

Philips FM92 (FM900) tech notes

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These notes refer to the Philips FM92 radios disposed of by the Victorian Country Fire Authority (CFA) in 1998 and later by the Victorian Police in 2001. They were distributed by the Wireless Institute of Australia (Victorian Division) for a very reasonable price. The North East Radio Group, Inc (NERG) purchased a number of units to help new novice operators get on the air and to encourage members to use the NERG 2-meter net.

Philips manufactured the FM900 range of VHF and UHF transceivers in the 1980's. All units are fully synthesised with microprocessor controllers. They came in several models:
FM93 - Economy model - a basic 10-channel unit, fixed 25 Watt output.
FM92 - Standard model - up to 99 channels, high and low output power, options for local controls or remote head.
FM91 - Deluxe model - FM92 features plus 3 power levels, extended keypad and display.
FM97 - "Water-Proof" version of FM92 - for boats.

The FM92s obtained by the NERG came in a number of configurations. All where "remote head" transceivers where the main radio "body" is mounted in a convenient location and connected by a multi-wire cable to a "remote head" which contains the user controls, displays, and a speaker. Many were used in CFA vehicles. Some were used as base station units with (separate) mains and battery backup power supplies. All are VHF high band units with remote control heads.

Some variations among the FM92 obtained:

- Serial numbers ranging from 4 digits (Very early) to 6 digits (possibly series-II).
- Early models with 10.7 MHz I.F., later models, 21.4 MHz I.F.'s .
- Lids on early models used 8 screws, later models 12 screws.
- Base station modifications -
(extra wiring to the MIC socket on the radio, short head-to-body cables).
- Various microphone connections:
 - Plugged (and glued) into the square connector on the front of the head, or
 - Soldered directly into the head (bottom entry), or
 - Microphone has RJ-11 connector plugged into an adaptor socket inside the head, or
 - Plugged into the 8 pin DIN plug on the radio.
- Various styles of microphones -
 - Some contain a "in-cradle" reed switch to disable scanning,
 - Some contain discrete component pre-amps, other with amplified mic inserts.
- Scanning options - requires magnetic reed switch in microphone, magnetic microphone holder, and appropriate microphone wiring
- Diecast covers over PLL synthesiser and over PA stage were optional in early models.
- Variations in PCB issues (and circuits) with different discrete, hybrid, and IC components.
- Original channel programming (most with channels 1 thru 54)
- "Super Cap" memory backup to maintain channel selection during short power outages.

Other variations found between our units:

- Various Bugs, Moths, Spiders, Mud, Dust, Corrosion.
- Covers fitted to body in all possible combinations (top/bottom/back/front)
(They are interchangeable to suit mounting location in vehicles).
- Damaged BNC connectors
- Damaged and/or missing fuse holders
- Obviously replaced front-end and VCO modules
- Head/body cables of various lengths and optional connector covers

All were configured for simplex operation, with no CTCSS or SELCALL options fitted. Most sets worked before conversion to 2 meters. One was water damaged and only good for parts. A few were missing EPROMs. One had a loose EPROM and worked when it was

reseated. Another (marked faulty) was discovered to have an inter-PCB ribbon cable that had NEVER been soldered to the PCB, and only relied on loose contact between wires and PCB holes(it worked when soldered properly!). Some units came with the head-body control cable cut in half. Many cables came without covers over the DB-15 connectors.

TUNE-UP TIPS:

Ferrite Slugs:

Use **EXTREME CARE** when adjusting ferrite slugs in the FM900 !!!.

Use a plastic adjustment tool designed for this sized slug, or trim one to fit EXACTLY. Never force the slugs - the thick sticky 'anti-vibration' grease flows slowly - rocking the slug gently back and forth may help loosen its grip.

Metal or incorrectly sized tools will more than likely fracture the slug inside the former. When this happens, try picking out the fractured pieces with a jeweller's screwdriver or large pin, then try turning the slug from the other end (not always accessible) - gently rocking the slug back and forth to dislodge any remaining fragments before replacing with a new slug (if desperate, clean the slug and re-insert upside down, exposing the good slot). If the whole slug is broken it may be necessary to remove the module and replace the former

- YOU DO NOT WANT TO DO THIS - EVER!

VCO tuneup:

Read the section on breaking Ferrite Slugs before doing ANY adjustments!

If the VCO is out of adjustment then the front panel RX lamp will flicker constantly, and the set cannot be un-squelched. This may occur for all or only some channels.

Monitor the VCO tuning voltage on test point TP201 (next to Audio power amp IC). VCO slugs must be tuned so that the VCO control voltage is within the limits of 4 to 12 volts across all channels. There are separate slugs for receive and transmit VCOs. The slug nearest the Audio amp (slug F) is the Tx VCO adjustment when the radio is programmed as Band-B (ie NERG3 or 4 EPROM). Use a dummy load when adjusting the Tx VCO. Adjust each VCO slug for 12 volts on the highest frequency channel. There is some interaction between RX and TX slugs. The control voltage should be above 4 volts for the lowest frequency channels. If the 12 volt point is not attainable, check the voltage doubler circuit operation (see troubleshooting).

It may not be possible to adjust the VCO to lock if the synthesiser reference frequency is set (by solder jumpers) to anything other than 25 Khz steps.

Receiver tuneup:

Read the section on Ferrite Slugs before doing ANY adjustments!

When converting from CFA (162 MHz) to 2 meters, start by screwing all RX module slugs inwards by 4 turns (Gently - being careful not to bottom out and seize the slug against the former bottom) - strong signals should then be receivable for further tuning.

Monitor the voltage on test-point TP 'S' while adjusting slugs for maximum voltage. Stagger tune the slugs to high and low frequencies of the desired band alternately. Reduce the signal source output as sensitivity improves.

Tx PA tuneup:

Keep the output power below 25 Watts. Higher output is possible but the internal voltage regulators may not be able to maintain supply to the PLL and modulators, causing distorted audio on transmit. Higher output may also reduce the reliability of the output stage transistors. Always tune-up into a 50 ohm dummy load.

Tune the final's trimmer cap for maximum output power with minimum supply current. (you may find power peaks and then falls while current rises - choose best combination for maximum output at lowest current).

Squash the associated coil together to increase inductance before tuning.

Adjust the trim pot on the PA PCB to the desired "high" output power level.

Adjust R402 on the synth/control PCB to set the "low" output level (on a low power channel).

Transmit Deviation:

These sets generally have low deviation. It is preferable to increase the deviation limiter adjustment (R367 DEV) in preference to the Mic Sensitivity (R365 Mic SENS), otherwise modulation may be clipped. Adjust Modulation Balance (R371 MOD) with care - it affects the frequency response of the audio modulation signal and should really be done with proper test equipment, especially if transmitting packet radio data.

CABLES:

Power cable:

For vehicle and base installations, heavy two core flex (15 Amp minimum) should be installed all the way back to the battery or power supply connector lugs.

The radio will not operate properly if light duty cable is used!

Do not rely on the vehicle metal chassis for ground (although it doesn't hurt to have a short RF ground from radio chassis to car chassis).

Original power cables had two 10 Amp 1¼" (3AG) in-line bayonet cap fuse-holders. The two fuse holders also double as power connectors. Compatible fuse holders are available from regular electronic component stores for 50¢ - \$2 each. Avoid cheap ones.

The radio is fitted with the cap half of the fuse holder on the negative line and the tube half on the positive line. The cable from the vehicle battery is fitted with the matching halves (with wire ties to prevent the active lead protruding from the tube and shorting to ground when the radio is disconnected).

Normal fast blow automotive 10 Amp fuses seem to be used by the CFA.

Two fuses should always be used in vehicle installations. The 'Earth' fuse may appear to be redundant, but it can prevent a fire hazard if the chassis to battery earth strap becomes faulty. Otherwise, all the engine's starter motor current may flow through the radio's relatively thin negative cable, causing it to melt if not fused properly.

Body to Head cable:

This is a custom made multi-wire shielded cable. The cable contains:

6 unshielded wires (power, ground, mute, speaker, PTT, on/off switch)

2 single shielded wires (RX audio in, RX audio out).

2 shielded pairs (mic in one pair, data/clock in other pair)

Connectors are standard DB-15 male and female types, although the screw threads are not metric. Short lengths (less than 12") of unshielded ribbon cable may work.

ANTENNAS:

Radios are fitted with BNC connectors and are intended to drive 50-Ohm impedance. The radio will supposedly operate into any load, however it is good practice to keep antenna SWR below 3:1. At 1:1, the radio consumes about 5 Amps. The radio consumes more than 8 Amps if operated into high SWR loads, and may reduce the reliability of the radio.

POWER SUPPLY:

A good 13.8 Volt power supply is essential to transmit at the rated 25 Watts. Voltage drop introduced by resistive losses in the power cable and fuse holders may cause intermittent or choppy transmissions due to the PLL falling out of lock as the transmitter turns on, or low frequency hum on transmitted audio.

A regulated power supply capable of up to 8 Amps is required for base station installation. (CFA mains power supplies are rated at 5 Amps but appear to supply more for short periods).

FUTURE MODIFICATION IDEAS:

Ideas for future modifications (some yet to be developed)

- Modify later series heads so that the rear 8-pin DIN option connector can be used as a Microphone connector for newer style microphones.
- Add external S-meter

- Silence the front panel beep by removing the 1 Mohm resistor.
- Add a toggle switch across TR401/TR402 to select high/med/low transmit power
- Replace the 4u7 electrolytic capacitor in the microphone's pre-amp (affecting gain and frequency response).
- Replace dynamic microphone with electret microphone insert (remove 4u7 cap in mic pre-amp and reduce microphone sensitivity adjustment inside radio).
- Modify speaker switch for internal / external speaker switching, or remove switch.
- Rewire speaker switch to act as 'cradle switch' - enabling scanning modes (instead of the microphone hook magnetic switch)
- Add extra channels by replacing the 2764 EPROM with 27256 EPROM and adding a selection switch to give up to 396 channels (4 banks of 99 channels - Useful for Repeater reverse, High/low power switch, etc)
- Modify for packet radio 1200 & 9600 bps (wire suitable unsquelched audio output and line-level inputs to a rear DIN sockets).
- 12.5 KHz channel spacings - for odd frequencies like the MIR space station FM packet and voice links (but increases the potential for more birdies).
- Program EPROM to use local oscillator on other side of receive frequencies to reduce troublesome images and interference from paging systems (if present).
- Program software selectable options for: Economiser mode, display power down, scanning modes, output power modes, channel spacing, etc.
- Computer control the radio for more sophisticated scanning, etc.

QUICK TROUBLE SHOOTING GUIDE:

Fails to switch on: (No lights, no noise - appears dead)

- Check power source is approx. 13.8 volts with correct polarisation.
- Check remote head cable connectors are seated correctly and pins are not bent or are pushed into connector body.
- Check Fuses (10 A fast blow) and Fuse holders for poor contact.
- Make sure EPROM and Microprocessor chips are seated firmly in IC sockets.
- Check internal voltages

Switches ON (Green lamp on) but turns OFF after a short period:

- Possible control head failure. Check all items in "Fails to switch on" above.
- Check Microprocessor chip is seated properly in the control head.

Only decimal point lights in channel display (no digits), and no Rx noise:

- Failed internal tests at power up. Turn set off and On again and activate PTT.
- Transmitter power may be out of range (PA failure) or very bad SWR.

No received carrier or noise at minimum squelch setting: (Rx lamp may flicker)

- If RX lamp operates normally, check remote head cable for breaks in Audio wiring.
- VCO may be out of lock
 - Check VCO tuning
 - Tighten VCO mounting screws (2).
 - Voltage Doubler circuit on Synth/Control PCB may be faulty, pin 8 of IC 306 should be ~17 Volts. If lower, replace both 10 uF capacitors (C342 & C349) in doubler circuit.
 - Replace VCO module?
 - Check coax cables from Control PCB are not broken

Won't transmit on high power, or

Hum on transmitted audio (even operating from battery):

- Check power supply. MUST be capable of more than 5 Amps.
- Use heavy-duty power cable with 15 Amp rating (26 x 0.3mm conductors)

Won't receive and/or transmit on some channels, other channels work properly:

- Check items above in "No received carrier" - VCO out of lock problems.
- VCO is out of tune on some channels:
 - Adjust TX and RX VCOs for lock on highest & lowest frequency channels.
 - Check VCO control voltage is within limits (4 to 12V).
- Check power supply capable of supplying >5 Amps for high power channels.

Poor sensitivity (front end transistors):

- Replace front end unit or attempt repair (dead pre-amp transistor or internal shorts).
- Check coax cables from PA PCB are not broken

Received Audio too loud - cannot adjust:

- Check remote head wiring and connectors for broken audio earth

Crackling audio on received signals:

- Tighten VCO and front-end module mounting screws.
- Replace VCO voltage doubler capacitors.

VCO / Front End / Discriminator Module repairs:

Repair of these modules is tricky. If possible, use a de-soldering iron to minimise damage to the main PCB when removing the module. Alternately, Solder-Wick may be used to de-solder connections. A large 'Plumbers' soldering iron is required to remove the module side covers. A special 'hot plate' is recommended by Philips. It heats the whole module case to the melting point of solder so the cover can be removed. If excessive temperatures are reached then internal components can be damaged. With care, an old electric fry pan may be used (according to rumours!). Stories of placing the module into an oven had grave results (everything melted!). A heat gun may also be useful. Once opened, the hybrids may be repaired using standard surface mount soldering techniques (with the aid of a big magnifying glass!). Additional notes from other sources yet to be confirmed.....

Common programming errors:

- *Selecting CTCSS tones without the correct hardware being installed at the hardware code and the like will cause error messages. This applies to things like SELCALL setups etc.
- *TX inhibit cannot be selected with Community repeater.
- *Tone periods 33 & 20 ms are incompatible with type 2 SELCALL.
- *Voting cannot be selected with mute defeat.
- *SELCALL decode (in software code) must =00 if encode =03 or =07.
- *SELCALL encode 04 & 08 with decode 00 is an invalid combination if type 2 SELCALL is fitted.
- *SELCALL software code 0400 & 0800 can still be used for special applications (no decode, ident with PTT, and base SELCALL encode when operating 'send' button).
- *Community repeater must have CTCSS encode/decode hardware available, and requires CTCSS tone to be entered.
- *Voting isn't selectable without NSC810 I/O expander hardware.
- *Can only have duplicate channel numbers with voting selected on those duplicate channel numbers.
- *Cannot select economiser and voting on same channel.
- *Cannot select economiser and SELCALL on same channel.
- *Cannot select SELCALL and scanning on same channel.
- *Must have more than one channel in a vote group.

Programming notes (for FPP ver 3.0 altered version):

NEVER program in XXXXXXXX for TX or RX frequency (VCO goes unlocked no matter what)
 NEVER program in 000.000 for TX or RX frequency (TX will be very spurious no matter what)
 IF you want to create a channel as RX only, program in a TX frequency that you are licensed for or a UHF CB channel if in U, W1 or W2 band.
 BE VERY CAREFUL when programming in frequencies - there should only be 4 digits after the decimal point and no spaces to pad out the last position, and no leading zeros in the digits before the decimal

point in the case of E band VHF.

Incorrect programming will have one of three effects:

- radio will not power up (most common)
- radio will have unlocked VCO on TX or RX or both (radio inoperable)
- radio will cause severe interference due to the transmission of spurii.
 - 3 scan groups available for FM91, FM97
 - 2 scan groups available for FM92, FM93 and all waterproof radios
 - 10 channels per scan group, with one of these only available as a priority channel
 - Channel number range for FM91, FM97 is 1-120; FM92 is 1-99; FM93 is 1-10
 - Power selection entry is by the letters H, M, L & S (for high, medium, low and selectable) and must be consistent with the type of radio.

CTCSS Tone selection table

67.0	Q	88.5	A	114.8	D	146.2	P	186.2	3	241.8	*
71.9	R	91.5	W	118.8	M	151.4	H	192.8	4	250.3	#
74.4	S	94.8	J	123.0	E	156.7	X	203.5	5	97.4	=
77.0	T	100.0	B	127.3	N	162.2	Y	210.7	6		
79.7	U	103.5	K	131.8	F	167.9	0	218.1	7		
82.5	I	107.2	C	136.5	0	173.1	1	225.7	8		
85.4	V	110.9	L	141.3	G	179.9	2	233.6	9		

Community repeater: select tone Z

Notes on FPP Version 3.0 (altered)

Normally, FPP will restrict programming of the radio in two ways: first, transmission and reception was fixed within the one band ie. If you had a U band radio 450 to 470 MHz, you could not program in any frequency for outside this band. In this altered version of FPP however, this restriction is lifted. Bear in mind that the VCO has its limits, however. Depending on your setup and tuning, upto 20 MHz reception outside of the band your radio was designed for may be possible. The second restriction was to only allow the selection of low or medium transmit power (1 or 5 Watts) on UHF CB. User selectable power levels was not an option. In this altered version of FPP, this restriction is also lifted, and as a by-product will allow high power selection for UHF CB as well. This altered version of FPP does have its bugs, too. If you try to program in a RX only channel by programming in xxxxxx or 000.0000 as the TX frequency, the radio will either not operate at all, go VCO unlocked on RX or transmit large amounts of spurious signals. BE WARNED!

Help! I get an error message saying the EPROM programmer is not initialised!
That is OK. FPP was designed to work with an internal EPROM programming card specific to FPP. What you will need to do is to take the file that FPP saves to disk, and write that file as it is to an EPROM. If you create a personality called, say, "myfreq", you will find a file called myfreq.bin in the directory x:\fpp\fm900\jobs\myfreq\ Take this file, and copy it to your root directory and then using whatever EPROM burning equipment/software you have, write this file to the EPROM.

Notes for Programming EPROMS using Electronics Australia kit (Dick Smith kit) with Eprom.exe software:

Eprom types suitable for use: 2764 (21-25 V pgm), 2764A (12.5 V pgm) or other 27x64-x EPROMs.
Set device switch on programmer
Set Vcc = 5V
Connect programmer, insert EPROM and turn on.

Select:

Vpp = 12.5V, write pulse 1ms, 1 pulse per byte, final pulse = 0, EPROM multi pulse. If this does not work, then try:

Vpp = 12.5V, write pulse 10ms, 1 pulse per byte, final pulse = 0, standard EPROM single pulse. If this does not work, then try:

Vpp = 12.5V, write pulse 50ms, 1 pulse per byte, final pulse = 0, standard EPROM single pulse. If this does not work, then try:

Vpp = 21V, write pulse 1ms, 20 pulses per byte, final pulse = 0, EPROM multi pulse. If this does not work, then try:

Vpp = 21V, write pulse 50ms, 1 pulse per byte, final pulse = 0, standard EPROM single pulse. If this does not work, then try:

Vpp = 25V, write pulse 50ms, 1 pulse per byte, final pulse = 0, standard EPROM single pulse.

When comparing binary files using DOS command 'FC', don't forget the binary code output from FPP contains the date; two identical personalities may not match using FC due to the different date encoded into the binary file, at locations 1FE2, 1FE3 & 1FE4 from the start of the file, and the checksum, see note below.

Location 1F64 appears to be a data checksum for the whole data stored on the EPROM.