

## TECHNICAL DESCRIPTION

### PCB 640 ANTENNA TUNING UNIT BOARD

The ATU consists of a Tuning Network, a Measuring System and a Microprocessor Part. During the tune sequence a 6 dB Attenuator is switched in to keep the load of the Power Amplifier at approx. 50 ohms. The MPU will set up the Tuning Network to give the best obtainable SWR, on basis of the measuring system. The Tuning Network comprises Capacitor Bank I, Capacitor Bank II and an Inductor Bank. With these it is possible to form either an L or a pi matching network. The capacitor Banks and the Inductor Bank are built up by binary related capacitors respectively binary related coils. The setting of the Capacitors and Coils is accomplished by relays. In the measuring system a Directional Coupler extracts information about forward and reflected RF-voltages. A 0 deg. Phasecomparator detects the phase difference between line and forward voltages, and the result is fed to the MPU via an Amplifier. A 90 deg. Phase-comparator detects the phase difference between forward and reflected voltages and the output is fed to the MPU via an Amplifier. Two detectors rectify forward and reflected voltages, and feed them to the MPU to calculate the SWR. The MPU choses the setting of the tuning network, on basis of the detector inputs. The output ports from the MPU are lead to the Port Expansions and Relay Drivers to control the Relays. The ATU is fitted with manual tuning switches for the 2182 kHz manual tune set-up (see chapter 5).

#### 6.3.2

When a TUNE pulse is received from the Transceiver Unit the first steps are:

- to inhibit keying.
- to insert the 6 dB attenuator.
- to measure and store the reference voltages of the detectors.
- to send a Tune Power Request to the Transceiver Unit.

The next steps are:

- to reset the tuning set-up, i.e. all capacitors disconnected and all coils shortcircuited and bypassed. The bypass relay is incorporated to lower the inductance.
- to measure the antenna impedance.

Measuring of the antenna impedance involves the two phase-detectors. On basis of the detector outputs the MPU will define the antenna impedance to be in one of four possible impedance areas. From the 90 deg. phase-detector the MPU determines if the impedance  $Z$  is less or greater than 50 ohms, and from the 0 deg. phase-detector the MPU determines if the antenna is either inductive or capacitive. The four possible impedance areas and corresponding detector input voltages to the MPU are listed below. The detector voltages refer to  $V_{ref}$  which is for both detectors half the supply voltage, i.e. 2.5 V.

1. Inductive or purely resistive:      0 deg. detector  $\leq V_{ref}$

- |                                   |                                 |
|-----------------------------------|---------------------------------|
| $ Z  < 50 \text{ ohms:}$          | 90 deg. detector $> V_{ref}$    |
| 2. Capacitive:                    | 0 deg. detector $> V_{ref}$     |
| $ Z  < 50 \text{ ohms:}$          | 90 deg. detector $> V_{ref}$    |
| 3. Capacitive:                    | 0 deg. detector $> V_{ref}$     |
| $ Z  \geq 50 \text{ ohms:}$       | 90 deg. detector $\leq V_{ref}$ |
| 4. Inductive or purely resistive: | 0 deg. detector $\leq V_{ref}$  |
| $ Z  \geq 50 \text{ ohms:}$       | 90 deg. detector $\leq V_{ref}$ |

Having located the antenna impedance to be in Area 1 the tuning procedure is:

to increase the capacitance in Capacitor Bank I until the impedance is purely resistive (0 deg. detector  $\approx V_{ref}$ ).  
to measure the admittance.

The admittance  $Y$  is separated in two areas.

1.  $Y > 0.02 \text{ mho:}$  90 deg. detector  $> V_{ref}$
2.  $Y \leq 0.02 \text{ mho:}$  90 deg. detector  $\leq V_{ref}$

For  $Y > 0.02 \text{ mho:}$  Tuning procedure A is used:

Capacitor Bank I is reset. By increasing the inductance in the Inductor Bank the impedance is transformed to lie as close as possible to Impedance Area 4 but with the impedance still being in Area 1. Then the capacitance in Capacitor Bank I is increased until Area 4 is reached, i.e. 90 deg. detector  $\leq V_{ref}$ , and then the inductance is decreased until Impedance Area 1 is reached again. This increasing of capacitance and decreasing of inductance continues until the output from the 0 deg. detector  $> V_{ref}$ . The antenna impedance is then transformed within one bit of resolution to constitute a pure resistance of 50 ohms, seen from the Power Amplifier.

The MPU finally calculates the SWR for the two nearest settings, chooses the best, and the tuning is completed.

For  $Y \leq 0.02 \text{ mho:}$  Tuning Procedure B is used:

Capacitor Bank I is reset, and by means of Capacitor Bank II the impedance is transformed to Impedance Area 2, i.e. 0 deg. detector  $> V_{ref}$  and 90 deg. detector  $> V_{ref}$ .

To optimize the efficiency, the MPU calculates the reflection coefficient  $p$  ( $V_{reflected}$  divided by  $V_{forward}$ ).

If  $\rho < 0.66$ , the Tuning Procedure A is used to complete the tuning. The

capacitance of Capacitor Bank II is retained.

If  $\rho \geq 0.66$ , the inductance of the Inductor Bank is increased until Impedance Area 3 is reached. Then the capacitance of Capacitor Bank II is decreased until Impedance Area 2 is reached again and so forth until  $\rho < 0.66$ . Now the Inductor Bank will be reset and Tuning Procedure A will take over and finalize the tuning.

If the antenna impedance is located to be in Area 2, Tuning Procedure A is chosen.

If the antenna impedance is located to be in Area 3 the first steps are:

- to increase the inductance of the Inductor Bank until the impedance is purely resistive ( $0 \text{ deg. detector} \simeq V_{\text{ref}}$ ).
- to measure the admittance  $Y$ .
- to reset the Inductor Bank.

For  $Y > 0.02 \text{ mho}$ : Tuning Procedure A is used.

For  $Y \leq 0.02 \text{ mho}$ : Tuning Procedure B is used.

If the antenna impedance is located to be in Area 4, Tuning Procedure B is used.

When the tuning is completed, Tune Power Request is inhibited, the Tune Attenuator bypassed and the ATU is ready for transmitting.

There are a few circuits incorporated in the ATU, not directly related to the tuning procedure.

A current transformer at the antenna output terminal is used for measuring the antenna current. The transformed current is rectified, amplified and used as signal for the Antenna Current Display in the Control Unit.

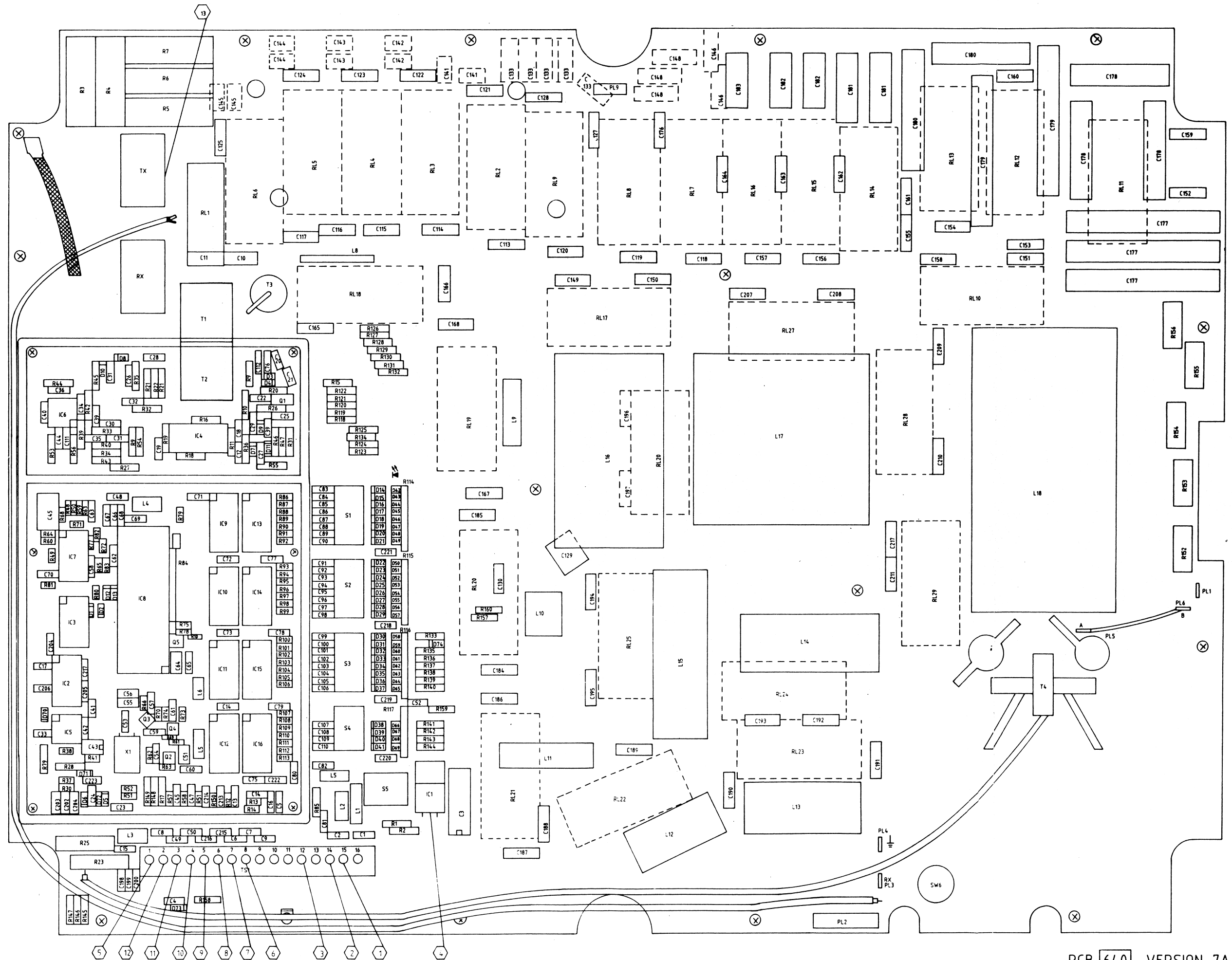
To prevent overload of the relays a current sensing transformer is incorporated. The output from the current transformer is rectified and fed to an amplifier. The output from this is led to the ALC circuit in the Transceiver Unit to decrease the output power if the maximum permissible current is exceeded.

To prevent overheating of the Antenna Tuning Unit a temperature sensor is incorporated which at excessive temperatures commands the Transceiver Unit to reduce the output power by 5 dB.

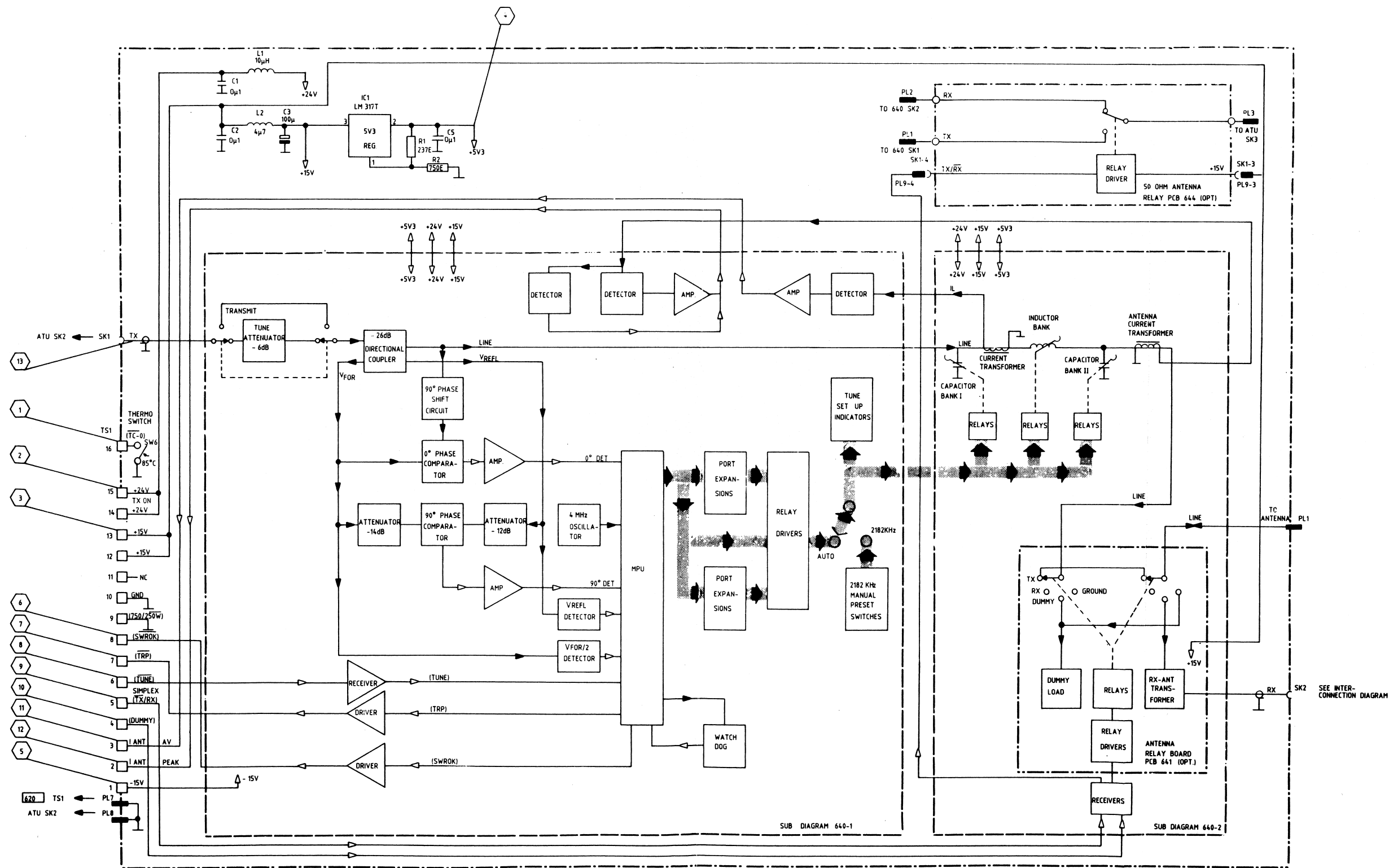
The MPU constantly monitors the SWR at the input of the tuner and if it exceeds approximately 3 the Power Display Annunciator in the Control Unit starts to flash.

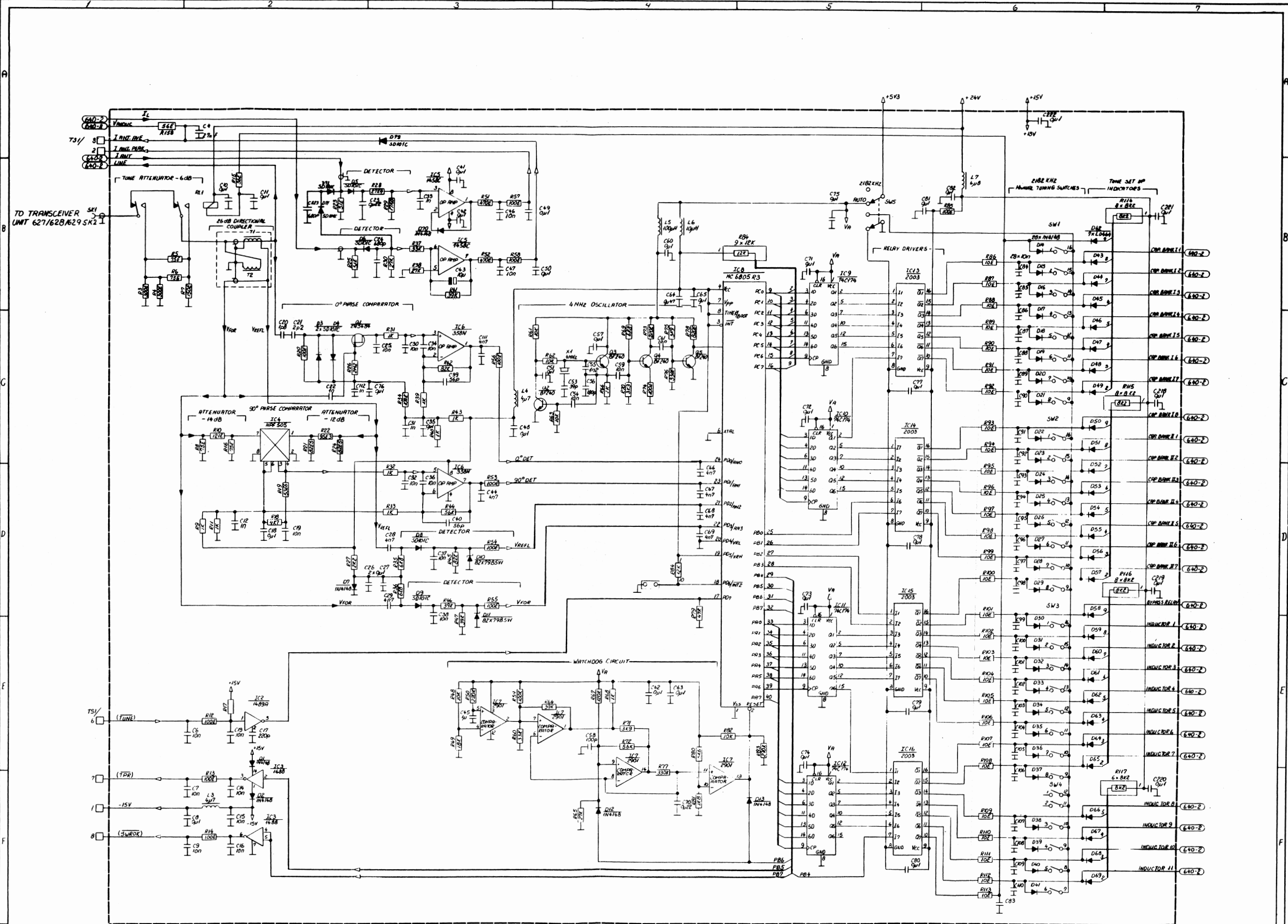
As an option an Antenna Relay Board 641 can be incorporated in the Antenna Tuning Unit.

The Antenna Relay is a fast switching Simplex relay permitting ARQ-telex on one antenna. It also contains a dummy-load and acts as grounding relay, connecting the antenna to ground when the equipment is switched off.

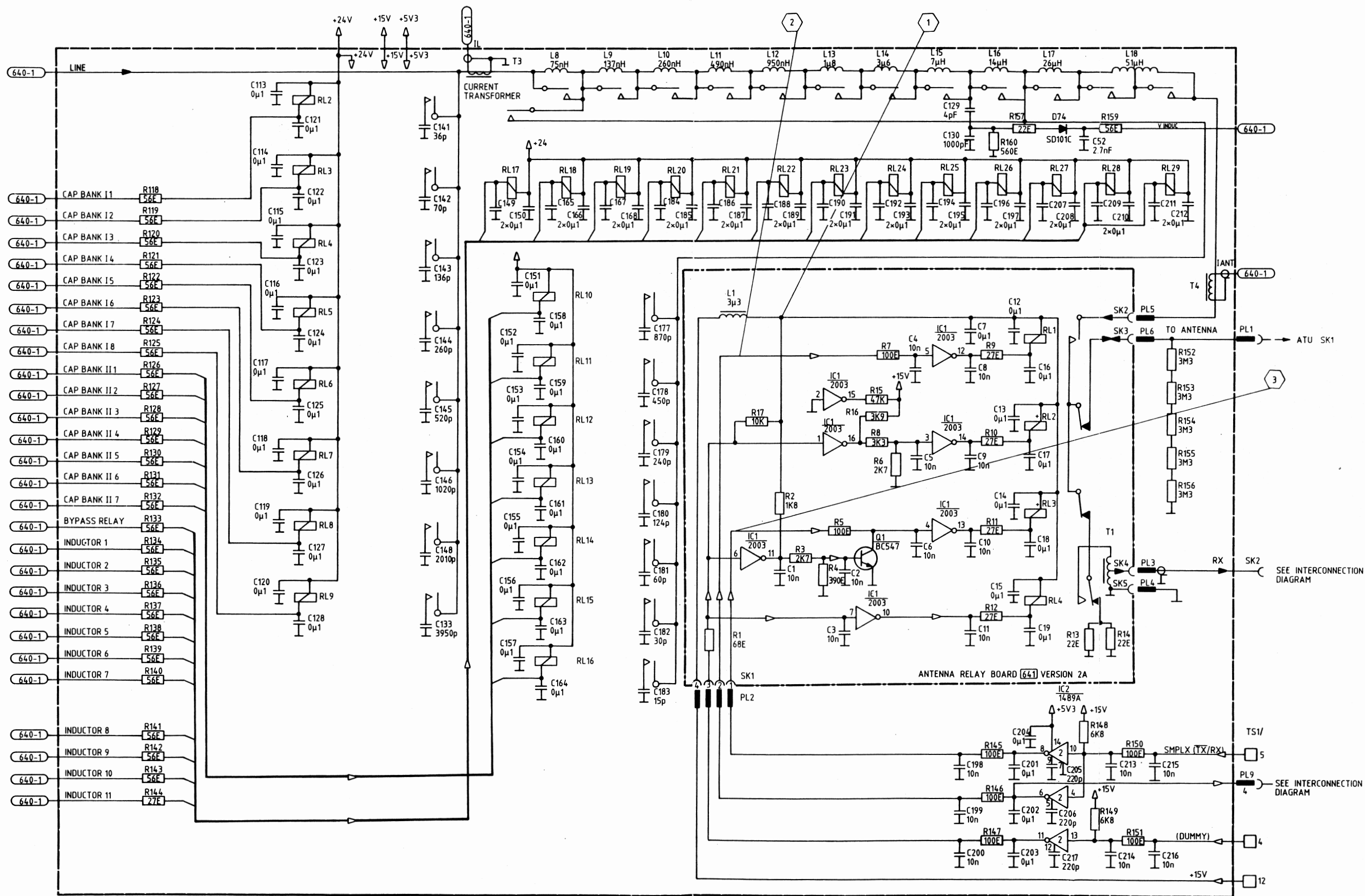


PCB 640 VERSION 7A  
ANTENNA TUNING UNIT  
VIEWED FROM COMPONENT SIDE





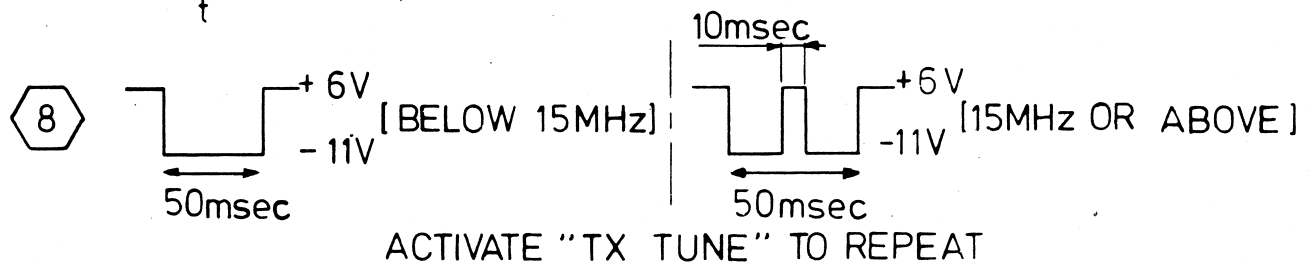
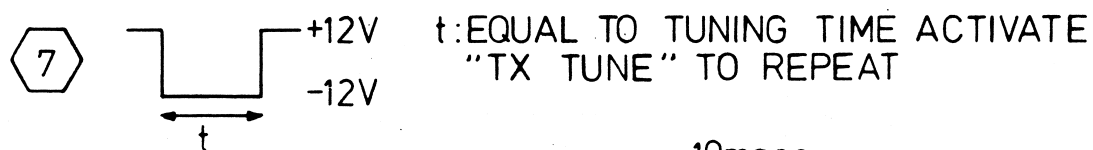
PCB 640 ANTENNA TUNING UNIT  
VERSION 7A SUBDIAGRAM 1 OF 2





# TEST POINTS FOR ATU 8250 PCB 640

- 1 5V
- 2 24V
- 3 15V
- 4 5,3V
- 5 -15V
- 6 -12V ~ SWR < 3, +12V ~ SWR > 3



- 9 RX=5,5V TX-KEYED=-7,5V
- 10 -10V WHEN "TEST ALARM" AND IF DUMMY LOAD ENABLE +6V DURING TEST.
- 11 0,1V
- 12 0 V
- 13 320Vpp ~ 250W<sub>pep</sub> INTO 50 OHMS

TEST POINTS FOR 641 ANTENNA RELAY BOARD.

1

+15V

2 3

RX = 0.1V    TX = 4.0V

## PARTS LIST FOR ANTENNA TUNING UNIT BOARD 640 VERSION 7A

## PARTS LIST FOR ANTENNA TUNING UNIT BOARD 640 VERSION 7A

Printed Circuit Board Complete 640			107 564 01	R20,34,53-56, 85,145-147			5%	100 ohm	5%	1/4W	Car.	501 210 00
IC1	LM317T	5V3	850 031 70	R21,24			1%	82.5 ohm	1%	1/4W	MF	511 182 50
IC2	1489P		850 148 90	R22			1%	95.3 ohm	1%	1/4W	MF	511 195 30
IC3	1488P		850 148 80	R23,25			5%	51 ohm	5%	2W	MF	546 151 00
IC4	HPF505		850 000 11	R26			5%	2.2 Mohm	5%	1/4W	Car.	541 622 00
IC5	MC1458C		850 145 80	R27			5%	2.2 kohm	5%	1/4W	Car.	501 322 00
IC6	LM358N		850 035 80	R28			1%	27.4 kohm	1%	1/4W	MF	511 427 40
IC7	LM2901		850 290 10	R29			1%	17.8 kohm	1%	1/4W	MF	511 417 80
IC8	MC68705R3CS (programmed)		856 805 31	R30,38,65			5%	27 kohm	5%	1/8W	MF	500 427 00
IC9-12	74C174		857 417 40	R37,60			5%	33 kohm	5%	1/8W	MF	500 433 00
IC13-16	2003A		850 200 30	R41			5%	39 kohm	5%	1/8W	MF	500 439 00
Q1	2N5484		840 548 40	R42,45			5%	82 kohm	5%	1/4W	Car.	501 482 00
Q2-5	BF240		840 024 00	R44			5%	56 kohm	5%	1/4W	Car.	501 456 00
D1,2,7,12-41,70	LN4148		830 414 80	R46,47			5%	39 kohm	5%	1/4W	Car.	501 439 00
D3-6,8,9,71-74	SD101C		830 010 10	R48,61-63,82			5%	10 kohm	5%	1/8W	MF	500 410 00
D10,11	BZX79B5V1		832 795 11	R49			5%	18 kohm	5%	1/8W	MF	500 418 00
D42-69	LD464		823 000 06	R50			5%	220 kohm	5%	1/8W	MF	500 522 00
X1	4MHz	CRYSTAL	812 000 00	R51,52			5%	470 ohm	5%	1/8W	MF	500 247 00
RL1	24V		780 000 37	R59			5%	100 kohm	5%	1/8W	MF	500 510 00
RL2-9,18-20	REED RELAY 500V		373 588 51	R64			5%	39 kohm	5%	1/8W	MF	500 439 00
RL10-17,25-26	REED RELAY 5KV		373 588 41	R66,68			5%	1 kohm	5%	1/8W	MF	500 310 00
RL21-24	REED RELAY 2.5KV		373 588 61	R67			5%	120 kohm	5%	1/8W	MF	500 512 00
RL27-29	REED RELAY 10KV		373 588 71	R69			5%	6.8 kohm	5%	1/8W	MF	500 368 00
R1	237 ohm	1%	511 223 70	R70			5%	3.3 kohm	5%	1/8W	MF	500 333 00
R2	750 ohm	1%	511 275 00	R71,75			5%	3.9 kohm	5%	1/8W	MF	500 339 00
R3,4	300 ohm	5%	547 230 00	R72			5%	56 kohm	5%	1/8W	MF	500 456 00
R5,6	75 ohm	5%	547 175 00	R73			5%	220 ohm	5%	1/8W	MF	500 222 00
R7	150 ohm	5%	547 215 00	R76			5%	330 ohm	5%	1/8W	MF	500 233 00
R8,16	75 ohm	1%	511 175 00	R77			5%	330 kohm	5%	1/8W	MF	500 533 00
R9,11,31-33,39, 40,43	1 kohm	5%	501 310 00	R78			5%	820 ohm	5%	1/8W	MF	500 282 00
R10	121 ohm	1%	511 212 10	R79			5%	47 kohm	5%	1/8W	MF	500 447 00
R12-14,57,58,74, 150,151	100 ohm	5%	500 210 00	R80			5%	5.6 kohm	5%	1/8W	MF	500 356 00
R15,118-143,158,159	56 ohm	5%	501 156 00	R81			5%	1.8 kohm	5%	1/8W	MF	500 318 00
R17,35,36,148,149	6.8 kohm	5%	501 368 00	R83			5%	270 kohm	5%	1/8W	MF	500 527 00
R18	4.7 kohm	5%	501 347 00	R84			5%	9x12 kohm	5%	1/8W	Sil	530 000 16
R19	53.6 ohm	1%	511 153 60	R86-113			5%	10 ohm	5%	1/8W	Sil	530 110 01
				R114-116			5%	8x8.2 kohm	5%	1/8W	Sil	530 000 15
				R117			5%	6x8.2 kohm	5%	1/4W	Sil	530 000 14
				R144			5%	27 ohm	5%	1W	Car.	501 127 00
				R152-156			5%	3.3 Mohm	5%	1/4W	Car.	523 633 00
				R157			5%	22 ohm	5%	1/4W	Car.	501 122 00
				R160			5%	560 ohm	5%	1/4W	Car.	501 256 00
				C1,2,5,8,18, 26,27,35,41,42, 48,51,57,60, 62,63,65,71-82, 201-204,218-222			20%	0.1 uF	20%	63V	Polyes.	622 510 00

## PARTS LIST FOR ANTENNA TUNING UNIT BOARD 640 VERSION 7A

## PARTS LIST FOR ANTENNA TUNING UNIT BOARD 640 VERSION 7A

C3	100 uF	25V	W.alum.	652 810 00	C177	870 pF	10%	2kV	Cer	608 287 00
C4, 52	2.7 nF	63V	Cer.	602 327 00	alternative	2 x 300 pF	10%	1.6kV	Cer	607 230 00
C6, 7, 9, 13-16, 34, 36, 49, 50, 54, 59, 61, 83-110, 198-200, 213-216	10 nF	100V	Cer.	602 410 01	plus	270 pF	10%	1.6kV	Cer	607 227 01
	-20+50%				C178	450 pF	10%	2kV	Cer	608 245 00
C10, 11, 113-128, 149-168, 184-197, 207-212	0.1 uF	100V	Polyes.	623 510 01	alternative	3 x 150 pF	10%	1.6kV	Cer	607 215 00
C12, 22, 31, 33, 112 C17, 205, 206, 217	1 nF	63V	Cer.	602 310 02	alternative	240 pF	10%	2kV	Cer	608 224 00
	220 pF	63V	Cer.	602 222 00	plus	2 x 120 pF	10%	1.6kV	Cer	607 212 00
C19, 25, 30, 32, 37, 38	10 nF	63V	Polyes.	622 410 01	C180	124 pF	10%	2kV	Cer	608 212 40
C20	1.8 pF	400V	Cer.	605 018 00	alternative	56 pF	10%	1.6kV	Cer	607 156 00
C21	2.2 pF	400V	Cer.	605 022 00	plus	68 pF	10%	1.6kV	Cer	607 168 01
C23, 70	0.22 uF	63V	Polyes.	622 522 01	C181	60 pF	10%	2kV	Cer	608 160 03
C24, 223	680 pF	125V	Micro.	602 268 00	alternative	27 pF	10%	1.6kV	Cer	607 127 01
C28, 29, 44, 66-69, 111,	4.7 nF	100V	Cer.	602 347 02	plus	33 pF	10%	1.6kV	Cer	607 133 00
C39, 40	56 pF	63V	Cer.	602 156 00	C182	30 pF	10%	2kV	Cer	608 130 02
C43	10 uF	16V	Sol.al	651 710 03	alternative	2 x 15 pF	10%	1.6kV	Cer	607 115 01
C45	1 uF	63V	Polyes.	623 610 01	C183	15 pF	10%	2kV	Cer	608 115 00
C46, 47	47 nF	63V	Polyes.	622 447 00	alternative	15 pF	10%	1.6kV	Cer	607 115 01
C53	39 pF	63V	Cer.	602 139 01	L1	10 uH				740 110 00
C55	1.2 nF	63V	Cer.	602 312 00	L2-4	4.7 uH				740 047 01
C56	180 pF	63V	Cer.	602 218 00	L5	100 uH				740 210 07
C58	100 pF	100V	Cer.	602 210 00	L6	10 uH				740 110 01
C64	0.47 uF	63V	Polyes.	622 547 01	L7	6.8 uH				740 068 00
C129	4 pF	4KV	Cer.	608 004 00	L8	75 nH				103 579 1X
C130	1000 pF	100V	CD15	643 310 00	L9	137 nH				103 579 2X
C133	5 x 790 pF	500V	Mi	645 279 00	L10	260 nH				103 579 3X
C141	2 x 18 pF	500V	Mi	645 118 00	L11	490 nH				103 579 4X
C142	2 x 35 pF	500V	Mi	645 135 00	L12	950 nH				103 579 5X
C143	2 x 68 pF	500V	Mi	645 168 00	L13	1.8 uH				103 579 6X
C144	2 x 130 pF	500V	Mi	645 213 01	L14	3.6 uH				103 579 7X
C145	2 x 260 pF	500V	Mi	645 226 00	L15	7 uH				103 579 8X
C146	2 x 510 pF	500V	Mi	645 251 02	L16	14 uH				103 711 9X
C148	2 x 680 pF	500V	Mi	645 268 02	L17	26 uH				103 580 0X
plus	650 pF	500V	Mi	645 265 00	L18	51 uH				103 580 1X
					T1, T2	DIRECTIONAL COUPLER				107 600 80
					T3	TRANSFORMER				103 578 6X
					T4	TRANSFORMER				103 578 7X
					SW1-3					762 000 24
					SW4					762 000 26
					SW5					762 000 23
					SW6					769 000 05
					THERMO SWITCH					
					PL1, 3-6	SPADE				750 001 51

# PARTS LIST FOR ANTENNA TUNING UNIT BOARD 640 VERSION 7A

PL2	8 POL. MOLEX	751 000 98
PL7,8	SPADE	750 000 21
PL9	4 POL. MOLEX	751 001 50
TS1	TERMINAL STRIP	770 000 19

# PARTS LIST FOR ANTENNA RELAY BOARD 641 VERSION 2A

Printed Circuit Board Complete 641				107 564 11
IC1	2003			850 200 30
Q1	BC547			850 054 70
RL1	REED RELAY			373 589 81
RL2	REED RELAY			373 590 01
RL3	REED RELAY			373 590 0X
RL4	RELAY			780 000 35
R1	68 ohm	5%	1/4W	501 168 00
R5,7	100 ohm	5%	1/4W	501 210 00
R2	1.8 kohm	5%	1/4W	501 318 00
R3,6	2.7 kohm	5%	1/4W	501 327 00
R4	390 ohm	5%	1/4W	501 239 00
R8	3.3 kohm	5%	1/4W	501 333 00
R9-12	27 ohm	5%	1/4W	501 127 00
R13,14	22 ohm	5%	5W	547 122 00
R15	47 kohm	5%	1/4W	501 447 00
R16	3.9 kohm	5%	1/4W	501 339 00
R17	10 kohm	5%	1/4W	501 410 00
C1-6,8-11	10 nF	-20+50%	63V	602 410 02
C7,12-19	0.1 uF	10%	100V	623 510 01
L1	3.3 uH	10%		740 033 02
T1				103 580 21
SK1				106 602 70
SK2-5				106 602 80