TUNER, HF, VEHICLE ANTENNA (TN-F100)

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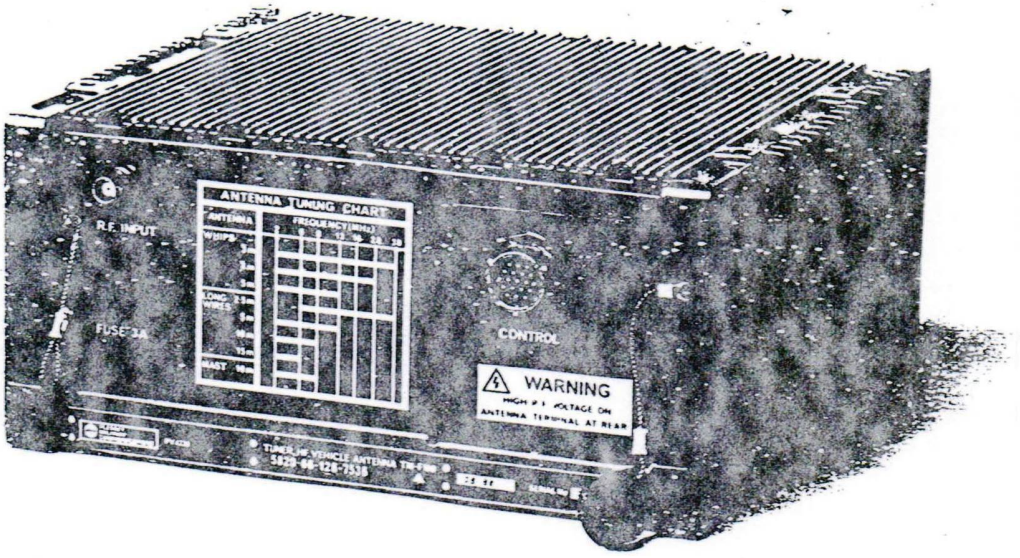

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(TN - F100)

PRECIS NO: 21

TCH 003/3/a
Issue 1 July 89

INTRODUCTION

WARNING

WHEN TRANSMITTING, HIGH RF VOLTAGES CAN EXIST AT THE ANTENNA CONNECTOR WHICH CAN CAUSE BURNING OF THE SKIN.

GENERAL

1. The HF Antenna Tuning Unit (ATU) is fitted in ground or vehicle borne HF transceiver stations incorporating equipment which cannot automatically match an antenna to the output circuits over the operating frequency range of 2MHz to 30MHz. The HF ATU is fitted in the rf line between the rf source (HF R/T, HF CSF or HF PA) and the antenna.

2. Control signals from the rf source cause the HF ATU to insert and tune an LC matching network to obtain optimum power transfer between the source and antenna. When the tuning has been completed the VSWR is measured.

3. The tuning process is initiated by the first operation of the PRESSEL after the transceiver has changed frequency. During the tuning process a 2KHz tone can be heard in the operator headset and tuning is normally completed within 1.5 seconds. If the HF ATU fails to obtain a preset minimum VSWR (3:1) an interrupted 300Hz "failed" tone is heard.

4. The HF ATU has no controls or indicators. Its nominal +28V d.c. is derived from the unit to which it is attached.

CONNECTIONS

5. Three connectors are fitted. On the front panel RF INPUT, a 50 ohm BNC rf input, and CONTROL, the connection for the 19 way system control cable. On the rear panel, ANNTENNA, a screw terminal connector carrying the rf output to the aerial.

PRINCIPLES OF OPERATION

Refer to Fig 1.

GENERAL

6. The HF ATU is powered by 28V d.c. derived from the HF R/T or CSF in a low power station, or the HF PA in a high power station.

7. Instructions from the HF R/T to the HF ATU are sent via three control lines; Tx/Rx, RESET and 2FS. The HF ATU indicates its status to the HF R/T with two signal lines,

READY and FAULT.

8. The HF ATU comprises a tuneable LC matching network inserted in series with the rf path between rf source and antenna. The LC network is tuned by a system of microprocessor controlled relays which insert various values of capacitance and inductance until the best impedance match possible is achieved between the rf source and the antenna.

MAJOR FUNCTIONAL ELEMENTS

9. The major functional elements within the equipment are :

a. Transmission line monitoring detectors.

b. The tuning network inductors and capacitors.

c. The microprocessor control circuits.

TUNING SEQUENCE

10. Tuning is carried out in response to three monitored parameters - frequency, conductance and the phase angle of the presented impedance. The sequence of operations for a tune are as follows :

a. The R/T operating frequency is changed and RESET is issued. The ATU microprocessor sets relays to by-pass tuning network elements. The READY signal is set low.

b. The PRESSEL is operated. The R/T issues a 5W CW tuning signal and sets Tx/Rx low.

c. In the ATU the rf is directed to the 50 ohm load and the power detector via 4RLA and 4RLB. The microprocessor checks that the POWER of the RF is between 1W and 7W.

d. The DC resistance of the aerial is measured; Less than 75 ohms is considered as a short circuit.

e. The frequency of the tuning signal is measured and an appropriate value of inductance, obtained from a stored table of preset values, is inserted in the rf path. RLB directs the signal to the PHASE and CONDUCTANCE DETECTOR.

f. Capacitive and inductive elements in the tuning network are then inserted or removed until a 50 ohm resistive match is achieved.

g. The VSWR is measured and, if it is better than 3:1, the READY line is set high and 4RLA connects the rf input directly to the tuned circuit and thus to the antenna.

h. If the tune is not successful the HF R/T is informed via the FAULT line.

The sequence is summarised in flow chart Figure 2.

2FS

11. The HF ATU is operated in two modes, normal and 'two frequency' simplex (2FS). In the 2FS mode, in which the receive and transmit frequencies are different, the tuned circuits in the HF ATU are by-passed during receive. In the normal mode the received and transmitted frequencies are the same and the tuned circuits within the HF ATU remain in the antenna path.

PROTECTION SIGNALS

12. The protection signals ATU PROT 1 and ATU PROT 2 are produced when a fault condition exists which, if prolonged, could damage the ATU. The signals have the effect of lowering the power output of the system in stages, if an HF PA is fitted, or in one step in a low power system. The sequence and effect of the signals is shown in Figure 3.

DETAILED FUNCTIONAL DESCRIPTION
(EMEI TELS T042 Figure 1001)

MODULES

13. The HF ATU comprises six modules:

a. **Module 1.** Provides LC filter and EMP protection for the ten input/output lines.

b. **Module 2.** Provides regulated d.c. power supplies for Modules 3, 4, 5 and 6 from the +28V vehicle supply.

c. **Module 3.** Contains the microprocessor, and controls the operation of the HF ATU. System control signals are fed to/from Module 3 via Module 1 and the equipment CONTROL connector.

d. **Module 4.** Contains detectors for VSWR and Phase/Conductance as well as the Fine values of Inductance and Capacitance.

e. **Module 5.** Contains the Medium values of Inductance, Coarse values of Capacitance and the Line Shortening Capacitors.

f. **Module 6.** Contains the final values of Inductance and the Broad Band Capacitors. The rf output is taken from this module.

RESET FROM R/T

14. The HF R/T sends a nominal 3 ms low-going RESET pulse under the following circumstances:

a. On initial switch-on.

b. After a frequency change of:

(1) At least 1kHz to a frequency below 3MHz.

(2) At least 10kHz to a frequency above 3MHz.

c. After an operation of the HF R/T ANT/50 OHM switch. This would normally indicate that a different antenna has been connected.

d. 2FS MODE ONLY. At the end of each operation of the pressel.

TRANSMIT FOLLOWING RESET

15. The RESET pulse is applied to the Microprocessor on Module 3. Commands are sent on the data bus to the relay driver circuits which set the relays on Modules 4, 5, and 6 to by-pass the tuned circuits and set the READY line low. In Normal mode, with 2FS high, the tuning action detailed in para 13 is performed on the next operation of the pressel (Tx/Rx going low) but in the 2FS mode, 2FS low, the last LC combination is re-inserted when the pressel is operated.

16. When a successful tune (or re-insertion) has been completed Module 3 sets the READY line high to inform the HF R/T. If the tune was unsuccessful the FAULT line is set high and the READY line set low.

17. With the READY line low the ATU by-pass route is selected and a high on the FAULT line will cause a "BAD VSWR" message to be displayed on the HF R/T.

RF POWER AND ANTENNA DC RESISTANCE MEASUREMENT

18. The upper and lower power measurement functions are performed by the Module 4 POWER DETECTOR to which the tuning signal is fed via 4RLA in the de-energised state. The incoming rf is detected and the resultant voltage applied to a pair of voltage comparators. The reference levels for the comparators are set to provide an indication of whether the power input level is in the 1W to 7W 'window'.

19. With 4RLA de-energised, the antenna line is switched to the ANTENNA DC RESISTANCE DETECTOR. A voltage is applied to the antenna line and the current measured to obtain the impedance, which should be 75 ohms or greater. An impedance of less than 75 ohms is considered a short circuit. (An open circuit will be detected by a failure to tune.)

20. The POWER DETECTOR and ANTENNA DC RESISTANCE DETECTOR outputs are both connected to the control line WINDOW which will be set high if either the power or impedance measurement is incorrect. WINDOW is fed to the CONTROL FLAG SELECTION MULTIPLEXER on Module 3. The multiplexer, which decides which of its inputs is currently significant under the control of the Microprocessor, which informs it of the tune state of the equipment, selects and passes WINDOW on to the data bus and thence to the Microprocessor. The tune will be aborted if the line does not go low.

INITIAL COMPONENT SELECTION

21. If the power and resistance measurements are acceptable the 5W rf power is

switched, via RLB in Module 4, to Module 3, where it is input to a Frequency Counter, the output of which is fed to the Microprocessor.

22. The Microprocessor uses a look up table to decide, from the input frequency, an initial value of inductance to be inserted into the antenna path.

FINAL TUNING

23. Most antennas to be tuned by the ATU are less than a 1/4 wave in length, and therefore 'look' capacitive, and require series inductance to tune them. Some antennas may be resonant at a frequency lower than that required and are therefore inductive. To overcome this, Broad Band and Line Shortening Capacitors are available, to be switched in if necessary.

24. The rf is fed to the PHASE and CONDUCTANCE DETECTORS by RLB, and values of inductance and capacitance are inserted in, or removed from, the tuning network by relays under the control of the microprocessor.

25. The detectors produce the analogue signals PHASE and CONDUCTANCE which vary between 0V and 5V. These signals are fed to A/D converters, the digital output of which go to the Microprocessor. The Microprocessor selects which detector to use (Conductance for Inductor removal and Phase for Capacitor insertion).

26. Inductors are removed until the CONDUCTANCE DETECTOR indicates a resistive component of 50 ohms. This is indicated by the output of the A/D representing 2.5V. The detectors are then switched and capacitance is inserted until the inductive component is removed and only the resistive component remains; again indicated by an A/D output of 2.5V.

27. The VSWR is then measured and, if 3:1 or better (nominally 1.5:1), the detectors are switched out and the READY line is released.

ATU PROTECTION

28. The ATU PROTECTION CIRCUIT provides an automatic reaction to adverse conditions within the unit. It receives inputs from the CURRENT DETECTOR on Module 4, the +19V REGULATOR on Module 2 and temperature sensing BI-METALLIC STRIPS on the chassis.

Excess Current

29. The Inductors and Capacitors on Module 4 are low power components and can be easily damaged by excess current. Current greater than 7 Amps will cause the CURRENT TRIP output from the CURRENT DETECTOR to go high.

Low Voltage

30. If the 28V input voltage to the unit falls to 19.5V the LOW VOLTAGE DETECTOR output goes high.

31. A CROWBAR circuit on Module 4 also monitors the 19V supply. If the voltage falls to 13.5V a short will be placed on the rf input causing the HF R/T to shut down.

Chassis Temperature Sensors

32. The bi-metallic chassis temperature sensors produce an output if the temperature rises to over 100°C.

VSWR & Tx

33. This input is active if a VSWR fault occurs during transmission.

'ATU PROT 1' and 'ATU PROT 2'

34. The ATU PROT 1 line is connected to the HF PA via the CONTROL cable and, if the signal goes high, the output power of the HF PA falls to 50W. In low power systems the signal has no effect.

35. The ATU PROT 2 signal, also connected to the HF PA, will become active if the ATU PROT 1 action fails to alleviate the condition which caused it. With the signal active (high) the amplification circuits of the HF PA are by-passed and the output power of the R/T set to 1.25W. The operator then has the option of raising the output power to a maximum of 20W. In low power systems where the ATU is connected directly to the R/T, an active ATU PROT 2 causes the power to fall to 1.25W with no option to raise it.

36. When ATU PROT 2 goes high ATU PROT 1 will go low. If, however, action by the operator, in raising the output power above 1.25W after the incidence of ATU PROT 2, causes a Module 4 excess current signal
then ATU PROT 1 will go high again. The effect of both protection signals occurring together is to set the HF R/T to a fixed output power of 1.25W.

STARTING DISTURBANCE

37. The CONTROL FLAG SELECTION MULTIPLEXER has an input from a Starting Disturbance Circuit (not shown on Figure 1001) which provides an indication of whether a supply failure has lasted less than one second (e.g. during vehicle starter motor operation) and therefore whether the equipment requires a retune.

POWER SUPPLIES

38. The nominal 28V vehicle supply is fed to Module 1, filtered and passed to Module 2 via a front panel fuse. The voltage regulators on Module 2 produce 19V and 5V regulated supplies and 10V and 5V switched regulated supplies.

39. SYSTEM ON from the HF R/T switches on the 19V regulator, which provides the supply for the other regulators and also an ATU PRESENT output to the HF R/T, signifying the ATU is on.

40. The outputs of the 10V and one of the 5V regulators are switched by the PSU CONTROL line from the microprocessor on Module 3. These voltages are only present for the 'tune' period and are switched off afterwards to reduce processor interference. (Because CMOS devices require their supply to be established before any signals are applied, production of the switched 5V is delayed on that of the continuous 5V supply.)

41. The voltage outputs; 19V, 5V, 10V(SWD) and 5V(SWD) are fed to Module 3 where a 12V output is derived from the 19V. The 19V, 10V(SWD) and 12V are further distributed to Modules 4, 5 and 6. The following LED indicators show the supplies are available :-

a. D6 - +19V
b. D7 - +5V
c. D8 - +5V(SWD)

BITE

42. The HF ATU contains a software program which will test the RAM and EPROM on switch on. If the test fails the FAULT line is set high.

43. The BITE operates automatically when the system is powered up and illuminates an LED (D10) on Module 3 if successful. The BITE may also be initiated, after power up during testing, by removing 4PL2 from Module 4. This causes D10 to flash once a second if successful.

44. LEDs D6, D7, D8 and D10 are mounted on Modules 2 & 3 and are only visible when the equipment covers have been removed.

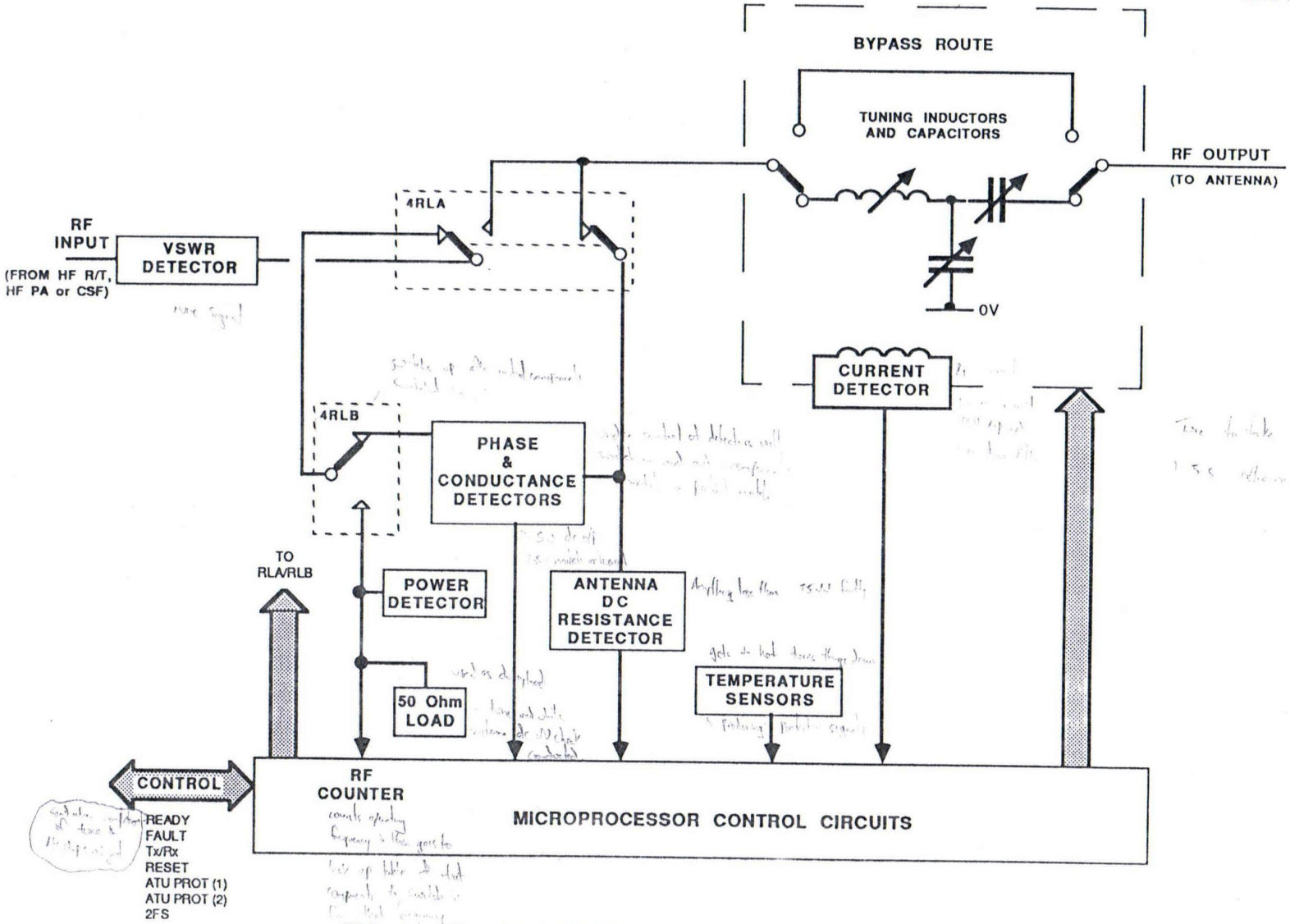


FIG. 1 HF ATU FUNCTIONAL BLOCK DIAGRAM

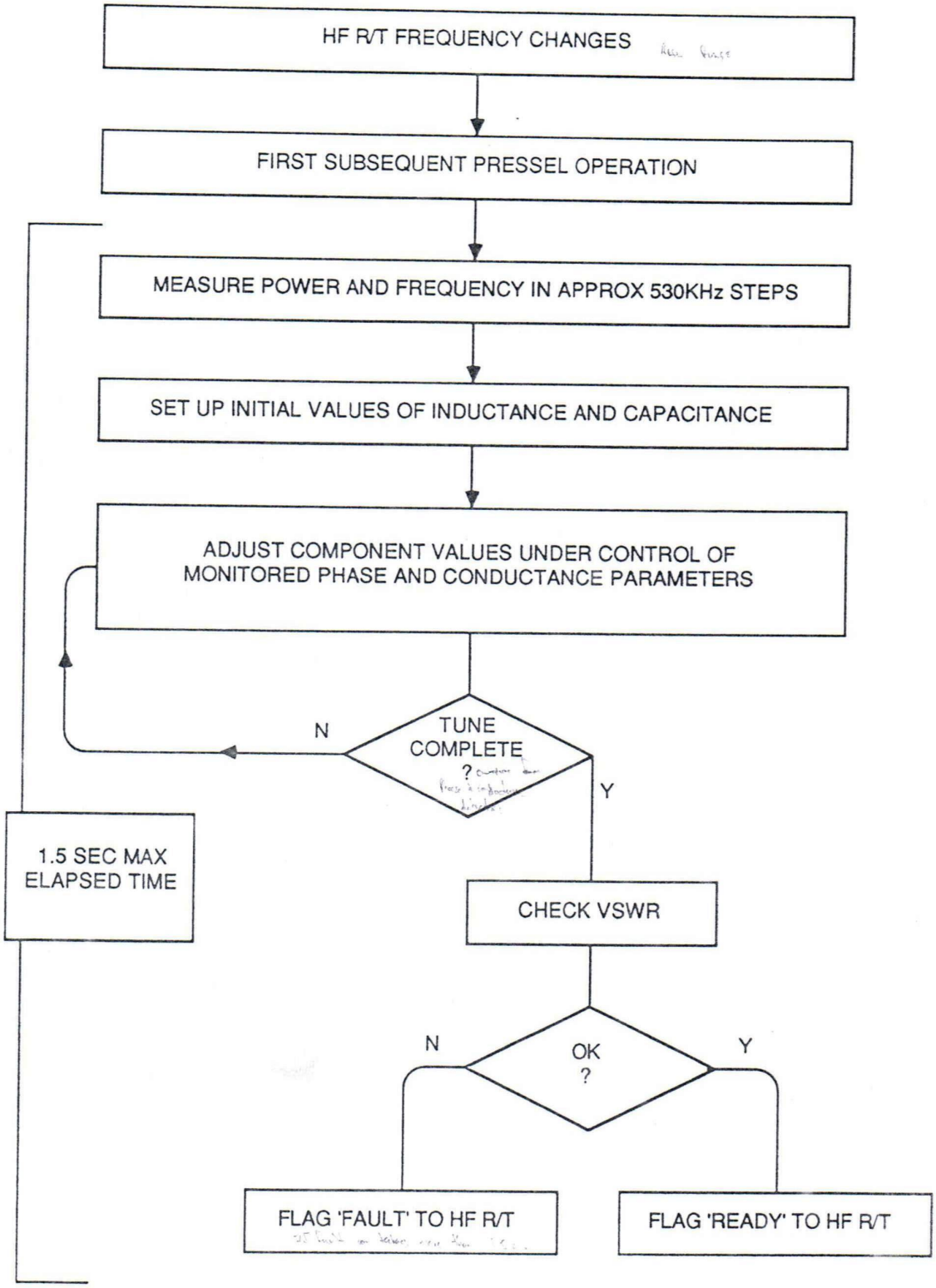
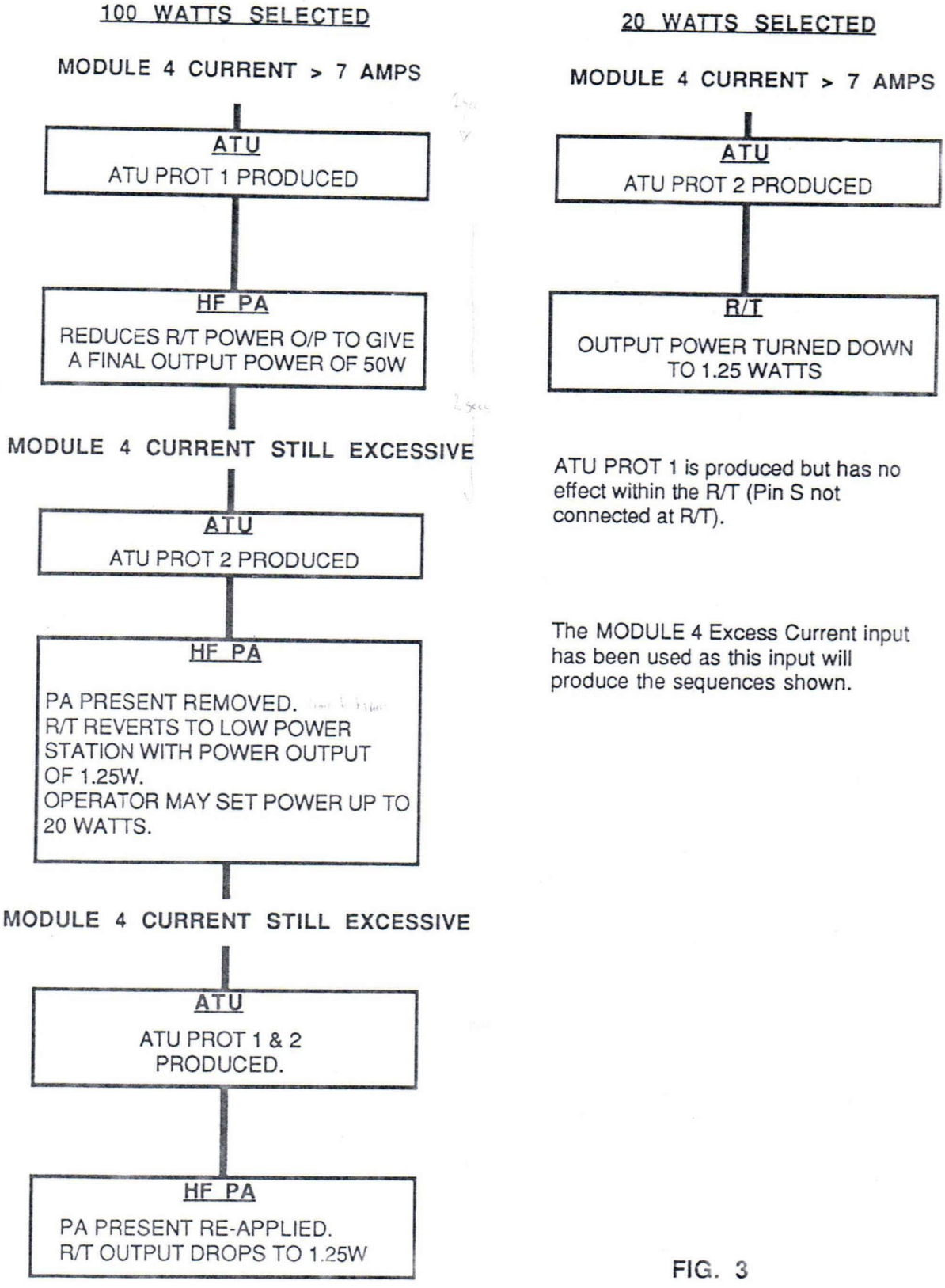

HF R/T FREQUENCY CHANGES
FIRST SUBSEQUENT PRESSEL OPERATION
MEASURE POWER AND FREQUENCY IN APPROX 530KHz STEPS
SET UP INITIAL VALUES OF INDUCTANCE AND CAPACITANCE
ADJUST COMPONENT VALUES UNDER CONTROL OF MONITORED PHASE AND CONDUCTANCE PARAMETERS
TUNE COMPLETE ?
N
Y
1.5 SEC MAX ELAPSED TIME
CHECK VSWR
OK ?
N
Y
FLAG 'FAULT' TO HF R/T
FLAG 'READY' TO HF R/T

FIG. 2



ATU PROT 1 is produced but has no effect within the R/T (Pin S not connected at R/T).

The MODULE 4 Excess Current input has been used as this input will produce the sequences shown.

FIG. 3

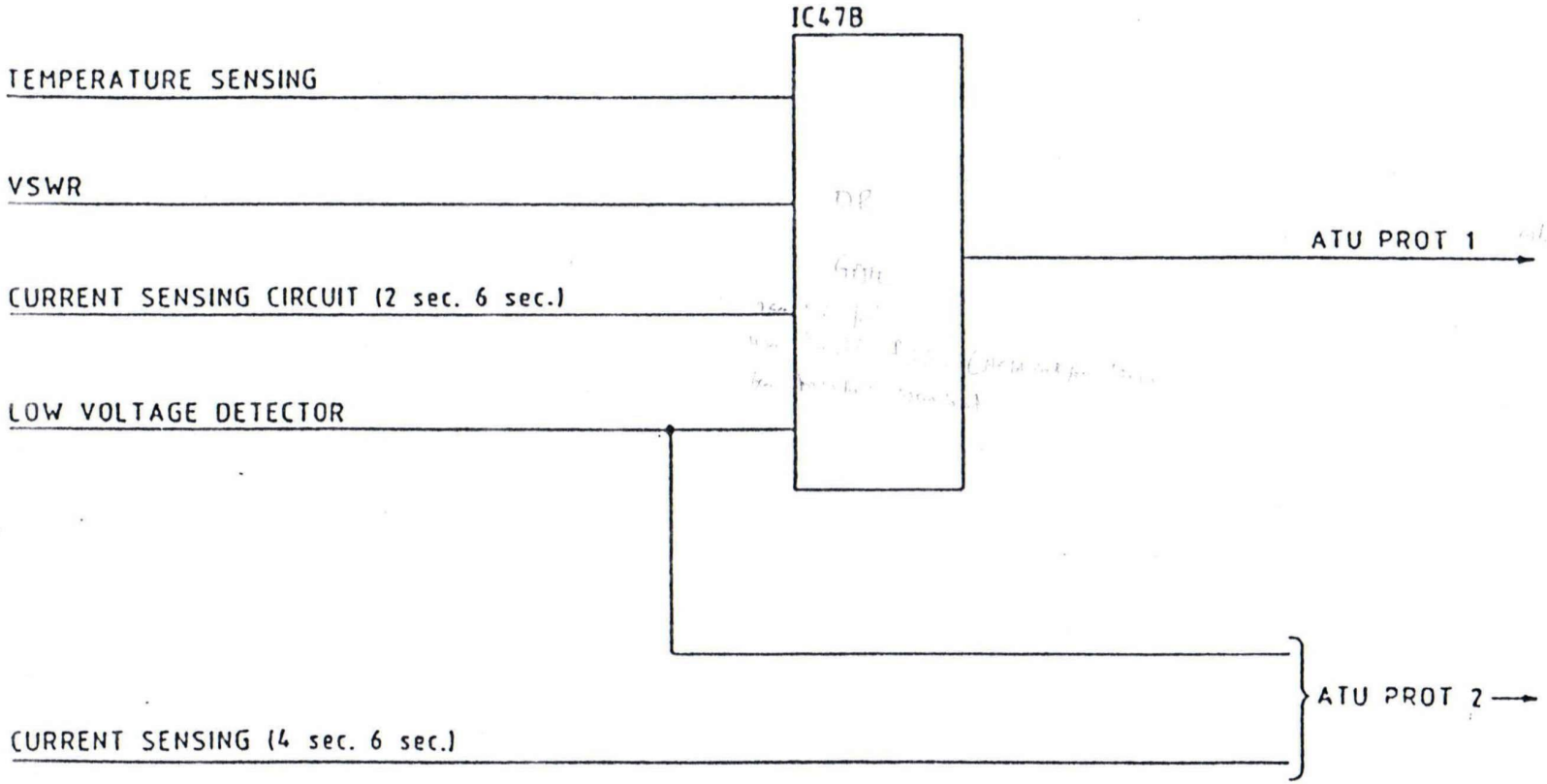
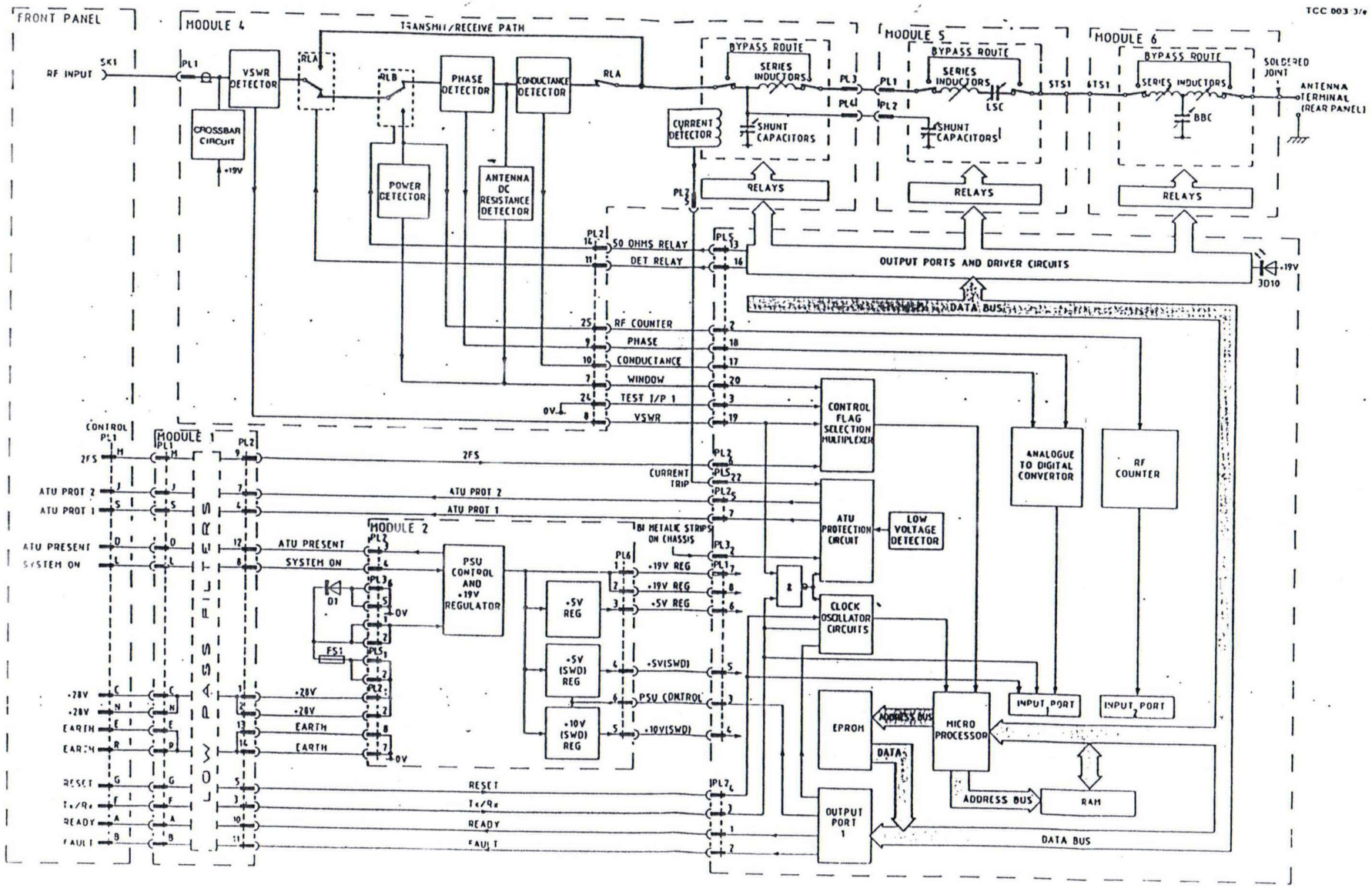


FIGURE 33 - ATU PROT 1/ATU PROT 2 LOGIC DIAGRAM



HF ATU (TN-F100)
EQUIPMENT FUNCTIONAL BLOCK DIAGRAM