HANDBOOK
for
MODELS 2A AND 2A-01
OFF-AIR FREQUENCY STANDARDS

The content of this handbook is applicable to instruments with serial numbers of 9034 and above. Units supplied to specific customer requirements may differ from the descriptions to be found in this handbook.

Quartzlock reserves the right to alter and improve the specifications without notice.

Off Air Frequency Standard Models 2A and 2A-01

User's Handbook

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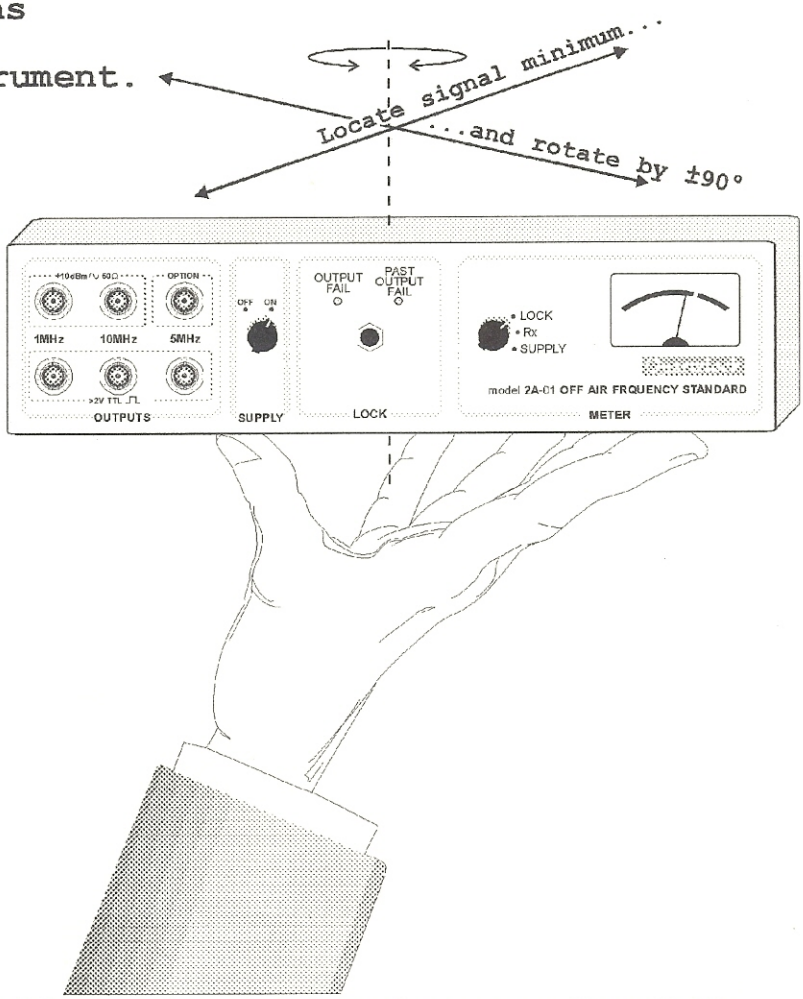
IMPORTANT

Please follow
the instructions
below before
using the instrument.



☞ **It is essential that this procedure is followed to ensure the reliable operation of the instrument when using the integral ferrite antennal.**

☞ **Power up the instrument and select the "Rx" position on the "METER" switch. Hold the instrument as shown and rotate until the indicated signal strength dips to a minimum.**

☞ **The orientation of the instrument during normal operation must be at right angles to the "signal minimum" position identified during the previous step.**

Ref: rotate.

CONTENTS

1 SAFETY NOTICE

The tests and procedures described in this manual are applied with the unit's protective cover removed. These tests and procedures should, therefore, only be performed by competent personnel who are aware of any hazards and risks involved in such operations.

- NEVER remove any p.c.b.s, fuses or components unless the unit is completely unplugged from any power source, either mains or external low voltage.
- ALWAYS use tools with insulated handgrips when making any adjustment with power applied.
- Care should he taken when handling any MOS devices to avoid possible damage due to static charges.
- Under no circumstances should the unit be operated with the mains earth connection be removed from the unit chassis.
- If the IEC mains socket is removed or replaced for any reason then the earth connection should be checked by a competent person.
- Always ensure that the mains filter earth connector is bonded to the chassis before touching this component.

2 INTRODUCTION

The Model 2A Off Air Frequency Standard is a compact, lightweight instrument which provides outputs phase-locked to a standard frequency transmission at either 162kHz or 198kHz. In the UK, this will be the BBC Radio 4 transmission at 198kHz. The primary service is radiated from Droitwich, with fill-in coverage from transmitters at Aberdeen and Westerglen.

The unit is normally mains powered, but for field use may be operated from nominal 9V and 12V battery supplies. The Model 2A-01 Off Air Frequency Standard is similar to the Model 2A, but incorporates circuitry to detect and indicate out-of-lock conditions. In addition, this option also provides sinewave outputs at 1MHz and 10MHz and disables outputs on loss of lock.

3 SPECIFICATION

3.1 OUTPUTS

- TTL compatible square wave outputs at 10MHz, 5MHz and 1MHz. (50Ω drive capability with TTL compatible levels).
- CORE output at 162/198kHz (1KΩ source impedance).
- Sinewave signals at 1MHz and 10MHz into 50Ω (*model 2A-01 only*):
  2V pk-pk terminated.
  ±0.05dB at +10dBm at 20°C
  Harmonic distn. <-50dBc (typically -60dBc)
  VSWR <1.5:1

3.2 FREQUENCY ACCURACY AND STABILITY

- <2 parts in 10^8 over 1 second. (Typically 1 part in 10^8)
- <2 parts in 10^9 over 10 seconds. (Typically 1 part in 10^9)
- Long term stability is that of the frequency standard broadcast employed.

3.3 Phase Jitter

- Better than 0.1 cycle peak-to-peak.

3.4 Settling Time

- Within specification 60 seconds after switch-on.

3.5 Input Sensitivity

- Better than 2μV from external antenna.
- The integral ferrite antenna is adequate for use over most of the UK .

3.6 Power Requirements

- 210V - 250V a.c. / 46Hz - 56Hz
- Battery supply 8V minimum, 13.8V maximum, via rear connector.
- Current consumption (d.c. supply) - 90mA for Model 2A, 150mA for Model 2A-01.

3.7 Operating Temperature Range

- 0°C - 40°C ambient.

3.8 Weight and Dimensions

- 1.6kg (3.5lbs) approx.
- Max. dimensions - 222mm by 32mm by 180mm.

4 CONTROLS AND INDICATORS

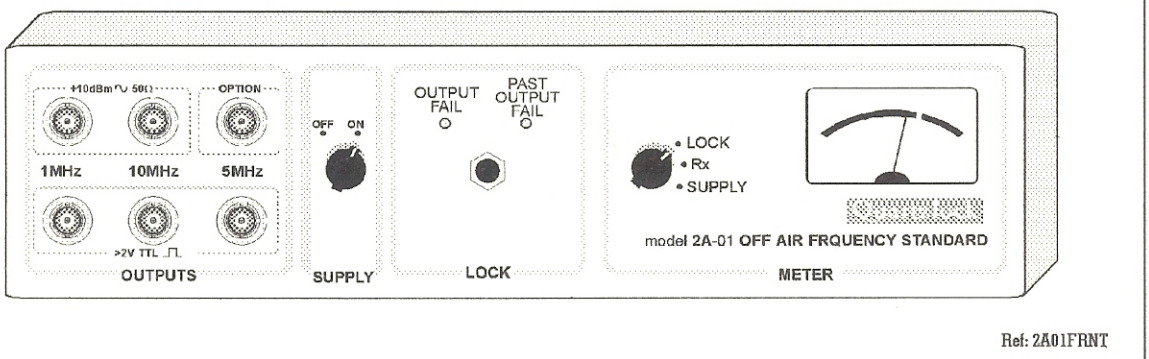


Fig. 1.2 Front Panel Layout - Model 2A-01

- **FRONT PANEL METER**. Provides the facility to monitor internal supply rail voltage, received signal level, and lock status. The meter function is selected by a front panel switch.
- **MAINS ON/OFF.** Located on the rear panel of the instrument.
- **ANTENNA SELECT.** Located on the rear panel of the instrument. Enables the selection of either the integral ferrite antenna (INT) or an external antenna (EXT) to be used as the signal source for the instrument.
- **DC ON/OFF.** A front-panel control which allows the d.c. power supply to the main p.c.b. to be isolated. This switch operates on both battery and mains derived supplies.
- **METER SWITCH.** This selects the function of the front-panel meter: DC supply monitoring (SUPPLY), received signal level (RX), and lock condition (LOCK).
- **LOCK INDICATION**. (*Model 2A - 01only*) A red LED (OUTPUT FAIL), accompanied by a bleeper, indicates that the instrument is currently out-of-lock and that as a result all outputs are inhibited. A flashing orange LED (PAST OUTPUT FAIL) indicates that an out-of-lock event has taken place. The PAST OUTPUT FAIL indication may be cleared by pressing the button below the LED indicators.

5 OPERATION

5.1 LOCATION, POSITIONING AND ANTENNAS

The instrument should ideally be located so that the integral ferrite antenna is not affected by large magnetic or metallic objects close to it. If a satisfactory signal is not obtained because of local screening, an external antenna should be used. Although a wire antenna may be used for this purpose, a Quartzlock active antenna, type AE198, is recommended.

Unsatisfactory operation may also be the result of interference from a variety of sources, including florescent lighting, computers and VDUs. If such interference cannot be avoided by a suitable choice of location for the instrument, the use of a suitably positioned external antenna, as mentioned above, is recommended.

If the instrument is operated using the integral ferrite antenna, the instrument must be positioned to obtain the maximum signal level, as described on page i.

When a wire antenna is used, it should be connected to the INPUT BNC connector on the rear panel, and the SELECT switch moved to the EXT position. The external wire antenna should be as long as possible and insulated at the far end. It should be positioned so that a stable signal-strength reading is obtained (see below).

If an active antenna is used, it should be connected to the INPUT BNC and OPTIONS D-type connector on the rear panel, and the SELECT switch moved to the EXT position. (The latter connector is used to supply power to the active antenna.)

5.2 CHECKING FOR A SATISFACTORY SIGNAL

To monitor received signal strength, the meter switch should be set to the RX position. For satisfactory operation, the meter indication must be:

- at or above the scale marker to indicate satisfactory signal strength.
- steady. Any jitter indicates an unusable signal.

If the signal from the internal antenna does not meet these conditions, an external antenna must be used.

5.3 Checking the Lock Condition

To check the instrument's lock condition, the meter switch should be set to the LOCK position. Immediately after switch-on, or an interruption of the off-air signal, the meter will reading will read initially read low, rising close to the scale marker on the meter within the first 40 seconds and settle to a final value after another 10 seconds. At the same time, the OUTPUT FAIL and PAST OUTPUT FAIL indicators will light and the internal bleeper sound (*model 2A-01 only*). After 60 seconds, the meter should show a stable lock indication, at or near the meter scale marker.

5.4 Operation from External D.C. Supplies

ENSURE THAT THE A.C. MAINS SUPPLY IS DISCONNECTED BEFORE CONNECTING AN EXTERNAL D.C. SUPPLY.

An external d.c. supply of between 8V and 13.8V may be connected via the D-type socket on the rear panel. The polarity of the supply must be:

Positive . . . . . Pin 1

Negative . . . . . Pin 9 (9-pin connector)

or . . . . . Pin 15 (15-pin connector)

5.5 Mains Fusing

Some versions of this instrument have a second, internally located, mains fuse. This may be found under a cover below the rear panel mains on/off switch.

To check or replace this fuse, DISCONNECT MAINS SUPPLY and lift the fuse cover. It should be replaced by a 1A or 0.5A anti-surge ceramic fuse.

6 CIRCUIT DESCRIPTION

6.1 MAIN P.C.B.

The broadcast signal at 162Khz or 198Khz is received and selected by a high-Q ferrite antenna, or an external antenna. This signal is then amplified by an RC-coupled amplifier consisting of Tr1, Tr2, Tr3 and the output emitter follower, Tr4.

The input amplifier is followed by a single-crystal filter, based on X1. The purpose of this filter is to reduce the amplitude modulation sidebands present on the signal.

After filtering, amplitude variations on the the signal are further reduced by a non-saturating limiting amplifier consisting of Tr6,Tr7, and Tr8. Tr9 serves to drive the following frequency divider (IC1, IC2, D1, D2 and D3). Link LK1 allows the division ratio to be selected to match the received signal frequency and to ensure that the output of the divider is at 1kHz.

Tr13 acts a buffer stage for the output of the frequency divider and drives an edge-triggered phase comparator (IC3) and the lock-detect circuitry on the 01option board, where fitted.

Tr10 and Tr11 form a Butler-type crystal-controlled oscillator operating at 10MHz. The capacity loading for the crystal consists of C28 and the junction capacitances of D7 and D8. A control voltage applied to these diodes allows the oscillator frequency to varied by small amounts.

Tr12 buffers the output of the 10MHz crystal oscillator and drives a ÷10 counter (IC7) to produce a 1MHz signal, which in turn drives a ÷1000 counter (IC8). The buffered 10MHz signal, the 1MHz signal, and an intermediate output from IC7 at 5MHz are buffered by three sections of IC6, a quad TTL NOR line driver, to provide the square wave outputs at these frequencies. The output inhibit function is achieved by applying the active-high INHIBIT signal to the control inputs of these gates (model 2A-01 only).

The output of IC8, at 1kHz, forms the second input to the phase comparator (IC3) and is also fed to the 01 options p.c.b. via pin 19 (*model 2A-01 only*).

The voltage resulting from the phase errors between the two 1kHz signals is low-pass filtered by the active filter based around IC4, before being applied to D7 and D8 in order to correct the phase of the 10MHz crystal oscillator.

6.2 P.C.B. FOR THE 01 OPTION

This board provides two separate functions. The first is the INHIBIT function which disables all outputs (except CORE) when the phase-lock of the instrument has an error of greater than 1 part in 10^7. The second is to convert the 10MHz and 1MHz squarewaves into sinewave outputs.

In normal operation, there is a time difference between the two inputs to the phase comparator (IC3), located on the main p.c.b. These two signals are routed to pins 3 and 4 on the 01 options p.c.b via pins 19 and 20 on the main p.c.b.

IC1 produces a strobe pulse from the signal on pin 3 and the width of this pulse determines the acceptable range of error between the output and off-air frequency standard signals. The strobe delay is temperature compensated over the operating temperature range by the action of Th1.

If the delay between the signals on pins 3 and 4 exceeds a preset strobe time (set by IC1) then IC2a is toggled. The result is a high level INHIBIT signal (pin 12) which inhibits all the phase-locked outputs from the main board, and activation of the bleeper and the red OUTPUT FAIL LED. IC2a is reset by pressing the front panel LOCK push button.

The transition resulting from the start of an out-of-lock condition also sets the bistable comprising IC3a and IC3b. The change in output state of this bistable allows IC2b to divide the 4Hz signal generated by the astable multivibrator, IC3c and IC3d. The output of IC2b flashes the orange PAST OUTPUT FAIL LED at 2Hz.

The bistable, IC3a and IC3b, together with the flashing indication, is cleared by the LOCK push button as for the functions above.

Two similar circuits are used for the conversion of the 10MHz and 1MHZ squarewaves to provide sinewave outputs. The 1MHz TTL-level squareware from the main p.c.b. is applied, via pin 8, to the base of Tr1. This forms a long-tailed pair amplifier with Tr2. The output at the collector of Tr2 feeds a three-section undercoupled LC filter, using L1, L2 and L3. The filter output is a low-distortion sinewave at pin 9.

The 10Mhz sinewave signal is generated by a similar circuit based on Tr3 and Tr4.

7 ALIGNMENT & SETTING UP PROCEDURES

7.1 TEST EQUIPMENT

The procedures given here enables the unit to be set up and tested to the performance given in the Specification (Section 3, page 3). The equipment required for these tests is listed in Table 1. Equivalent equipment that satisfies the critical parameters may be used.

It is assumed that any person carrying out this testing is conversant with the procedures appropriate to using the various items of test equipment, (e.g, spectrum analyzers), as only the results required are detailed.

Cables, test leads etc. are not specified and are left to the discretion of the tester.

7.2 ALIGNMENT AND ADJUSTMENTS

It a essential that the main p.c.b. is correctly aligned before any adjustments are carried out on the option 01 p.c.b. (*model 2A-01 only*). All relevant measurements and checks should be recorded.

7.2.1 General and Visual Inspection

(a) Check that all switches and the integral antenna assembly are mechanically satisfactory.

(b) Check the following safety points:

- the correct type of 500mA mains fuse is fitted and that the cover is secure (fuse not fitted to all models).
- that all mains wires are sleeved at connection points.
- that protective insulation is present over the mains transformer primary pins.

(c) Check all coaxial leads and connections for possible shorts before applying power.

(d) Check that satisfactory and correct sine wave output filters are fitted.

(e) Ensure that LK1 is in the 1 - 2 position.

(f) Visually check all p.c.b.s for misplaced or damaged components.

ITEM		CRITICAL PARAMETERS / NOTES
1	Dual Beam Oscilloscope	Available with suitable high-impedance probes and bandwidth of 50MHz or better.
2	Synthesised Signal Generator	e.g. Racal-Dana Model 9084
3	Digital Multimeter	-
4	True R.M.S. RF Level Meter	Resolution better than 0.01dBm to at least 10MHz (e.g. Racal-Dana Model 9303)
5	Spectrum Analyzer	-
6	Radiating Signal Generator	Required to set integral ferrite antenna in the absence of an adequate signal from a broadcast service.
7	Independent 10MHz Frequency Standard	A calibrated Model 2A Off Air Frequency Standard, or a Rubidium Standard.
8	Terminations	BNC / 50Ω

Table 1 - Equipment Required for Alignment

7.2.2 Initial Checks

(a) Set the following switches to the indicated positions:

- rear panel mains SUPPLY switch to OFF.
- front panel SUPPLY switch to OFF.
- METER switch to SUPPLY.
- rear panel INPUT switch to EXT.

(b) Set C5 fully open and C28 to 75% open. Apply a 30µV sinewave at 198.000kHz to the INPUT socket and connect the unit to the a.c. mains supply.

(c) Put the SUPPLY switches on the both the front and rear panel to the ON position, and check the following:

- the front panel meter should show a reading close to the scale mark. Operating either switch should result in the meter reading dropping back to zero.
- the bleeper should sound and the red, OUTPUT FAIL LED should be illuminated.
- Measure the voltages at the following p.c.b. pins :

  pins 9 & 10 . . . 13.7V ±2V d.c.

  pins 11 & 12 . . 5V ±0.20V d.c.

7.2.3 Main P.C.B. Alignment

(a) Monitor the emitter of Tr5 at R13 with the oscilloscope on an internal positive trigger. Positive going pulses of approximately 2.5V amplitude and at 198.00kHz/162.00kHz should be present.

(b) Select RX on the METER switch. A reading above the meter scale mark should be obtained.

(c) Reduce the input level to 5µV and adjust C5 to give the maximum reading. NOTE: the setting of C5 should not be more than 75% meshed.

(d) Adjust the input level to 10µV. Check that a signal of the same frequency as the input is present at the CORE output, and that this has an amplitude of approximately 4V and a rise time better than 5µs.

(e) Put the rear panel input SELECT switch to the INT position. If a suitable broadcast signal is not available, a radiating signal source should be placed at least 200mm away from the integral ferrite antenna.

(f) Monitor the signal at R13 and adjust the antenna tuning capacitor (located on the rear of the chassis) for maximum signal amplitude. Reduce the output level of the signal generator as necessary to achieve correct tuning. Switch off the radiating signal generator.

(g) Check p.c.b. pins 19 and 20 for positive and negative going 1kHz pulses respectively.

(h) Monitor p.c.b. pin 14 with the multimeter and adjust C28 to give a voltage reading as indicated in the list below. Note that a time should be allowed after each adjustment of C28 for the unit to settle.

Ambient Temp. Voltage at P14

12°C 1.50V

18°C 1.75V

22°C 2.05V

25°C 2.15V

30°C 2.25V

(i) Select LOCK on the METER switch and check that a reading at or near the meter scale mark is obtained.

(j) Put the rear panel input SELECT switch to the EXT position, and measure the frequency of the signal at pin 4 of IC7. The reading should be close to 9.999850MHz. The exact frequency depends on the 10MHz crystal.

(k) Return the rear panel input SELECT switch to the INT position and allow the unit to lock.

7.2.4 01 P.C.B. Alignment *(Model 2A-01 only)*

(a) Monitor pin 11 of IC3 (a cross-coupled astable) and check that a 5V square wave signal of approximately 4Hz is present at this point.

(b) If the orange PAST OUTPUT FAIL LED is flashing, press the LOCK reset button on the front panel. The bleeper should be sounding and no signals present at the front panel outputs.

(c) Use the negative edge of the pulse signal at p.c.b. pin 3 to trigger the oscilloscope and display the pulse signal on p.c.b. pin 4. Note the delay from the trigger point to the leading edge of the pulse on pin 4. This should be 16µs ±4µs. Jitter on the displayed pulse stream from pin 4 is normal.

(d) Check that a positive-going pulse is present at pin 6 of IC1 and that the pulse width can be varied by adjusting R1.

(e) Check that a positive-going pulses of duration 3µs (±1µs) are present at pin 10 of IC1 and trigger the display from this signal. Use the second channel of the oscilloscope to monitor the signal at p.c.b. pin 4. Use R1 to adjust the timing of the 3µs pulses so that their negative-going edges occur approximately 1.5µs after the positive-going edges of the pulses on pin 4. The bleeper should now stop sounding and the amber PAST OUTPUT FAIL LED start to flash. Reset the PAST OUTPUT FAIL indication by means of the front panel LOCK reset button.

(f) Check that signals are now present at the front panel outputs.

(g) Monitor the 1MHz sinewave output with both the oscilloscope and the r.m.s. power meter. Ensure that the output is terminated with 50Ω.

(h) Adjust L4, L5, and L6 for maximum undistorted signal, and then use R19 to set the output to +10dBm (±0.05dBm).

(i) Monitor the 10MHz sinewave output with both the oscilloscope and the r.m.s. power meter. Ensure that the output is terminated with 50Ω.

(j) Adjust L1, L2, and L3 for maximum undistorted signal, and then use R13 to set the output to +10dBm (±0.05dBm).

(k) Check both the 1MHz and the 10MHz sinewave outputs using a spectrum analyzer, ensuring that each output is terminated with 50Ω. All harmonics should be less than -50dBc. If necessary make small adjustments to the filter inductors to achieve this.

7.2.5 Temperature Tests

(a) Check that the unit performs correctly over the temperature range of 0 to 40°C.

The unit is now ready for use.

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8 Pin and Wiring Connections

8.1 Main Printed Board.

Pin No.	Function
1	198kHz coax input from Ant. Switch.
2	Ground/braid connection for Pin 1.
3, 4, 5	Rx, supply and Lock outputs to meter switch.
6, 7, 8	5Mz, 10Mz and 1Mz square wave outputs to front panel.
9	Unregulated supply input from PSU.
10	Supply ground.
11¶	5V regulated supply to 01 option board.
12¶	Supply ground to 01 option board.
13	CORE output at 198kHz.
14	VCO control voltage test point.
15¶	Inhibit control from 01 option board.
16	Ground/braid connection for Pin 13.
17	+5V supply.
18	Braid connection for pins 6, 7 and 8.
19¶	VCO derived 1kHz pulse to 01 board.
20¶	198/162kHz derived 1kHz ref. pulse to 01 board

¶ - model 2A-01 only.

8.2 01 Option Board (*Model 2A-01 only*)

Pin No.	Function
1*	+5V supply input (from pin 11 on main p.c.b.).
2*	Supply ground (from pin 12 on main p.c.b.).
3*	1kHz ref. pulse (from pin 20 on main p.c.b.).
4*	1kHz VCO freq. (from pin 19 on main p.c.b.).
5*	"OUTPUT FAIL" LED +ve supply.
6*	Ground connection for "RESET" button.
7*	"PAST OUTPUT FAIL" LED +ve supply.
8	1MHz square wave input (from pin 8 on main p.c.b.).
9	1MHz sine wave output to front panel filter.
10	10MHZ square wave input (from pin 7 main p.c.b.).
11	10MHz sine wave output to front panel filter.
12	INHIBIT output (to pin 15 main p.c.b.).

* - these signals may be carried on 7-way ribbon cable.

9 COMPONENT LISTS

9.1 Main Circuit Board

9.1.1 Resistors

(All resistors are 0.125W)

R1	10k	R31	-
R2	22k	R32	10k
R3	220	R33	6k8
R4	1k2	R34	4k7
R5	5k6	R35	560k
R6	1k	R36	4k7
R7	27k	R37	47
R8	8k2	R38	1M5
R9	470	R39	3k9
R11	2k2	R40	2k2
R12	1M	R41	820
R13	1k	R42	820
R14	1k8	R43	22k
R15	47	R44	100k
R16	6k8	R45	1M
R17	120	R46	100
R18	470	R47	820
R19	3k3	R48	33k
R20	820	R49	820
R21	1k2	R50	22k
R22	100k	R51	2k2
R23	22k	R52	10k
R24	100	R53	39k
R25	1k5	R54	680k
R26	150	R55	22k
R27	22k	R56	1k
R28	22k	R57	1k
R29	22k	R58	1k
R30	1k5	R59	470k
		R60	-

9.1.2 Capacitors

(BT = Bead Tantalum, all others are metallised poyester unless specified)

C1	10n	C20	1µ
C2	1µ 10V BT	C21	22µ 10V BT
C3	100n	C22	1µ 10V BT
C4	10n	C23	1µ 10V BT
C5	60pf trimmer	C24	47n
C6	1µ 10V BT	C25	1n ceramic
C7	100n	C26	100n
C8	100n	C27	47n
C9	1µ 10V BT	C28	60p trimmer
C10	100n	C29	100n
C11	1n	C30	100n
C12	100n	C31	100n
C13	47µ 35V BT	C32	100n
C14	100n	C33	100n
C15	100n	C34	22µ 10V BT
C16	100n	C35	470p ceramic
C17	100n	C36	1n
C18	10n	C37	100n
C19	1µ 10V BT	C38	47p ceramic

9.1.3 Semiconductors

D1	1N1914	IC1	4040B
D2	1N1914	IC2	4023B
D3	BAT42	IC3	4046B
D4	BAT42	IC4	LM308
D5	1N1914	IC5	7805
D6	1N1914	IC6	74128
D7	BZX79C22	IC7	74LS390
D8	(BZX79C22)	IC8	MC14553B
D9	1N1914	Tr1 - 14	ZTX109C
D10	1N1914		

9.1.4 Miscellaneous Components

X1 crystal - 198kHz/162kHz parallel mode
X2 crystal - 10.00Mhz series mode

9.2 Option 01 Circuit Board

9.2.1 Resistors

(All resistors are 0.125W)

R1	50k (cermet)	R13	100 (cermet)
R2	10	R14	470
R3	12k	R15	100 (cermet)
R4	270	R16	1k5
R5	100k	R17	68
R6	470	R18	33
R7	100k	R19	100 (cermet)
R8	100k	R20	470
R9	100k	R21	1k
R11	270	R22	1k5
R12	33		

9.2.2 Capacitors

(BT = Bead Tantalum, all others are metallised poyester unless specified)

C1	10n	C12	180p poly.
C2	47µ 20V BT	C13	33p poly.
C3	150p	C14	390p poly.
C4	100n	C15	560p poly.
C5	33p ceramic	C16	10n
C6	10µ 10V BT	C17	2n7 poly.
C7	470n	C18	330p poly.
C8	470n	C19	2n4 poly.
C9	10n	C20	330p poly.
C10	220p poly.	C21	4n7 poly.
C11	33p poly.	C22	6n8 poly.

9.2.3 Semiconductors

IC1	4098B	Tr2	BCY70/ZTX502
IC2	74HC74	Tr3	BCY70/ZTX502
IC3	4011B	Tr4	BCY70/ZTX502
Tr1	BCY70/ZTX502	Tr5	ZTX109C

9.2.4 Miscellaneous Components

L1,2,3	1µH	Antenna Assy.	Quartzlock Insts.
L4,5,6	8µ2H	Sine Wave Filters:	
Th1	VA1097	10MHz	0.56µH, 220p
Bleeper	RS 249-794	1Mhz	4µ7H, 1n8
Mains p.s.u.	Quartzlock Insts.	Meter	200µA f.s.d.
Mains Filter	1A Ovaloid		

All replacement parts may be obtained from our Sales Office. Units may be returned for routine maintenance, modification or update.

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