

Technical Report
Transmitter Model QUATTRO
FCC ID# BRWQUATTRO

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1.0 INTRODUCTION

1.1 Definition

The Model QUATTRO is a transmitter for the Remote Control (R/C) of models such as airplane, helicopters, cars, boats, etc.

This Transmitter is for FM System, available for the PPM(Pulse Position Modulation).

This Transmitter is a part of the Horizon Hobbies PPM "family" of Remote Control Transmitters which at this time consists of:

Transmitter Model #	FCC ID #
F400 NET-E104	BRWNET-E104
F400EX	BRWF400EX
XF421EX	BRWXF421EX

Separate Applications for each transmitter and for the receiver is submitted as required by the Commission.

The Manufacturer, Japan Remote Control Company (JR), Manufactures all transmitters and receivers.

The PPM family of R/C systems is exported by JR to the united States of America, and several European and Asian Countries.

The Applicant for this Equipment Authorization, HORIZON HOBBIES, INC. will, following receipt of Grant of Equipment Authorization, import only those versions of these R/C radios which are allowed for use in the USA under the Rules and Regulations of the Federal Communications

The 72 - 73 MHz version of this transmitter is the subject of this Application; these are the units which will be offered for sale to the general public.

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1.2 Application

The Model QUATTRO R/C transmitter utilizes "Frequency Modulation" to convey the PPM encoded position of its control sticks (joysticks) and toggle switches to its companion R/C receiver, where the PPM encoded pulse train is demodulated, decoded, and supplied to a number of servo-mechanisms for positioning of control surfaces, throttle etc. on the model.

The Frequency-Shift-Keying of the transmitter carrier takes place in the rhythm of the PPM pulse train.

Transmitter and receiver are very narrow band units; they have been designed to comply with the European requirements of 10 KHz channel spacing. As a result, they operate safely in the present 20 KHz channel spacing environment allowed at this time in the USA.

1.3 Construction

The Model QUATTRO Transmitter all consists of a plastic case.

(Reference is made to Fig. 5.1, Transmitter Block Diagram)

- * control sticks and control switches
- * a 9.6V rechargeable (Nicad) battery
- * a commutator to sample the analog control voltages in sequence
- * an analog-to-digital converter (ADC)
- * a microprocessor (μ P) to create the PPM pulse train
- * a modulator driver stage
- * a RF power stage
- * a telescopic antenna

This Transmitter is to be made available by the JAPAN and USA on those carrier frequencies in the 72 - 73 MHz frequency band which are at present authorized for R/C use.

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2.0 ENCODER THEORY OF OPERATION

Reference is made to Figure 5.1, Transmitter Block Diagram.

The functions of the encoder are to:

- * accept the analog voltages from the control inputs (joysticks, toggle switch).
- * process the analog voltages to create control mixing, adding, reversing, etc., as desired by the user.
- * sample these voltages in a cyclic rhythm under control of the system's internal timing generator.
(This process is called commutation.)
- * process these analog voltages into binary weighted digital control words by means of an Analog-to-Digital Converter (ADC).
- * store these digital representations of the analog control input into a temporary memory (RAM).
- * supply this serial data stream to a buffer-driver for modulation of the RF Transmitter.
- * provide "housekeeping" of the encoding process by means of a quartz crystal controlled internal clock.
- * provide supply voltages to the RF section ($V_{cc} = 9.6V$ battery voltage; $V_{reg} = 6.0V$ regulated voltage).

The entire program which controls the timing housekeeping, parallel-to-serial conversion process, and insertion of synchronization words and error detection codes is governed by a Central Processing Unit (CPU) under control by an internally stored program residing in Read-Only Memory (ROM). The CPU, RAM and ROM are all part of a single-chip microprocessor (μp).

Resolution of the Analog-to-Digital conversion process is nine (9) bits for a control accuracy of $1:2^9$ or 0.2 percent.

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3.0 RF SECTION THEORY OF OPERATION

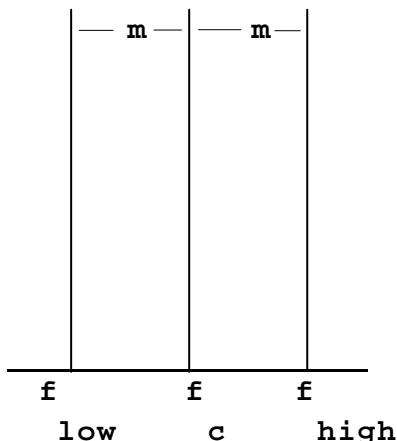
3.1 General

Reference is made to Figure 5.1, Transmitter Block Diagram.

The Horizon Hobbies Model QUATTRO R/C Transmitter is a tow sticks type Transmitter.

It operates on any of the R/C frequency (Channels) allowed by the Commission in the 72 -73 MHz frequency band. Selection of the desired RF channel is made by Quarts crystal.

This transmitter employs Frequency-Sift-Keying (FSK) of the carrier frequency, whereby the output frequency is either low or high due to the symmetrical FSK modulation process, the (center) output frequency cannot be directly measured, but must be calculated by taking the average of the high and low frequency states.



m = shift from center frequency
 m = approx. 1.8 KHz

$$f \text{ carrier} = \frac{f \text{ low} + f \text{ high}}{2}$$

The peak-to-peak deviation of the FSK signal is approximately 4 KHz ("sliver modulation")

Because of the unfamiliarity of the general public with the term FSK, this modulation technique is commonly named FM.

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3.2 Block Diagram

(Reference is made to Figure 5.1)

The (up to) four control potentiometers are at the right side of the schematic drawing.

The control potentiometer, which is mechanically coupled to the control (joy) stick, is supplied with the regulated 5.0V voltage. The wiper on this pot is exactly centered in the neutral control stick position. All analog processing is performed as deviations from this center (reference) voltage.

It acts as a buffer/driver for the control potentiometer output voltage, and it allows additional input to be analog mixed to the control voltage.

The oscillator consists of an ECO type oscillator, excited by a quartz crystal. The crystal supports oscillation at the crystal's fundamental frequency (approximately 18MHz). The tuned circuit in the oscillator transistor's collector is tuned to the second harmonic of this frequency (approx. 36MHz).

Q12 acts as a frequency multiplier ($\times 2$)/buffer; it drives the Power Amplifier (PA). Its output frequency is $4\times$ crystal frequency.

The straight-through PA stage is followed by a matching and band pass/low-pass network. This network matches the low PA stage output impedance to the whip antenna.

The crystal load capacitance is affected by varicap CR1,2, which is voltage-controlled by the "rounded-off square wave from the modulator transistor. The oscillator frequency is therefore switched in the rhythm of the modulate modulation pattern (FSK).

Two DC Supply Voltage enter the RF section: 9.6 Volt "law" battery voltage supplies the PA stage only. All other stages, and bias current for all stages, including the PA, are derived from the regulated 6.0 Volt source on the main encoder board.

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4.0 FAILURE ANALYSIS

A failure analysis was conducted to ascertain that single-component failure will not result in unauthorized radiation.

It should be noted that component failure would result in return of the unit to the factory, or to an authorized repair station.

(Reference is made to Figure 5.2, Transmitter Schematic Diagram)

Failure of any of the transistors (predominant failure mode: emitter-collector short) will result in the unit becoming inoperative:

In the case of Q3 oscillator short, RF output will be nonexistent.

Q6 or Q7 failure will result in very low, if any, output.

Failure of the MOD IN input (latch at 0 or 9.6 Volt) or modulator transistor Q2, Q4, will result in either the high frequency (carrier frequency + 1.8 KHz), or the low frequency (carrier frequency - 1.8 KHz) being transmitted. Although this failure would render the unit inoperative, the frequency tolerance would still fall within the channel bandwidth and tolerance requirements of .002% of 72 MHz = 1.44 KHz.

Failure of the varactor diode D1 (open or short) results in a measured frequency drop of 9.2 KHz (varactor short) or no change (varactor open).

Although a varactor-short failure would bring the generated frequency out-of-tolerance, the unit will become inoperative, power will be turned off, and the unit will be returned for service (Note that even in this failure mode, no harmful energy is being transmitted on neighboring channels).

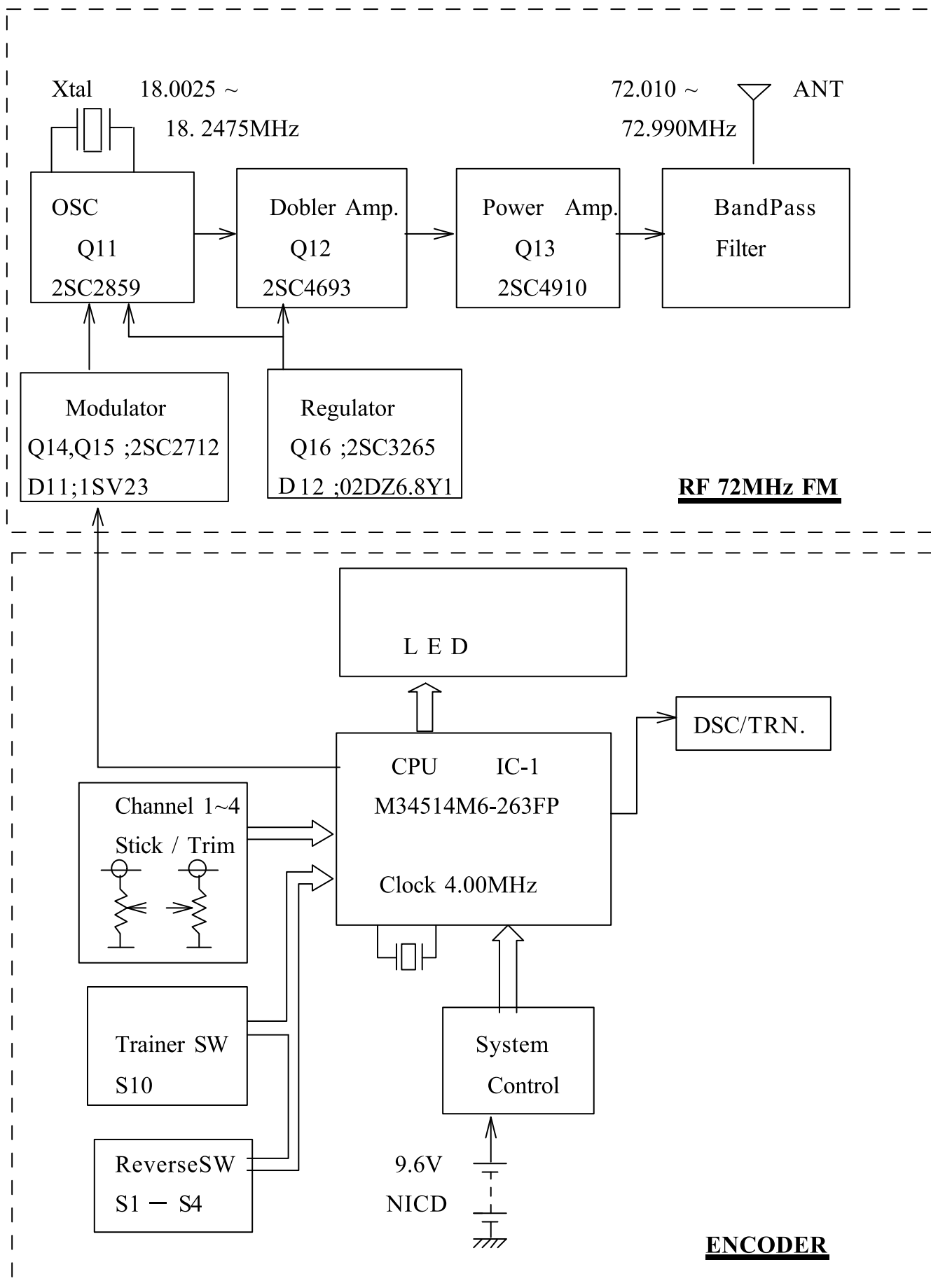
Failure of the quartz crystal, X1, will inevitably result in no, or strongly reduced, output.

All other incidental failures will render the unit inoperative and because for return of the transmitter to the service facility.

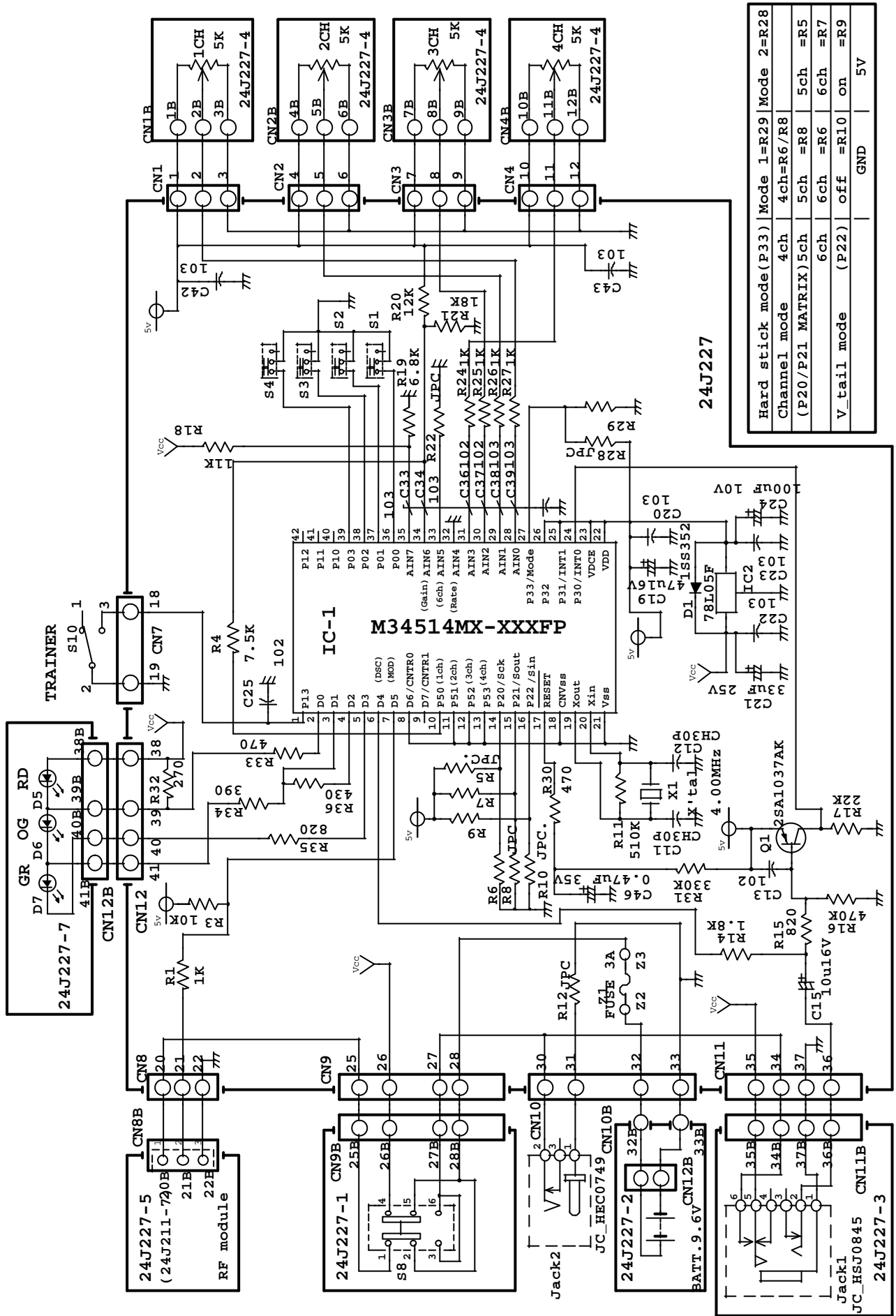
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Transmitter R.F. Tune Up Procedure

1. Remove four screws from transmitter.
Remove PC assembly. Put PC assembly on bench,
component side up.
2. Refer to transmitter schematic Figure 5.2.2.
Soften bee's wax on cores in L1, L2, L3 and L5.
Using oscilloscope with small 50 ohm loop, starting at L1,
adjust these cores for maximum oscilloscope reading.
Repeat this tuning sequence until no further increase in
oscilloscope reading can be obtained.
3. The MOD. IN input latch at 0 volt. Observe frequency counter.
Adjust the small ceramic trimmer capacitor on the PC assembly
so that output frequency is exactly 1.8 KHz higher than
the channel frequency.
4. The MOD. IN input latch at 9.6 Volt.
Adjust the small trimmer resistor on PC assembly so that
output frequency is exactly 1.8 KHz lower than channel
frequency for the module.
5. Repeat step 2.
Repeat step 3 and 4.
6. Using spectrum analyzer with small 50 ohm loop, verify that
sub harmonic and harmonic components are at least 50 dB below
carrier component. Pay special attention to 90 MHz and 144
MHz components.
7. Remove PC assembly from Transmitter. Reapply bee's wax to L1,
L2, L3 and L5. Put PC assembly back into its case, replace
the four screws and re-seal opposite edge.



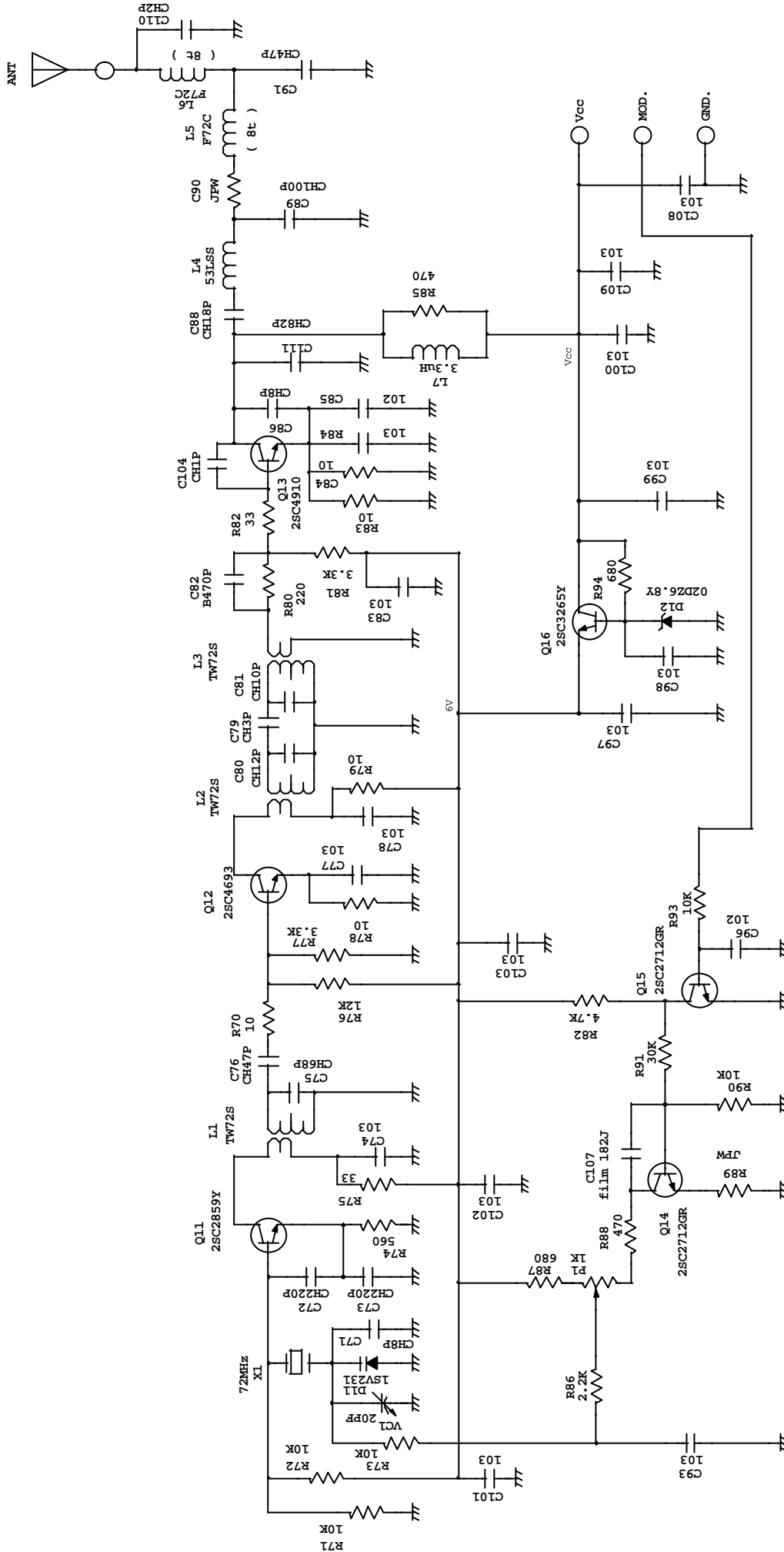
FCC ID# BRWQUATTRO Figure 5.1 Transmitter Block Diagram



Transmitter Schematic Diagram

Figure 5.2.1.

FCC ID# BRWQUATRO



FCC ID# BRWQUATTRO Transmitter Schematic Diagram

Figure 5.2.2.

SPECIFICATION OF CRYSTAL UNIT

1.FREQUENCY	18MHz (72MHz) TX
2.HOLDER TYPE	HC-50/U
3.FREQUENCY TOLERANCE	+ - 7 PPM / +25C.
4.EQUIVALENT RESISTANCE	20 OHMS MAX/SERIES
5.OPERABLE TEMPERATURE RANGE	-20 C. ----- +60 C.
6.TEMPERARURE DRIFT	+ - 20 PPM
7.LOADING CAPACITY	52 PF
8.DRIVE LEVEL	1 mW
9.SHUNT CAPACITY	7 PF MAX
10.MODE OF OSCILLATION	FUNDAMENTAL (AT CUT)
11.INSULATION RESISTANCE	500 M OHMS MIN AT 100 V DC
12.SHOCK TEST	
	DROPPING FROM 75 CM HEIGHT 3 TIMES ON FIRM WOOD
	VARIATION : FREQUENCY LESS THAN +-5 PPM
	RESISTANCE LESS THAN +-15 %
13.VIBRATION TEST	
	FREQUENCY 10 TO 55Hz; AMPLITUDE 1.5mmP-P 1 CYCLE/MINUTES
	TEST TIME 120 MINUTES IN EACH DIRECTION
	VARIATION : FREQUENCY LESS THAN +-5 PPM
	RESISTANCE LESS THAN +-15 %
14.AGING	
	+ - 5 PPM/YEAR

Figure 4.5



