

1.5 kW Automatic Remote Controlled Antenna Balanced Tuner

Model AT- 615B

Operating Manual and Technical Data

10/2010



Dipl.Ing. Klaus Bemmerer
RF Communication Electronics
Niendorf-Middeldor 11
23769 Fehmarn
GERMANY
Phone +49 4371 869145
Fax +49 4371 869154
www.hamware.de
eMail: service@hamware.de

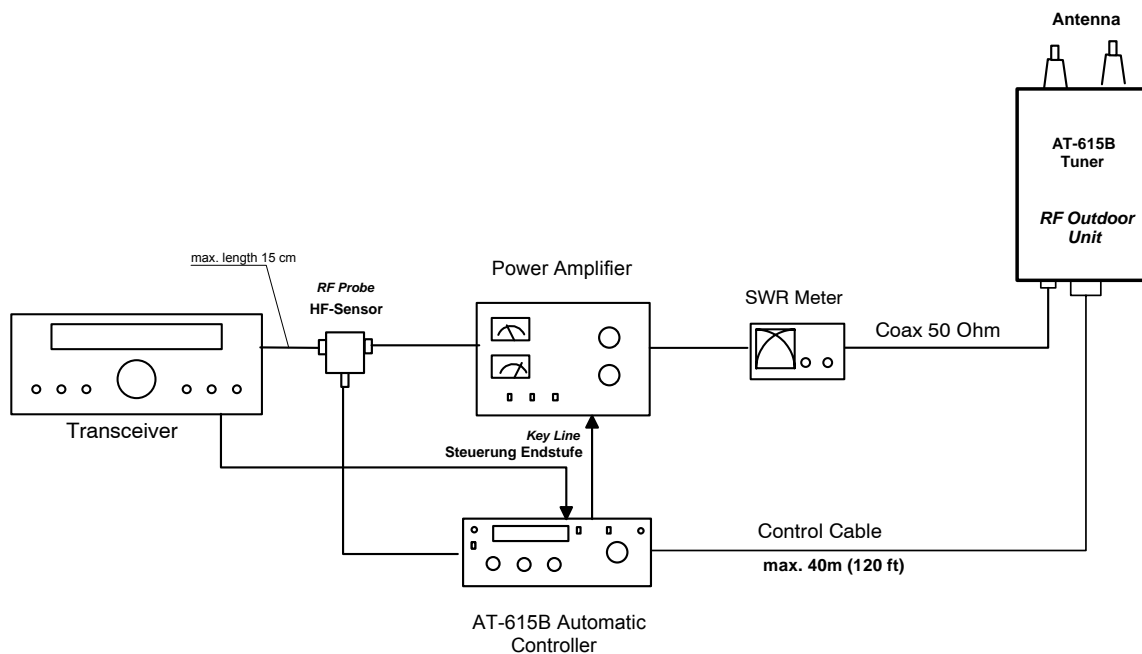
Antenna Tuner System AT-615B Description

This tuner is designed to match remotely, balanced HF antennas. This unit features automatic selection of tuner settings based upon transmitted frequency. Unique to this tuner, no special cabling or adapters are required. The operator simply transmits into the antenna and the tuner detects the transmitted frequency and selects the correct settings from memory. The Ham bands are divided into 85 operator programmable memory locations. It will handle 1500 watts of SSB or CW power, and it can be used in either automatic or manual mode.

The matching circuit consists of a remotely tuned balanced π circuit. The balun is placed at the input of the tuner. The Output capacitor is a stepper motor controlled High Voltage variable capacitor.

The Control Cabinet contains the tuning controls, memory location selection, Automatic or Manual switching and a display that indicates the memory location in use, the frequency range as well as the span, and the tuner settings.

Tuner System Block Diagram



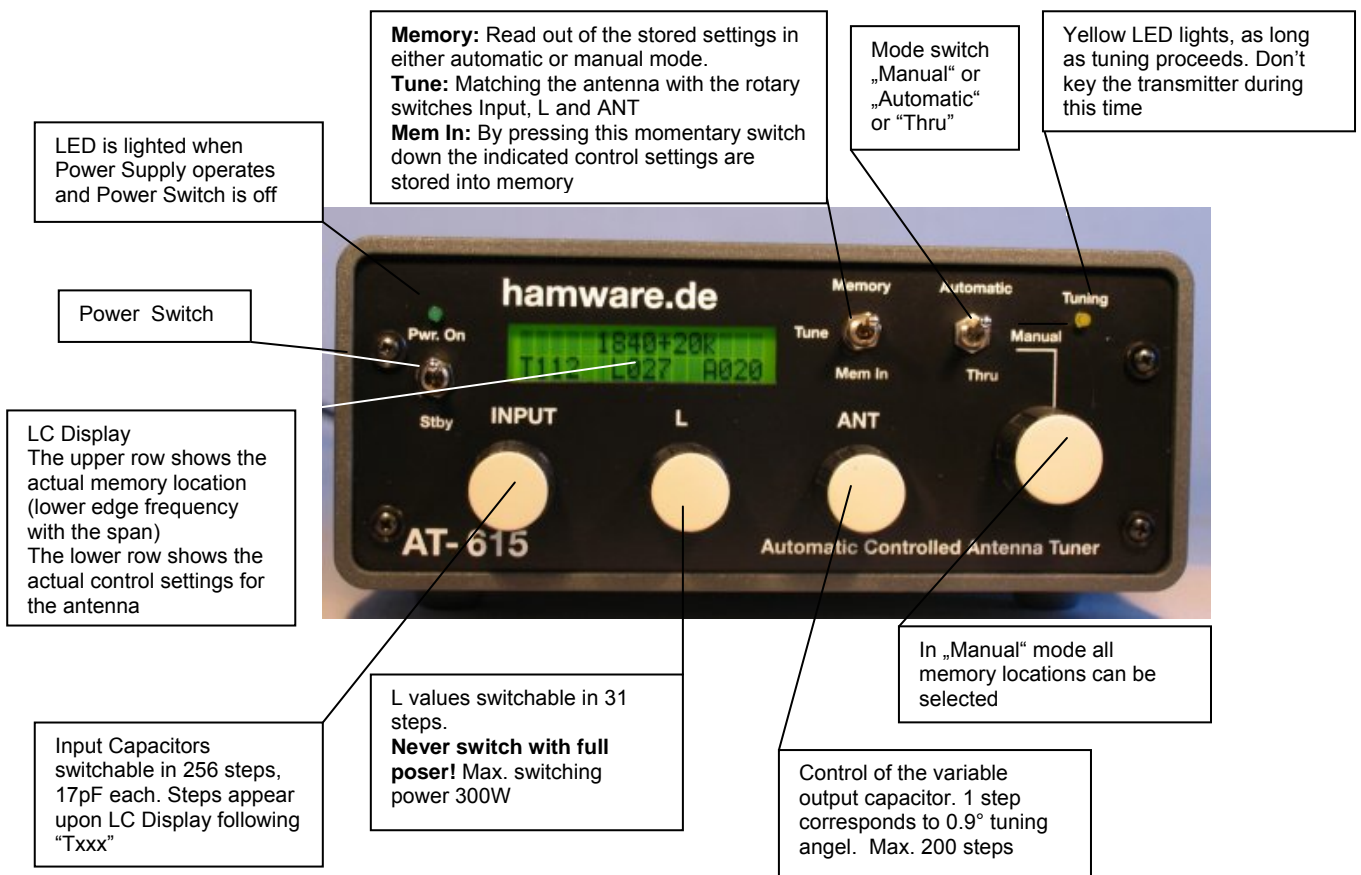
Controller Unit:

Antenna matches are stored into a bank of 85 memory locations. Each memory location is a fraction of an amateur band. Refer to the technical section for the fractional segments for each band. As shown in the picture below, the upper line of the LCD shows the actual memory location chosen (lower edge frequency 1840 kHz) with its span (20 kHz). The control settings for this frequency are shown in the lower line of the LCD. In the Automatic Mode the memory location and its stored settings is selected by the transmitted input frequency. The input frequency is obtained from an RF probe. The memory location contents can be erased by a push button on the back of the controller.

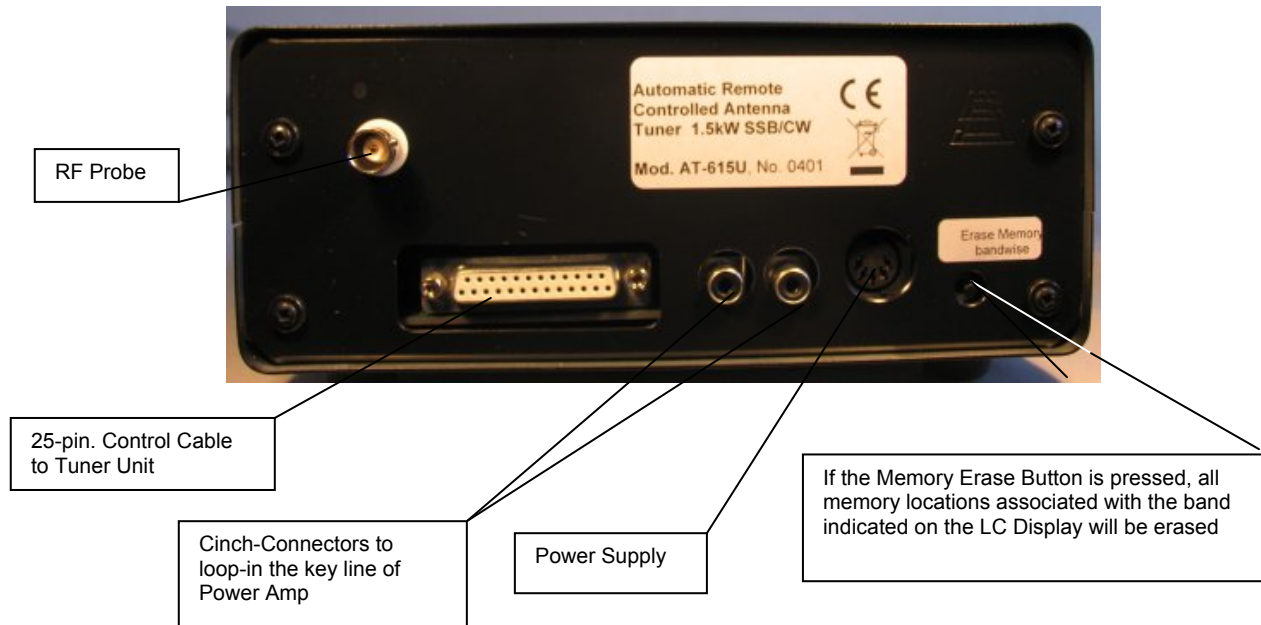
The controller contains 3 rotary encoders that control the tuner elements TRX, L, and ANT. TRX controls the Input Capacitance, L controls the Inductance and ANT the output capacitance values. The lower line on the display shows these values.

A manual selector switch is provided for memory selection in the Manual mode.

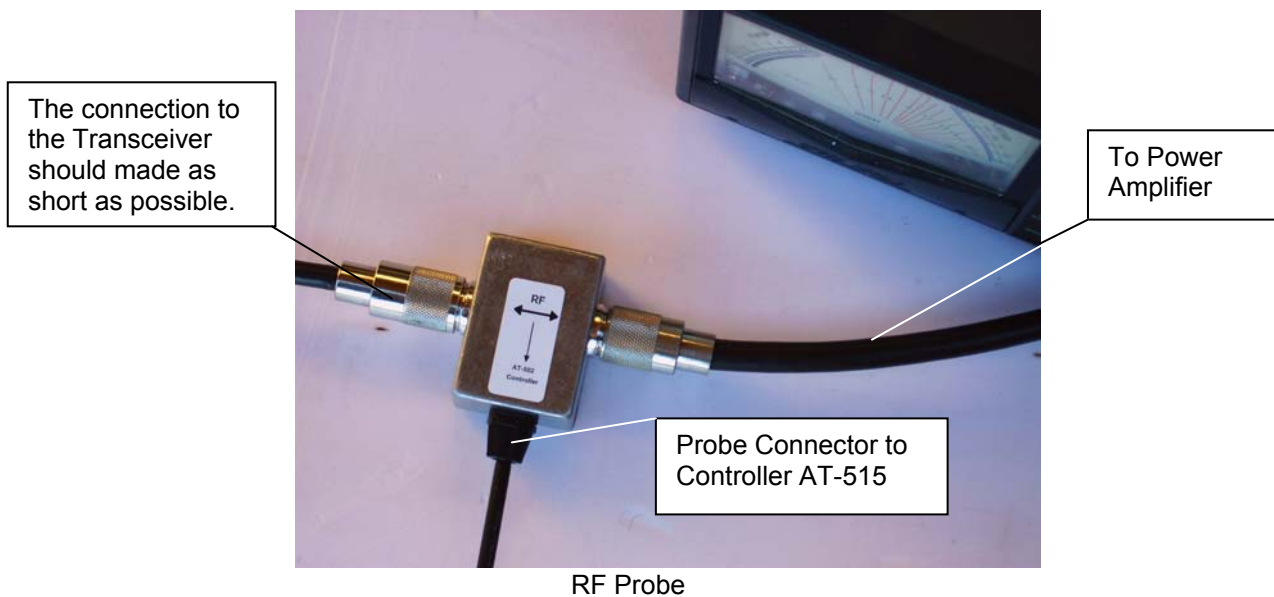
Controller Unit



Controller Connections (Rear Side)



RF Probe Installation



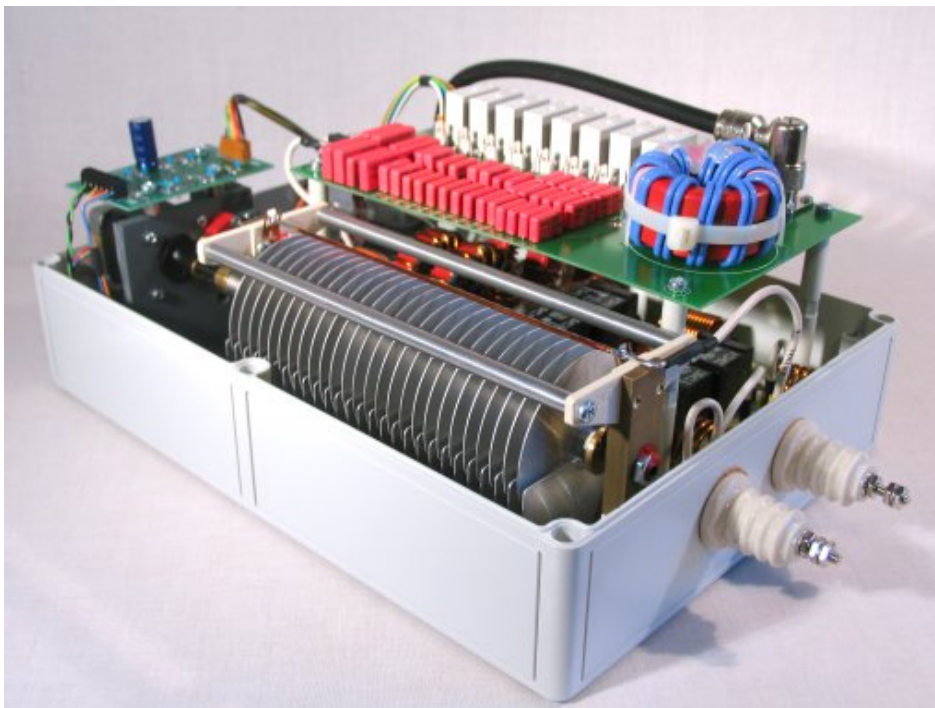
If possible, the RF Probe should be attached directly to the antenna jack of the transceiver using an adaptor or a very short cable.

RF Unit:

The RF Unit is contained in a weather-protected cabinet (IP66) and is UV resistant. There are two feed-thru insulators to connect to the antenna elements. The coaxial cable and the control cable are connected via a N and a 254 pin connectors. There is no active circuitry inside the RF Unit. This is to insure reliable operation even under non-matched condition.

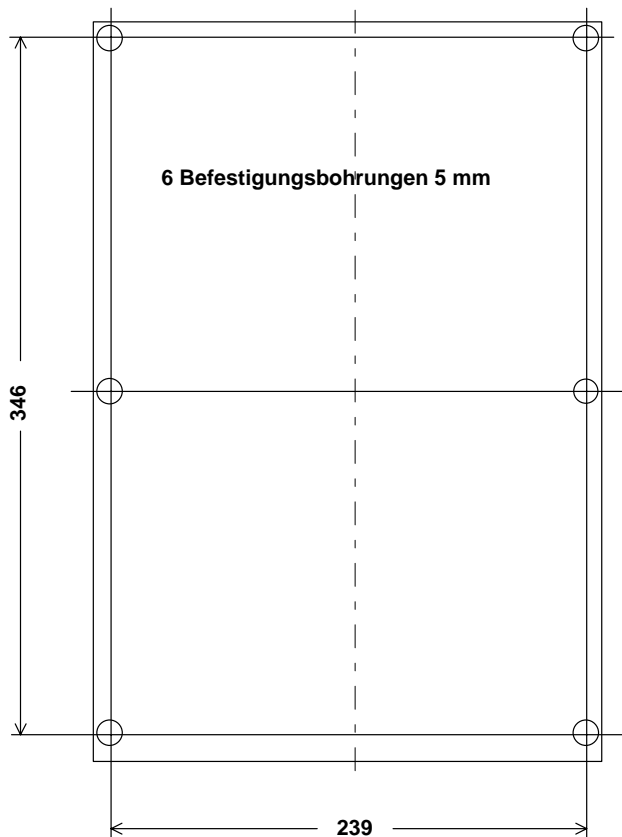
The LC network is known as Balanced PI. At the front end of the network there is a balun transformer that matches the unsymmetrical coax cable to the symmetrical tuner elements. This is the only place where the impedance of the system is purely resistive (when matched) and is the ideal place for the Balun. The regular station SWR meter (or the built-in meter in the TRX) is used as an indicator to match the antenna.

The capacitors at front end are switched in 256 steps of 17 pF per step. The capacitor at antenna side is a variable capacitor of 400 pF. The control of this capacitor is by a stepper motor with 0.9° per step. The inductive paths between the capacitors are switched in 31 steps from $0.2 \mu\text{H}$ to $35 \mu\text{H}$. Switching is done by power relays. With the circuit components used it is possible to match short antennas up to an unlimited antenna length within the RF range from 1.8 to 30 MHz.



Interior view of the RF unit looking at the capacitor board, the inductor board is located below

Installation of the RF Unit



The weather proof cabinet has 6 mounting holes.

The backside of the cabinet should be mounted on a flat surface.

Hole spacing is 13.62"H x 9.41"W (346mm x 239mm)

Connect the ground bolt between the two antenna insulators with the lightning rod.

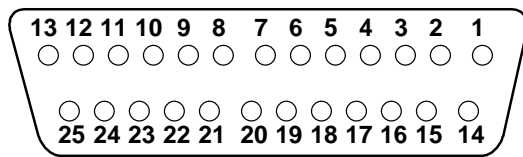
An application example



If the RF Unit is installed outside, a small roof or overhang is recommended to protect the unit from direct sun. If the tuner is not protected, the excessive temperatures inside the cabinet could damage the antenna tuner elements.

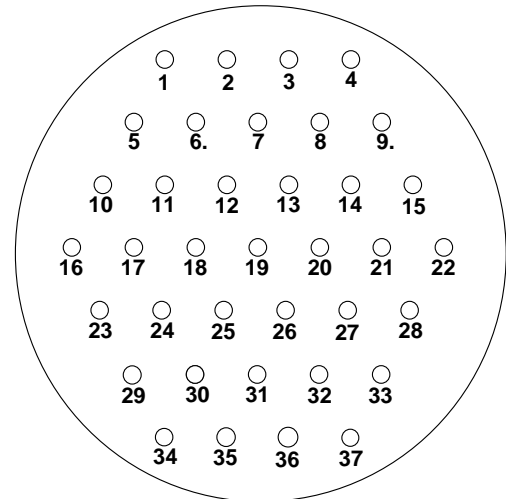
Control Cable

With a 25conductor (AWG22) wire control cable, the RF Unit can be controlled within a length of 120ft. (40 meters). Lengths in excess require larger wire diameters. Cable shield is not necessary.



DB-25 Controller Plug

View upon selder side of the plug



**Anschluss der HF-Einheit
Blick auf die Lötseite der
Buchsenkupplung**

**Control Cable Interface
RF Unit
View upon solder side
of the jack**

Nr.	Farbe	Funktion
1	Black	Stepper Motor A
2	Wht/Blue	Stepper Motor B
3	Red	Stepper Mptor D
4	Blue	GND
5	Pink	+15VDC
6	Pink/Bwn	RFU C9
7	Grey	L-Ctl. 2^5
8	Yellow	L-Ctl. 2^3
9	Wht/Pink	L-Ctl. 2^1 (LSB)
10	Green	Input-C Ctl. 2^7
11	Brown	Input-C Ctl. 2^5
12	White	Input-C Ctl. 2^3
13	Violet	Input-C Ctl. 2^1 (LSB)

Nr.	Farbe	Funktion
14	Blue/Bwn	+15VDC
15	Grey/Pink	Stepper Mptor C
16	Wht/Yel	+36VDC
17	Wht/Red	Stepper End Position Sw.
18	Yel/Bwn	RFU C10
19	Bwn/Red	L-Ctl. 2^6 (MSB)
20	Blue/Red	L-Ctl. 2^4
21	Wht/Grey	L-Ctl. 2^2
22	Wht/Grn	Input-C Ctl. 2^8 (MSB)
23	Grey/Bwn	Input-C Ctl. 2^6
24	Grn/Bwn	Input-C Ctl. 2^4
25	Wht/Blck	Input-C Ctl. 2^2

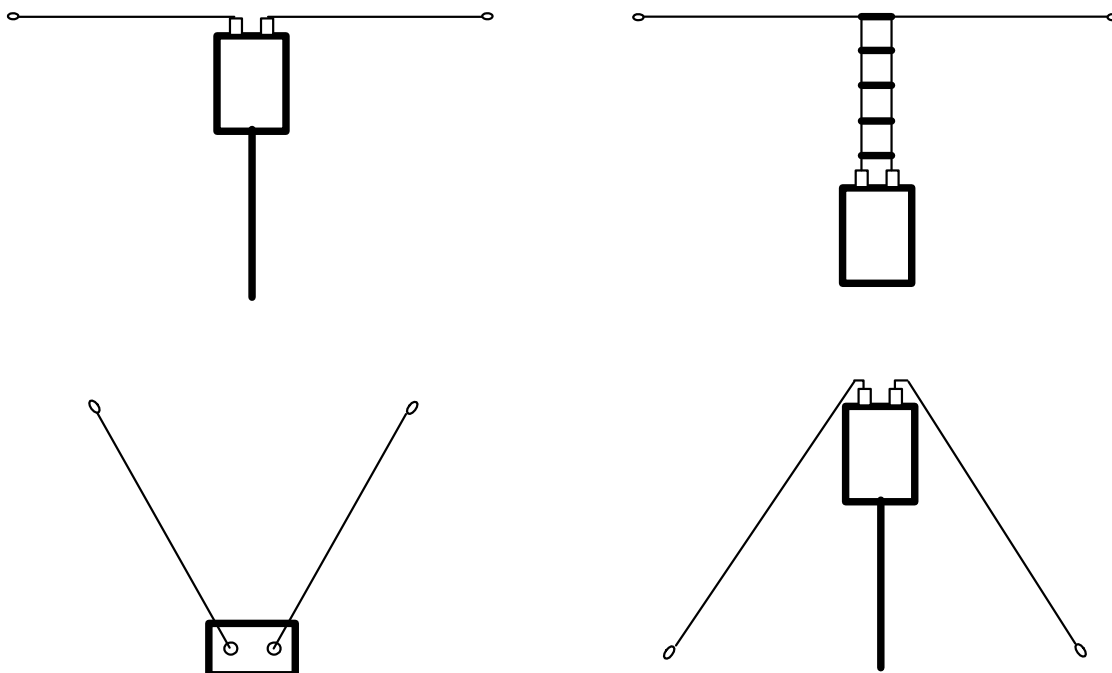
Hints to mount the DB-25 plug at controller side

- Strip the cable coat about 30mm
- Form the conductors in 2 rows 1 to 13 and 14 to 25
- Strip stranded wires 3 to 4 mm
- Solder the plug according drawing

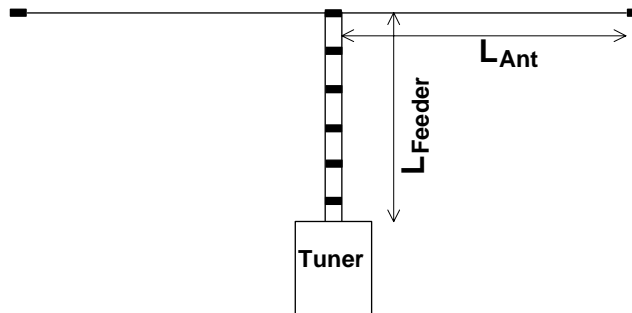
Antenna Descriptions and Design Hints

The remote controlled matching system AT-615B is capable of matching symmetrical antennas from a minimum length of 62 ft. within a frequency range of 1.8 to 30 MHz. The antenna length is dictated by the space available rather than the usual resonant length. It easily covers all amateur bands (including WARC) using a single wire dipole without traps. Traps have long been known to induce losses and antenna's designed using them are frequently limited in overall bandwidth.

Some possible Installation Configurations



Some baseline rules for matching “random“ antenna lengths to specific frequencies or frequency bands:



- If the antenna is fed via a balanced feeder (ladder, twin lead etc.) the value of the relation L_{Ant} / L_{Feeder} should be more than 2/1
- The length $L_{Ant} + L_{Feeder}$ should be more than $\lambda/2$
- The antenna system $L_{Ant} + L_{Feeder}$ need not be resonant. Some antennas that are less than a quarter wavelength per side exhibit impedances that are very low. These very low impedances can be difficult to match and some adjustments to lengths may be necessary. Antennas are multiples of a half wave present very high impedances to the tuner and may result in internal arcing of the tuner elements
- If $L_{Ant} + L_{Feeder}$ is small in comparison to the wavelength (i.e. 160m Amateur Radio band); the internal tuner elements are exposed to very high RF voltages. An antenna i.e. 2 x 10 meters length could be matched at a wavelength of 160 meters, but the output power of the transmitter must be reduced (see “Antenna Matching”)

Antenna Matching (a way to start)

- Set the Mode switch to "Manual"
- Starting in the 14 MHz band
- Turn the Memory selection rotary switch to the indicated memory location "14000 +30k"
- Set the transmitter frequency to 14015 kHz (half the span of the memory location).

Do not exceed a power level of 200 Watts.

Note!

Damage to the Tuner caused by RF over voltage is not covered by the warranty!

- Begin with TRX control set to 15 and the ANT control set to 10
 1. - Turn the L knob until you note a (possibly weak) movement of the SWR meter's needle in the Reflected position
 2. - Try to maximize the forward power with the ANT control knob, the reflected power may increase as well.
 3. - Try to keep the forward power at its maximum by tuning the TRX and ANT controls so that the reflected power is minimum
 4. - Store the final values by pressing the momentary switch position "Mem In"
- Keeping the same values found, switch to the next memory location (14030+30k, set you transmitter to 14045 kHz (center frequency). Watch your SWR Meter; if little or no change can be found, store this value in memory. If changes are necessary, follow steps 1 thru 4. Go though all memory locations on this band and correct and store the settings.
- Go to an next band and proceed as before. It is a good idea to start with a setting found in the previous band.

NOTE

During SSB operation, the frequency counter may detect the wrong frequency due to the speech frequencies impressed on the signal. This will cause incorrect tuner settings to be selected. Simply place the tuner in manual and select the correct frequency range on the display.

Table of Programmed Memory Cells (Memory Allocations)

160m Band

Memory Cell	Center Freq. kHz
1800+20k	1810
1820+20k	1830
1840+20k	1850
1860+20k	1870
1880+20k	1890
1900+20k	1910
1920+20k	1930
1940+20k	1950
1960+20k	1970
1980+20k	1990

80m Band

3500+30k	3515
3530+30k	3545
3560+30k	3575
3590+30k	3605
3620+30k	3635
3650+30k	3665
3680+30k	3695
3710+30k	3725
3740+30k	3755
3770+30k	3785
3800+40k	3820
3840+40k	3860
3880+40k	3900
3920+40k	3940
3960+40k	3980

60m Band (US and UK only)

5320+40k	5340
5360+40k	5380

40m Band

7000+30k	7015
7030+30k	7045
7060+30k	7075
7090+30k	7105
7120+30k	7135
7150+30k	7165
7180+30k	7195
7210+30k	7225
7240+30k	7255
7270+30k	7285

30m Band

Memory Cell	Center Freq. kHz
10100+30k	10115
10130+30k	10145

20m Band

14000+30k	14015
14030+30k	14045
14060+30k	14075
14090+30k	14105
14120+30k	14135
14150+30k	14165
14180+30k	14195
14210+30k	14225
14240+30k	14255
14270+30k	14285
14300+30k	14315
14330+30k	14345

17m Band

18060+40k	18080
18100+40k	18120
18140+40k	18160

15m Band

21000+50k	21025
21050+50k	21075
21100+50k	21125
21150+50k	21175
21200+50k	21225
21250+50k	21275
21300+50k	21325
21350+50k	21375
21400+50k	21425

12m Band

24890+50k	24915
24940+50k	24965

10m Band

28000+100k	28050
↓	↓
29600+100k	29650

Operating with Power amplifier

- Preferably start with 14 MHz or 7 MHz. To recall the appropriate tuning values from the memory place the Tune/Memory switch in Memory position and select the appropriate frequency cell. Check the adjustment for lowest reflected power.
- Switch on the power amplifier and set the Output power to approximately 200 Watts. If you are using a tuneable (Plate and Load) PA, tune it for max. Output power by reading Forward Power on the SWR meter.
Increase the power step by step while you readjust the PA accordingly.
- **Keep the On time to less than 30 Seconds during full power tuning**
- For small corrections to bring the SWR to 1:1 use the ANT control knob only.
- **Never change L under full power condition!**

**When there is a sudden increase of the backward power while the amplifier power is increased, most probably an arcing happened in the RF Unit.
 Immediately switch of the transmitter.**

The antenna is too short for this band (frequency) or it is resonant.

Example Values for a Matched Antenna

Dipole 2 x 40ft. (2 x 13,5 meters), average height over ground 21ft. (7 meters) with 27ft. (9 meters) Wireman feeder line (here the shown antenna is too short in relation to the feeder length, see 1.8 MHz band)

Band MHz	TRX	L	ANT	Remarks
28	007	000	016	
24	014	000	021	
21	004	000	051	
18	012	002	013	
14	003	003	016	
10	036	003	083	
7	059	002	116	
3,5	100	003	118	
1,8	255	029	019	antenna too short, max. output power 400 Watts

Technical Specifications

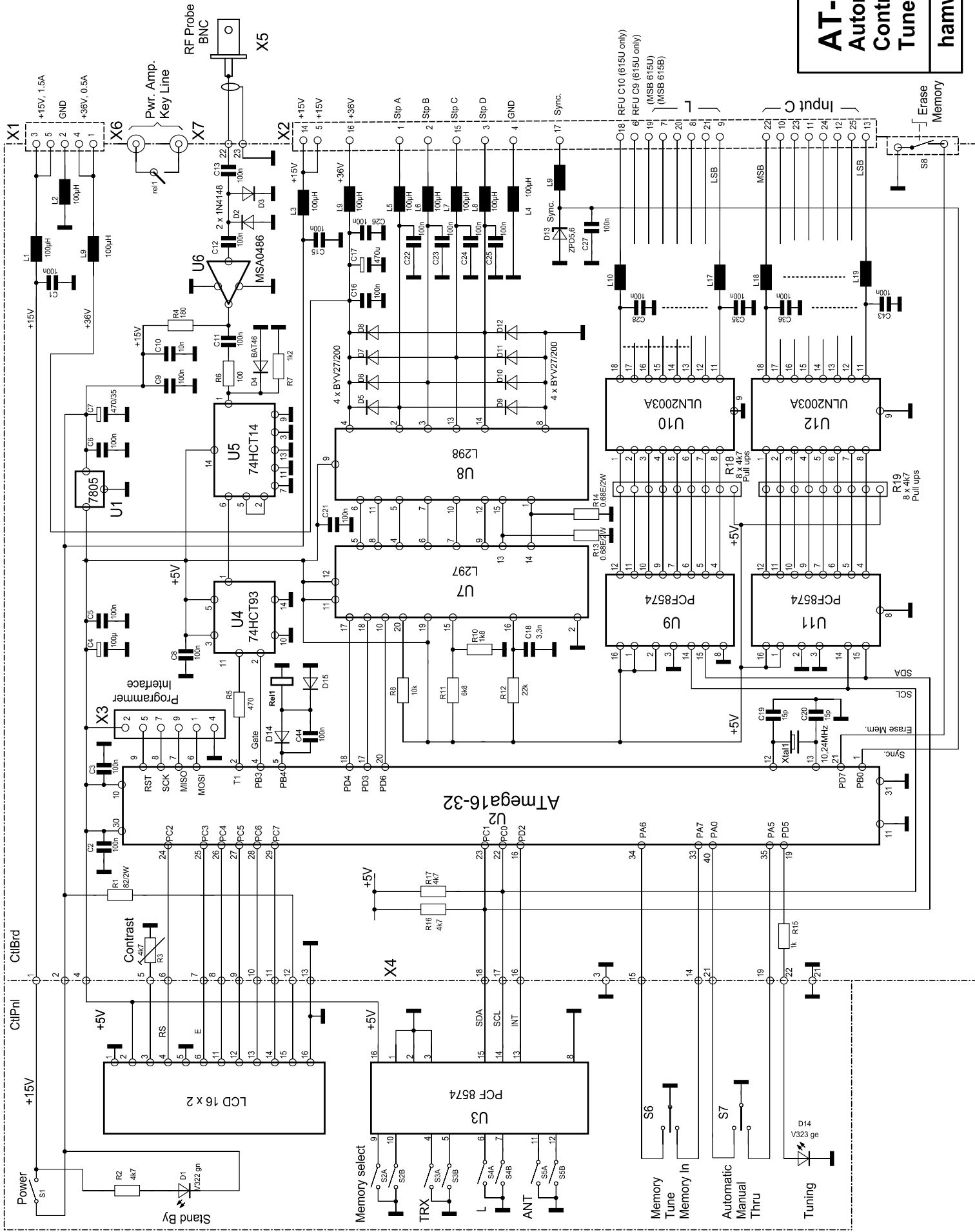
RF Unit

Frequency Range	Amateur Bands 1.8 to 30 MHz
Matching Circuit	balanced pi filter Input capacitors in 256 steps, 17 pF ea. Inductivities 32 steps exponential increasing 0,2 µH to 35 µH variable output capacitor 400 pF tuned by stepper motor with 200 steps of 0.9° ea.
Input	50 Ω, N-connector
RF Power	1500 Watts SSB/CW when tuned
Lightning Protection	2-Electrode-Arrester 2.5 kAmps
Control Cable	24 x AWG22 (0,35mm ²), AMP plug
Outdoor Cabinet	Polycarbonate, water tight, UV resistant
Dimensions	L x W x H = 14 x 10.2 x 6.5 inches
Weight	6 kg (13 lbs)

Controller

Controller	3 rotary encoders are used to adjust tuner elements
Tuning Memories	85, automatic or manual selectable
Automatic Mode	Frequency dependent selection of the memory locations. Frequency is sensed by RF probe
Displays	- LCD Display indicating single steps for input C, L and output C - Frequency Memory Location - Standby LED - LED while tuner is matched
Safety Circuit	Power Amp. Key Line Interruption when Input, L, Channel Selector, "Thru" will be changed. 30ms Delay

“Thru” Function	Input switched directly to Output
Displays	<ul style="list-style-type: none">- LCD Display indicating single steps for input C, L and output C- Frequency Memory Location- Standby LED- LED while tuner is matching
Power	+15VDC, 1.5A and +36VDC, 0.5A
Metal Bench Cabinet	W x D x H = 11 x 3.5 x 6.9 inches
Weight	1,8 kg (4 lbs)
Power	+15VDC, 1.5A and +36VDC, 0.5A
Metal Bench Cabinet	W x D x H = 11 x 3.5 x 6.9 inches
Weight	1,8 kg (4 lbs)



AT-615

Automatic Remote Controlled Antenna Tuner 1.5 kW

Parts List AT- 615B

1 – Controller Panel PCB 615-CtlPnl -1 (U and B)

Pos.	Pcs.	Type/Value	Component	Remarks
	1	AT- 615 Control Panel	Printed Board FR4, 165 x 60 mm	Double Sided
Br	1	RM 10	0 Ohm Bridge 0,5mm Diameter	
D1	1	LED 3mm, green	LED	
D4	1	LED 3mm, yellow	LED	
LCD	1	LCD 162C	LC Display 2 x 16 Char. Backlight	
R2	1	6k8	Carbon Resistor	RM 10
S1, S7	2	SPDT	Toggle Switch	PCB
S2 – S5	4	ECWOJ-B24-BD0009	Bourns, Rotary Encoder	
S6	1	SPDT	Switch with centre position	
X4-1	1	4pin	Board Connector, angle	RM 2,5
X4-2 to X4-4	3	6pin	Board Connector, straight	RM 2,5
X5	1	16pin	Board Connector, straight	
U3	1	PCF8574	Port Expander	
(U3)	1	16pin	IC Socket	

2 – Controller Main PCB 615-CtlBrd -1 (U and B)

Pos.	Pcs	Type/Value	Component	Remarks
	1	615-CtlBrd-1	PCB FR4, 184 x 159 mm	Double Sided
X2	1	DB-25 pin female	Female Connector	
X1	1	5-pol. DIN 180°, MABP 5S	DC Connector, female	
X3	1	Programming Plug, male	10pin	
X6, X7	2	CBP	Cinch Connectgor, female	
Rel1	1	SPDT	SIL, 5V	
	1	30 x 25mm	Heat Sink	RM 25
	1	40pin 15mm	IC Socket	f. U2
	1	20 pin 7,5mm	IC Socket	f. U7
	2	16 pin 7,5mm	IC Socket with Capacitor	
	2	18 pin 7,5mm	IC Socket	f. U9, U11
	1	14 pin 7,5mm	IC Socket	f. U4
	1	14 pin 7,5mm	IC Socket with Capacitor	f. U5
C20	1	470µF/16V	Electrolyte Cap	RM5
C1 – C3	3	0,1µF	Ceramic Disk Cap	RM2,5
C4	1	100µF/16V	Electrolyte Cap	RM5
C5, C6	2	0,1µF	Ceramic Disk Cap	RM2,5
C7	1	470uF/35V	Electrolyte Cap	RM5
C8, C9	2	0,1µF	Ceramic Disk Cap	RM2,5
C10, C14	2	10nF	Foil Capacitor	RM5
C11 – C16	5	0,1µF	Ceramic Disk Cap	RM2,5
C17	1	470uF/63C	Electrolyte Cap	RM5
C18	1	0,1µF	Ceramic Disk Cap	RM2,5
C19, C20	2	15pF	Ceramic Disk Cap	RM2,5
C21	1	0,1µF	Ceramic Disk Cap	RM2,5
D2,D3,D14,D15	4	1N4148	Si-Diode	RM10
D4	1	BAT46	Schottky-Diode	RM10
D5 – D12	8	BYV27/200	Schottky-Diode	RM12,5
D13	1	ZPD5,6	Zener-Diode	RM10
L10 – L26	17	220uH	Choke	
L1– L10	10	100uH	Choke	
Xtal1	1	10,24MHz	Quartz	RM10
R1	1	82E/2W	Metal Resistor	RM12,5
R3	1	5k	Potentiometer	RM5 x 10
R4	1	180E	Carbon Resistor	RM10
R5	1	470E	Carbon Resistor	RM10
R6	1	100E	Carbon Resistor	RM10
R7	1	1k2	Carbon Resistor	RM10

cont'd 2 – Controller Main PCB 615-CtlBrd -1

R8 – R12	5	1k	Carbon Resistor	RM10
R13, R14	2	0,68E/2W	Carbon Resistor	RM20
R15	1	1k	Carbon Resistor	RM10
R16, R17	2	4k7	Carbon Resistor	RM10
R18, R19	2	8 x 2k7	Multi Pull-up Resistor	
S8	1	1 x Ein	Button	
U1	1	7805	5V Controller	TO-220
U2	1	Atmega 32-16	Microcontoller Atmel	
U9, U14	2	PCF8574	Port Expander	
U4	1	74HCT93	Frequency Divider	
U5	1	74HCT14	Schmitt Trigger	
U6	1	MSA0486	Amplifier	
U7	1	L297	Stepper Motor Controller	
U8	1	L298	Stepper Motor Controller	
U10, U12	2	ULN2803	Relay Driver	U10, U11

3 – Controller Bench Cabinet AT- 615 (U and B)

Pos.	Pcs	Type/Value	Component	Description
	1	Bench Cabinet #218	WxHxD = 7.75 x 3.15 x 7.1 inches	
	1	AT-615	Mod. Sticker	
	1	Ø23mm, ¼"	Turning Knob	f. Encoder S2
	3	Ø20mm, ¼"	Turning Knob	f. Encoder S3 – S5
	12	M3x6mm	Screw, black	
	12	M3 Rosette		
	1	Aluminum Cast Cabinet		RF Probe
T1	1	RF Transformer		for RF Probe
X6	1	BNC Female, insulated		for RF Probe
X9, X10	2	SO-239	UHF-Connector	for RF Probe
(X6)	1	KAZU		for RF Probe
(X6)	1,5m	RG-58U	Coax Cable	for RF Probe
(X2)	1	DB-25	Plug male	for Control Cable

4 – Tuner PCB RFU615B -1 (Coil Board)

Pos.	Pcs	Type/Value	Component	Description
	1	RFU615-1	PCB FR4 250x150 mm	
L1, L2	2	10 µH	Toroid Coil T225-2	
L3, L4	2	5 µH	Toroid Coil T225-2	
L5, L6	2	1,75 µH	Air wound Coil	
L7, L8	2	0,5 µH	Air wound Coil	
L9, L10	2	0,2 µH	Air wound Coil	
X5, X6	2	FS-P 6,35	Jack	
X7	1	8pin	Board Connector	
R1 – R10	10	459170120310	Relay SPDT	
D1 – D5	5	1N4006	Si-Diode	
C1 – C5	6	0,1µF	Ceramic Disc Cap	
	4	M4 x 90	Plastic Distance Bolt	

5 – Tuner PCB RFU615B-2 (Input Capacitors, Balun)

Pos.	Pcs	Type/Value	Component	Description
	1	RFU615-2	PCB FR4 240x140 mm	
C1- C4	4	2,2n/2kV	Foil Capacitor FKP1	
C5 - C7	3	1n/2kV	Foil Capacitor FKP1	
C8	1	1,5n/2kV	Foil Capacitor FKP1	
C9 – C12, C17,C18	6	330p/2kV	Foil Capacitor FKP1	
C13 – C16, C19, C20	6	220p/2kV	Foil Capacitor FKP1	
C21 – C23, C30	4	150/2kV	Foil Capacitor FKP1	
C24 – C29, C31 – C42	18	100p/2kV	Foil Capacitor FKP1	
C43	1	15p/2,5kV	Chip Capacitor	
C44 – C51	8	0,1µ	Ceramic Disc Cap	RM 2,5
D1 – D8	8	1N4148	Si-Diode	RM 10
R1 – R8	8	DPDT/12V	Relay DPDT	
T1	1	unbal/bal 50Ω	Balun 2xT225-2 Cores	
X1	1	50 Ω, SO239	Coax Jack female	
X2, X3	2	FS-PW-6,35	Jack	
X4	1	10-pol.	Board Connector	

7 – Tuner PCB RFU615-3 (Stepper Motor Connection Board)

Pos.	Pcs	Type/Value	Component	Description
	1	RFU615-4	PCB FR4	Circuit Board
C1 – C8	8	0,1µ	Ceramic Disc Cap	RM5
C9	1	470µ/63V, radial	Electrolyte Cap	RM5
D1 – D8	8	BYV 27/200	Si-Diode	RM12,5
X8	1	8pol.	Board Connector	
X9	1	6pol.	Terminal	for Stepper Motor

8 – Tuner Weatherproof Cabinet

Pos.	Pcs	Type/Value	Component	Description
	1	14.2x10x6.5 inches IP66	Weatherproof Cabinet	
	1	13.5x8.7x0.315 inches	Base Mounting Board	
	1	3.15x3.15x0.315 inches	Mounting Board	for Stepper Motor
	1	3.15x1.58x0.4 inches	Supporting Board	for Stepper Motor
	7	M4/0.4 inch	Spacer	
C	1	400 pF	var. Capacitor	
S1	1	250V/6A	Micro Switch	
	1	6/5mm	Shaft Coupling Element	
	1	6mm	Shaft Coupling Element	
	2	Ø25mm	Ceramic Feed Through Insulator	RF Terminals
	1	103H548-5040	Stepper Motor SANYO	
X1	1	N-Connector, female		Input
	1	50 Ω, PL-256	Plug	