCUIT OPERATION

The transmitter utilizes a SAW resonator controlled oscillator to generate a carrier frequency of 315.0MHz. When a button is pressed, a Keeloq encoder will generate an associated encrypted command code; the code will be modulated onto the 315MHz carrier by means of ASK modulation; the modulated RF carrier then will be radiated through the onboard antenna.

The transmitter will enter sleep mode after the pressed button is released or after a button is pressed down for about 27.5 seconds, whichever comes first. The Keeloq encoder updates the content of coding with a specific encryption key after each transmission.

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BLOCK DIAGRAM

The transmitter circuit is comprised of PCB antenna, SAW oscillator, Keeloq encoder, buttons and battery.

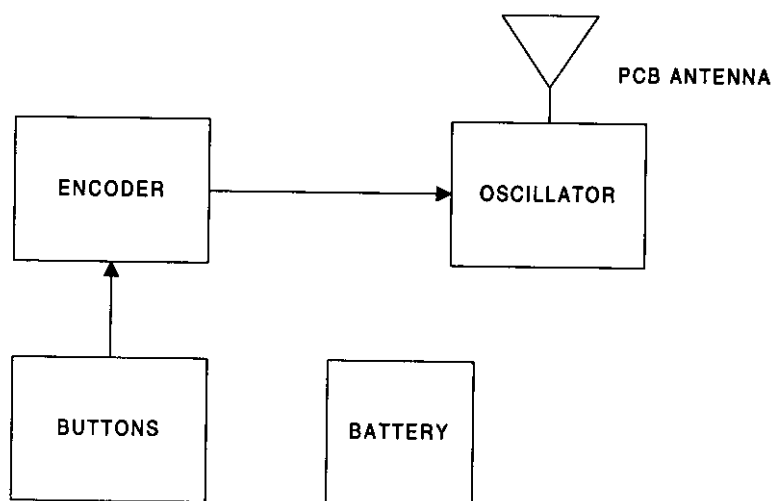


Figure 1. Transmitter Block Diagram