Codan Part Nº 15-03017 Issue 4, July 1996

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List of drawings

1. How to use this handbook

This handbook describes the installation, operation and technical details of the Type 9350 automatic tuning whip antenna. It is written for:

- users of the antenna
- Codan agents and dealers.

The handbook contains seven chapters. Before you start to use the antenna, read Chapter 2–Overview; Chapter 3–Installing the antenna and Chapter 4–Operating the antenna.

Chapter 5–Technical description, Chapter 6–Parts list and Chapter 7–Appendices are for authorised Codan agents and dealers rather than users.

We recommend that only Codan-approved service agents perform any maintenance on the antenna.

Standards and icons

In this handbook, the following standards and icons are used:

This icon...	Means...
❑	the end of a subject.
	a warning.

❑

Glossary

EEPROM	Electronically Erasable Programmable Read Only Memory
FET	Field Effect Transistor
HF	High Frequency
PCB	Printed Circuit Board
PEP	Peak Envelope Power
RAM	Random Access Memory
RF	Radio Frequency
ROM	Read Only Memory
VSWR	Voltage Standing Wave Ratio

2. Overview

This chapter briefly describes the Type 9350 Automatic tuning whip antenna.

The Type 9350 is a whip antenna designed for use with multi-channel transceivers. It is base-loaded and uses a microcontrolled stepper motor to give continuous tuning over the transceiver's operating frequency range.

If you wish to use Codan's 9001 HF Fax and data interface or 9002 HF data modem, contact your local Codan office for information.

On receipt of your antenna package, check the contents against the packing list. Ensure all items are available before commencing the installation.

When tuning, the antenna seeks the optimum tuning point for the operating conditions. This ensures the best communications possible. Press the **Tune** button on the transceiver to start the tuning action. Typically, it takes a few seconds to tune from one frequency to another.

The microcontroller holds the previously tuned frequency in an Electronically Erasable Programmable Read Only Memory (EEPROM). It compares the held frequency with the new frequency to determine the tuning direction.

The stepper motor then adjusts a tuning coil in the base of the antenna.

When the approximate position is found, the microcontroller changes the antenna loading and feed impedance until the optimum Voltage Standing Wave Ratio (VSWR) is obtained.

The antenna can also operate in scan mode, which allows it to receive over a wide range of frequencies.

The shroud of the antenna is made of glass-reinforced nylon. This provides a sturdy weatherproof housing for the tuning and control devices. The base section includes a robust flexible mount designed to withstand conditions likely to be met travelling on unsealed roads or tracks.

You can easily remove the flexible whip top when the antenna is not in use. The base has weatherproof connectors for the control and RF cables.

Accessories

Code	Accessories
307	Coaxial cable assembly (RG58) fitted with UHF type weatherproof connectors—6 metres.
318	Stainless steel whip top (1 metre long) for use with 9350. Suitable for operation over the transmit frequency range 2.5–27 MHz.
319	Standard or primary whip top (1.48 metre long) for use with 9350.
320	Heavy duty spring for 9350 whip top.
323	Antenna NVIS kit-9350 for short range communications. Frequency range 2–12MHz.
428	Type RG58 coaxial cable.
430	UHF type coaxial connector (weatherproof) to suit RG58 cable.
–	Control interface cable assembly to suit 9350 to transceiver connection—6 metres (part no. 08-05062-001).
753	Cable adaptor kit to interface installed 8558 control cable with 9350 auto tuning whip.
3017	Handbook for type 9350.

Specifications

Frequency range	Transmit/Receive operation: 2–27MHz Receive only (scan mode): 250kHz–30MHz.
Power rating	Voice—125 watts Peak Envelope Power (PEP).
Power consumption	Static—150mA Tuning—1A (typical) 12VDC (nominal) supplied from the transceiver.
Antenna mounting	Anti-vibration mount M16 x 2mm threaded, plated steel stud (supplied with nut and washer) 60mm long. A 7mm hole in the mounting stud allows you to insert a security device, such as a padlock.
Input impedance	50Ω VSWR typically 1.5:1.
Control cable	6m length of multi-core cable for interface with the transceiver. It has a bayonet connector at one end and a 15-pin ‘D’ connector at the other.

Coaxial cable	6m length of RG58 cable fitted with RF weatherproof connectors. Its purpose is to carry RF signals between the transceiver and the antenna.
Size and weight	Base, spring and whip: 2390mm H; 5.8kg Base only: 810mm; 4.4kg.
Temperature range	–40°C to +60°C.
Tuning speed	5.5 seconds over full range 2–27MHz. Typically 2 seconds for generally used operating range. For example, 3–7MHz, 7–22MHz.

If you wish to use the 9350 in fax and data systems, contact your Codan office for information.

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3. Installing the antenna

The antenna is a critical element in any communication system. Correct installation of the antenna is a very important factor in the operation of your transceiver.

The antenna is intended for use in mobile installations and should not be considered for fixed base station installations.

It is essential that the 9350 antenna is connected to an effective and stable RF ground point—the vehicle chassis. It is further recommended that body panels that are in close proximity to the installed antenna are also bonded to the vehicle chassis.

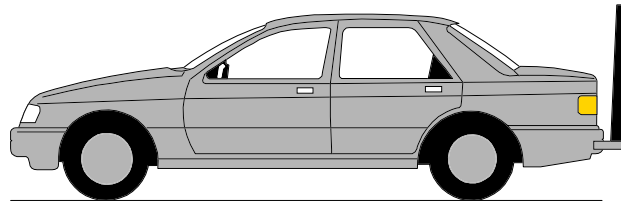
General

Mount the antenna on a strong metal bracket about 10 to 12mm thick with a 17mm hole for the M16 x 2mm threaded mounting stud. Position the bracket so that the base loading coil and the whip are well clear of the vehicle's metal body-work. This will increase the effectiveness of the antenna tuning and give the greatest radiation efficiency. The base loading coil occupies the top half of the shroud assembly (about 400mm).

Generally, on a vehicle with a protruding boot, the antenna should be placed at the rear so as not to obstruct the driver's vision. Many off-road vehicles do not have a protruding boot, so the antenna must be mounted at the front in these cases.

The mounting bracket and antenna must have a good earth connection to the vehicle body. A poor connection will result in poor performance. An earth strap is provided on the base of the antenna to ensure a satisfactory earth connection.

Position the bracket so that any flexing of the antenna will not damage the vehicle—bear in mind that the shroud assembly can flex as much as 15cm, without damage.



Note: At least the top half of the antenna should be above the height of the boot line.

Figure 3-1 Ideal position for the antenna

The coaxial and control cables are provided with connectors so that the antenna may be easily removed from the vehicle. These connectors are considered to be weatherproof when inserted in their mating sockets on the antenna. However, for added protection against dust or moisture entering the connectors, we recommended that you wrap the mated connectors in 'Telcohesive Polymerizing' tape.

Local regulations may control the location of antennas. For example, the antenna should not obstruct the view of lights and number plates. These laws must be observed.

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Occasional off-road use

The 9350 antenna is suitable for installation on an off-road vehicle provided care is taken to provide a rigid mounting bracket.

Where a crash bar is fitted to the vehicle, the antenna may be mounted behind the bar for added protection. However, for best radiation efficiency you should mount the antenna as high as possible and clear of the vehicle metal.

When driving in scrub or undergrowth, try to avoid overhanging branches which could damage the shroud of the antenna. When the antenna is not being used, it is recommended that you remove the whip section.

The shroud assembly is weatherproof, however, you should avoid immersing it in water for prolonged periods.

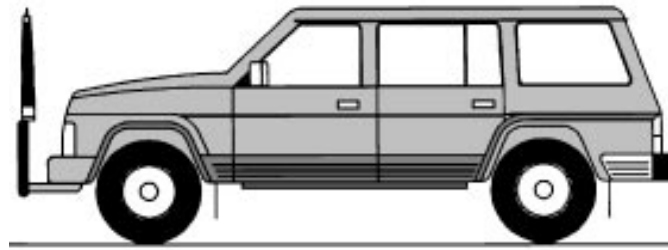

Figure 3-2 Recommended mounting position for vehicles with a crash-bar

The antenna should be mounted on the passenger side of the vehicle to minimise obscuring the driver's vision. If local regulations preclude mounting the antenna on the front of the vehicle, then the antenna can be mounted at the rear as shown in Figure 3-1. If you do this remember to keep the top half of the shroud assembly clear of the vehicle's metal parts.

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Regular off-road use

As well as the precautions you should take for occasional off-road use, think about some added safety measures. For example, when travelling in isolated areas it is a good idea to carry a spare antenna suitable for use if the primary antenna is damaged.

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Heavy transport

The antenna will operate correctly when mounted on heavy transport vehicles using sealed or good secondary roads provided you observe the following points:

- Mounting any antenna on the top of a vehicle's crash bar tends to produce extreme forces on it since any vibrations produced by the vehicle are amplified at the top of the bar. On the other hand, if you mount an antenna too low on a large vehicle, you will reduce its radiation efficiency.
- This problem is common to all 'High Frequency' (HF) whip antennas on large vehicles. It may be necessary to design a mounting location on the cab, bearing in mind the legal height limit and the required supporting strength. This is particularly true for vehicles used mainly on corrugated or unformed roads.
- Mounting the antenna behind the cabin, even with the tuning assembly above the level of the roof, can create problems because the load is often higher than the cabin.

It is also difficult to determine the best location to mount an antenna on vehicles such as that shown in Figure 3-3. We recommend that you mount the antenna as low as possible on the crash bar, but jutting out from the body at an angle of about 30° to the vertical.

Although the antenna whip is robust and flexible, avoid contact with low overhead obstructions, as damage may occur to the whip.

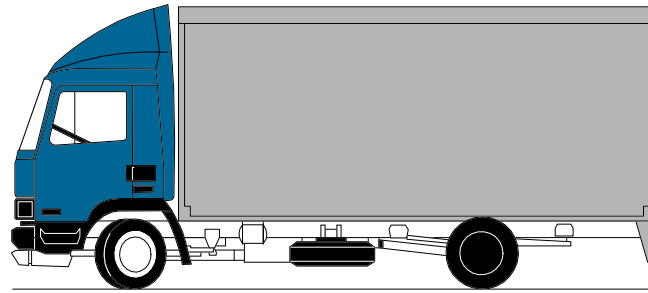

Figure 3-3 A typical vehicle highlighting the difficulty of where to mount the antenna

Transceiver to antenna cabling

Two cables are supplied with each antenna—a coaxial cable and a control cable. These cables connect directly from the transceiver to the sockets in the antenna base.

The coaxial cable is a 6m length of RG58 cable fitted with UHF type weatherproof connectors at either end. Screw one end of this cable into the appropriate socket in the base of the antenna and the other into the antenna socket at the back of the transceiver.

The control cable is a 6m length of multi-core cable with a bayonet connector at one end and a 15-pin 'D' connector at the other. Plug the 'D' connector into the female 'D' connector marked **Antenna Control** at the back of the transceiver. Plug the bayonet connector into the appropriate socket in the base of the antenna.

Protect the cables, as far as possible, by routing them within the body of the vehicle. Where they pass through bulkheads:

- minimise the size of the 'D' connector by removing the 'D' connector cover
- use grommets to protect the cable insulation from being damaged.

Control cable pin connections

The following table shows the standard pin connections for the control cable:

Transceiver	Antenna
12, 13	A—+12VDC
14, 15	B—Earth
4	C—Tune
5	D—Scan
11	E—Indicator
	F—Not used

Table 3-1 Control cable pin connections

Addendum–Application note 17-60034

CODAN

Issue 1—April 1995

9350 Automatic tuning whip antenna control cable installations

Scope

This application note identifies the various and accepted methods of installing the 9350 automatic tuning whip antenna to Codan transceivers, and the specific selection of the interface control cable.

Although it is preferred that the 9350 be installed with it's own nominated control cable, on some existing mobile installations this may be inconvenient. In this case, existing antenna control cabling may be retained through the use of the cable adaptor kit P/No 15-00753.

Details

8528B, 8528, 9313 and 9480 series transceivers fitted with Option AD (Antenna Driver)

Option AD is not compatible with the 9350 antenna and, if fitted within the transceiver, must be removed for it to operate. The existence of Option AD in a transceiver can be identified externally by the sticker "Warning, Connect to 8558 Only", above the Antenna Control port connector at the rear of the transceiver. Preferred practice is to remove the Option AD PCB - see addendum page 3-13, and use antenna control cable P/No 08-05062-001 to connect the transceiver to the antenna, minimising the number of connection points as shown in Figure 1.

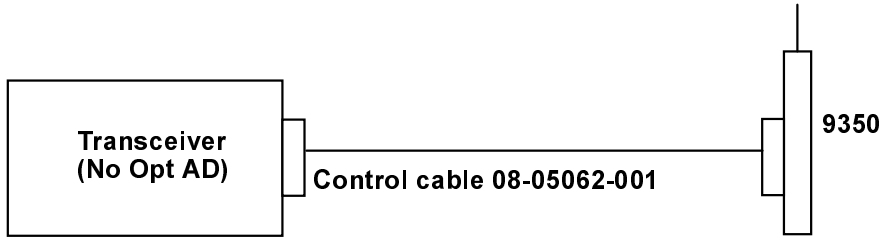

Figure 1: 8528B, 8528, 9313, 9480 series transceivers without Option AD but with standard 9350 control cable

However, if the installation previously had an 8558 automatic tuning whip antenna 'C' or 'D' series, then, by fitting the adaptor kit Code 753 - PCB P/No 08-05182-001 in the transceiver, it is possible to retain the existing antenna control cable P/No 08-04674-001. Also the adaptor cable (P/No 08-05183-001) must be fitted at the antenna end of the cable to be compatible with the 9350 connector as shown in Figure 2.

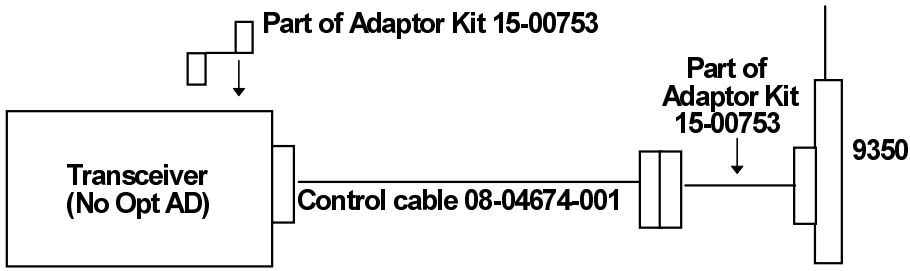

Figure 2: 8528B, 8528, 9313, 9480 series transceivers with existing 8558C/D control cable

8528B, 8528 and X2 transceivers operating with automatic tuning antennas connected via an 8551C antenna control unit

In this configuration, the 9350 and control cable P/No 08-05062-001 are a direct replacement for the 8551C antenna control unit and associated automatic tuning antenna. Existing control cables are not to be retained: RF coaxial cables may be retained if considered to be in a good state of repair.

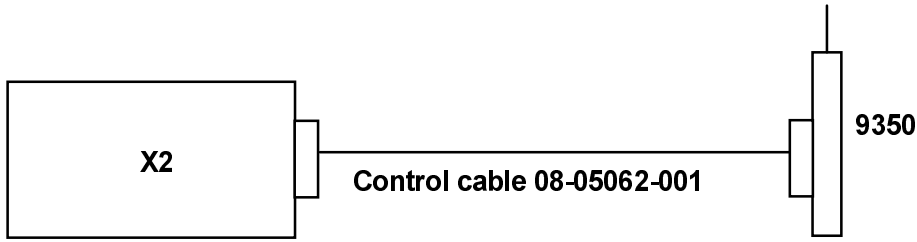

Figure 3: X2 transceiver with standard 9350 control cable 9323 and 9360 series transceivers.

Installations employing 9323 and 9360 series transceivers will generally be installed using antenna control cable P/No. 08-05062-001 as shown in Figure 4.

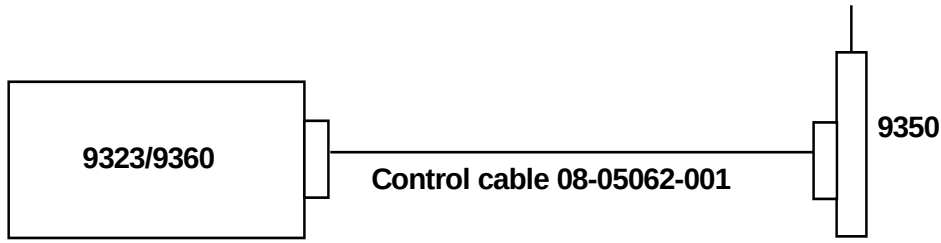

Figure 4: 9323, 9360 series transceivers with standard 9350 control cable

However, if the installation previously had an 8558 automatic tuning whip antenna 'C' or 'D' series, then, by fitting the adaptor kit Code 753 - PCB P/No 08-05182-001 in the transceiver, it is possible to retain the existing antenna control cable P/No 08-04674-001. Also the adaptor cable (P/No 08-05183-001) must be fitted at the antenna end of the cable to be compatible with the 9350 connector as shown in Figure 5.

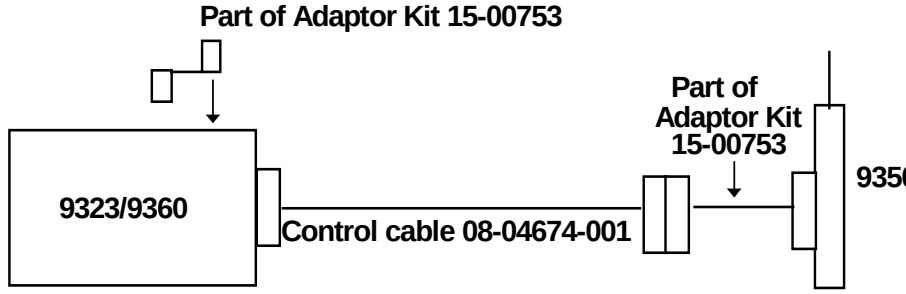

Figure 5: 9323, 9360 series transceivers with existing 8558C/D control cable

Option AD removal from 8528B, 8528, 9313 and 9480 series transceivers

Refer to item numbers in Figure 6.

i. Turn the transceiver off and disconnect power by unplugging the non reversible DC power connector at the rear of the transceiver. Disconnect any control and RF cables.

ii. Remove the transceiver from it's mounting arrangements so that it can be worked on with ease.

iii. Remove the 2 screws securing the bottom cover to the chassis. Remove the cover plate.

iv. Unplug the Antenna Control port ribbon cable from the Option AD PCB (P/No 08-04285-001). Disconnect the loom sockets from the 2 pin plugs on the Microprocessor PCB and Power Amplifier (PA) respectively, opening the cable clamp (Item 3) on the latter so that the loom can be removed from its fixing point on the PA metalwork. Remove the countersunk M3 cross head screw (Item 6) securing the regulator heatsink to the transceiver side panel. Withdraw the screw, nut and washer (Items 6, 7 & 8).

v. Remove the M3 x 20 cross head screw (Item 4) securing the Option AD PCB (Item 1) to the motherboard. Carefully remove the PCB from the motherboard connector and withdraw from the transceiver. Retain the M3 x 20 screw with the Option AD PCB.

vi. Replace the countersunk M3 cross head screw, nut and washer (Items 6, 7 & 8) securing the metal bracket to the transceiver side panel. Fit a new item 4 - M3 x 6 screw (provided with this Application note). This is important to retain the mechanical strength between internal assemblies.

vii. Connect the Antenna Control ribbon cable directly to the motherboard connector previously occupied by the Option AD PCB.

viii. Replace the transceiver bottom cover and the 2 securing screws. Remove the warning label (Item 2) and return the transceiver to it's original operating position. Reconnect power and any other cables that are required for operation.

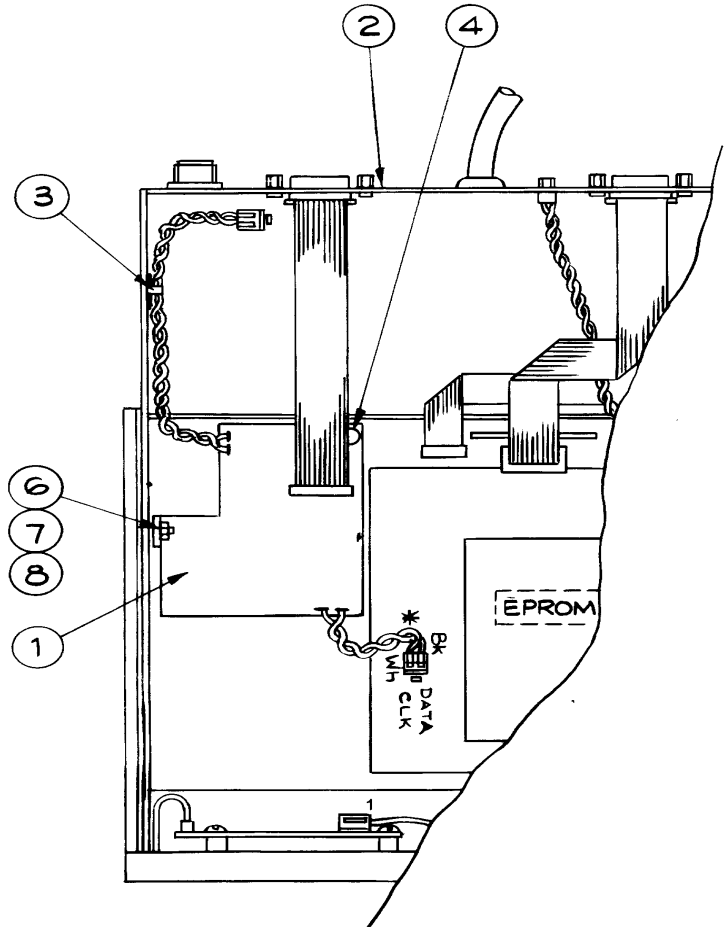

Figure 6: View of 8528B, 5828 transceiver with bottom cover removed showing Option AD

Summary table

Transceiver	Antenna Control Cable	Adaptor Kit 15-00753
8528B, 8528 without Opt. AD	08-05062-001	NO
8528B, 8528 with Opt. AD removed	08-05062-001	NO
	08-04674-001*	YES
8528B, 8528 with 8551 Control Unit	08-05062-001	NO
9313/9480 without Opt. AD	08-05062-001	NO
9313/9480 with Opt. AD removed	08-05062-001	NO
	08-04674-001*	YES
X2 with 8551 Control Unit	08-05062-001	NO
9323/9360	08-05062-001	NO
	08-04674-001*	YES

* assumes installation is using a control cable from a previously installed 8558 'C' or 'D'series auto whip.

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4. Operating the antenna

The Type 9350 antenna has two modes of operation:

- scan mode
- tuned mode.

Scan mode

When the antenna is in scan mode, the transceiver can operate as a simple receiver, scanning through all its programmed frequencies.

In scan mode, the antenna operates as an ‘active antenna’, that is, a small amplifier is switched into the antenna circuit making it sensitive enough to receive signals—any mismatch is disregarded. This removes the need to retune at each frequency.

To start the scan mode, press the **Scan** button on the transceiver.

Tuned mode

With the antenna in the tuned mode, the transceiver operates as a normal transceiver. That is, it can transmit and receive signals as required.

To tune the antenna, press the **Tune** button on the transceiver.

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5. Technical description

This Chapter describes the functions of the circuit on the Printed Circuit Board (PCB) assembly no. 08-05068-001, Control PCB in the base of the antenna. The circuit diagram is shown in chapter 7 on a fold-out page so you can look at the diagram while you read the explanation.

RF path

The transmitter output is coupled by a 50Ω coaxial cable to connector J2. From here, this output is applied through current and voltage transformers T1 and T2 to the first of two impedance matching auto-transformers T3 and T4.

From auto-transformer T4, the transmitted signal is fed through relay contacts K3/A and K3/B to the tuned whip antenna.

Current transformer T1, voltage transformer T2, and associated components form the VSWR detector circuit. This provides the microcontroller with information on the tuning of the antenna.

Tapped auto-transformers T3 and T4, selected by relays K1 and K2, provide four impedance settings between the antenna and the transmitter.

A sample of the RF is passed through C14 to the input of the first divider circuit IC2/B pin 13. Diodes D3 and D4 protect the divider by limiting the RF swing.

The receive signal follows the reverse path to that taken by the transmit path.

Scan

When scan mode is selected, the antenna is normally required to receive signals over a broad band of frequencies. To achieve this, the antenna is adjusted for minimum inductance and coupled through switched relay contacts K3/B to the input of a two-stage amplifier consisting of V13 and V12 and associated components. This provides a high input impedance and 50Ω output to match the receive input of the transceiver.

When terminated by the receiver, the amplifier has a nominal zero voltage gain.

Microcontroller

The microcontroller IC5, consists of Read Only Memory (ROM), Random Access Memory (RAM), two 8-bit and one 4-bit I/O ports and is clocked at a 4MHz rate. The static operation of the I/O ports means the outputs do not need to be latched on completion of the tune or scan program.

There are a number of components connected to IC5 which enable it to carry out the tuning process:

V1	This transistor conducts when the tuning process has started. It holds the transmitter in tune mode until the antenna is tuned.
IC2/A & IC2/B	The two dividers (each one dividing by eight) are cascaded to divide the RF by 64. This frequency is measured by the microcontroller by comparing it with the 4MHz clock. The value is now compared with the value held in the EEPROM (IC6), and the microcontroller can determine which direction to start driving the stepper motor.
IC6	This is an EEPROM which contains the last-tuned frequency. The microcontroller uses this information when it receives the next tune command to determine the direction to drive the tuning mechanism.
IC3/A	The signal from the forward detector is applied to pin 2 of this comparator, setting the output low. This informs the microcontroller, which has received a tuning command, that there is sufficient RF to proceed with the tuning sequence (about four watts of RF power is required to keep the output of the comparator low).

IC3/B	This comparator monitors the forward and reflected power levels and sets the output low when the VSWR is less than 3:1.
IC4/A	This comparator monitors the forward and reflected power levels and sets the output low when the VSWR is less than 2:1.
IC4/B	This comparator monitors the forward and reflected power levels and sets the output low when the VSWR is less than 1.5:1.
V5 to V8	These four Field Effect Transistors (FETs) provide the 4-phase current to drive the uni-pole stepper motor. The motor is driven in wave mode (one phase on at a time) under software control.
V10 & V11	These transistors, controlled by the microcontroller, energise the relays whose contacts select the four available impedance ratios provided by T3 and T4 through relays K1 and K2.
V9	After a tune cycle, this FET is switched on and provides (with R28) a brake current of 100mA to one pole of the motor. This prevents the tuning assembly from moving with vibration.
V4	This transistor, controlled by the microcontroller, provides information to the transceiver on whether or not the tuning sequence has been successful. It also receives a 'not tuned' signal from IC3/B if the VSWR is greater than 3:1.

V2 & V3	Both these transistors are used for scan operation. When the transceiver outputs low on the scan line, V2 conducts and provides the DC supply to the scan amplifier. Relay K3 is also energised, switching the amplifier in series with the antenna circuit. V3 polls an interrupt to the microcontroller by applying a low momentarily to input pin 2. At the same time a low is applied to pin 3, which informs the microcontroller that scan mode has been selected.
IC1	This DC regulator provides the five volts needed to power the microcontroller and other ICs in the control circuit. Diodes D1 and D2 provide protection against reverse polarity.

Tuning sequence

The tuning sequence of the microcontroller is as follows:

1. When tune is initialised by the operator or automatically by the transceiver, the TUNE line goes low. This applies a low to pin 2 of IC5, polling an interrupt to the microcontroller. A high is immediately output on pin 5, switching on V1 to continue to hold the TUNE line low.
2. The microcontroller verifies the tune command (pin 3 high).
3. The microcontroller checks all four comparator outputs (IC3/A & B and IC4/A & B):
   - if all are high, the tune programme is aborted and a 'tune fail' indication is given (low or no RF)
   - if all are low, a 'tune pass' indication is given (VSWR less than 1.5:1)
   - if only IC3/A is low (adequate RF) the tuning sequence continues.
4. The microcontroller measures the carrier frequency (output of IC2/A) and selects the default load impedance from the lookup table contained in the ROM. It also checks the last-tuned frequency contained in the EEPROM to determine the direction in which to start driving the tuning assembly.
5. The microcontroller searches for a tuning point within the three VSWR windows and selects the best attainable VSWR before ending the tune sequence with a 'tune pass' signal.
6. If no tuning point is found within the VSWR windows (if all outputs remain on high) then a 'tune fail' signal is given.
7. During the tuning cycle, the load impedance is checked. If no better match can be obtained, the default setting is retained.
8. The 'tune pass' and 'tune fail' are indicated to the transceiver by the logic level of the IND at the release of the TUNE line:

- **tune pass**—IND goes high before TUNE goes high at the end of a tune cycle
- **tune fail**—TUNE goes high before IND goes high at the end of a tune cycle.

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Scan sequence

In older generation transceivers, when **Scan** is selected, the microcontroller outputs a signal to the stepper motor to drive the tuning assembly to the top of its range (producing minimum inductance). At the same time, the scan amplifier is activated.

When scan is selected by the transceiver, the SCAN line goes low. This applies a low to pin 2 of the microcontroller through capacitor C10 which polls an interrupt to the microcontroller. It checks that pin 3 is low (transistor V3 on) indicating scan mode.

In later generation transceivers when **Scan** is selected, the transceiver first goes into scan tuning mode and the control head screen displays ‘Scan tuning’. During this mode, the transceiver checks the scan table and calculates a weighted average of the frequencies using the following formulae:

- 0.75(fmax–fmin)+fmin
  where:

  fmin—the minimum frequency of the scan table
  fmax—the maximum frequency of the scan table.
  As an example:

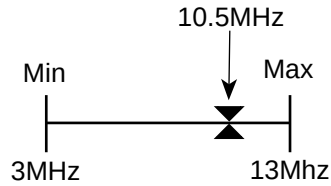

Figure 5-1 Scan tuning

The example above indicates the minimum frequency in the scan table is 3MHz and the maximum frequency is 13MHz. The frequency calculated by the transceiver is 10.5MHz.

The transceiver then checks for a channel closest to this frequency and tunes to it. Note, this frequency may not be in the scan table.

During the ‘Scan Tune’ there are no tune pips. A tune pass is not indicated, but a tune fail is. The transceiver then activates the scan line within 100ms of receiving a ‘tune pass’ from the antenna, which switches the scan amplifier on.

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DC–DC converter

The DC–DC converter is a switch mode power supply, which provides a nominal constant current to drive the antenna motor during the tuning cycle. The power supply is voltage limited to a nominal 30V DC. The control signal from IC5, pin 12 (drawing no. 04-03025) activates the converter.

The components of the DC–DC converter perform the following functions:

D1	This diode is used for reverse bias protection.
D2	An output rectifier and forms part of the charging circuit for C5.
C1	C1 is a low impedance capacitor because of the high switching rate of the circuit.
C5	Like C1, C5 is also a low impedance capacitor. C5 is charged via D2 when V4 is switched off.
IC1	Provides the reference for the current amplifier.
IC2	Provides +5V regulation for IC3.
IC3A/B	A voltage comparator and provides the switching signal for the FET, V4.
V1 & V2	These transistors form a current amplifier circuit. When the current sensing circuit detects a rise in current, the resultant voltage drop causes V2 to turn off, which causes V1 to turn on. This causes IC3A/B to turn off, which drives V4 with a variable mark to space ratio.

V3	A voltage limiter.
V4	Is the switching FET, which switches on and off at a rate between 30–50kHz.
R2 & R4	Sets the operating current.
R8, R9 & R10	Form the current sensing circuit. As the current through this circuit rises V4 switches off.
R13	Is used for short circuit protection.
L1	Is the switching inductor.

Fault-finding the converter

To fault find the converter:

1. Disconnect the motor from the converter.
2. Replace the motor with a 10W (nominal) 50Ω DC load.
3. Unsolder the 'Ctrl' line from the Converter PCB. Connect this line via a 15kΩ resistor to the +5V rail to switch on the converter.
4. Use an oscilloscope and drawing 04-03049 to fault-find the converter.

6. Parts list

Antenna, main assembly	Assembly No: 08-05063-001
Control PCB	Assembly No: 08-05068-001
DC–DC converter	Assembly No: 08-05134-001

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7. Appendices

Control PCB	Circuit Diagram	04-03025
	PCB Assembly	08-05068-001
DC–DC converter	Circuit Diagram	04-03049
	PCB Assembly	08-05134-001