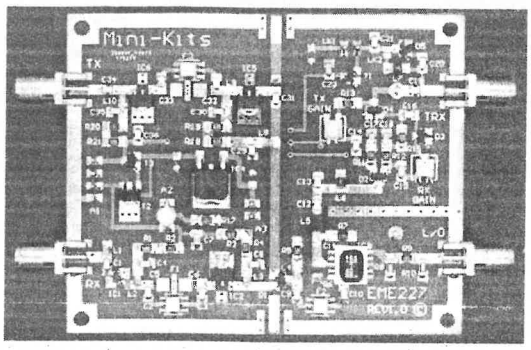
EME227-12CM 2.4GHz Transverter

Rev1.0

SPECIFICATIONS: EME227-12CM KIT

Frequency Range:	2400 to 2483.5MHz (Fixed SAW Filters)
Bandwidth:	83.5MHz @ 2dB
RX Conversion Gain:	24.5dB +/- 2dB @ 2403MHz
RX Noise Figure:	<2.8dB (typically 2.5dB)
Local Oscillator Input:	+10dBm, (10mW) 2256MHz (147MHz I/F)
	+10dBm, (10mW) 1968MHz (435MHz I/F)
TX RF Input Drive:	+36dBm (5W) maximum 144 / 432MHz
TX RF Output:	+19dBm (80mW) with +36dBm input @ 147MHz.
Spurious Output:	Refer to www.minikits.com.au/eme227
Power Supply	RX mode +10 to 15vdc (+12vdc @ 60mA)
	TX stages +10 to 15vdc (+12vdc @ 160mA)
Size:	PC Board EME227 80 x 65mm
Kit Webpage:	**www.minikits.com.au/eme227**



DESCRIPTION: The complete high performance 12cm 2.4GHz Transverter uses a low cost FR4 1mm PC board, and takes around 6 hours to construct and test. The Transverter is designed as a transmit up, and a receive down converter, with a fixed frequency range of 2400 to 2483.5MHz, and is suitable for either a 147MHz or 435MHz Transceiver. A large number of SMD components are used to make the design compact in size, and reproducible in performance.

RX CONVERTER DESCRIPTION: Refer to the circuit and component overlay diagrams. **The description refers to the Transverter being used on 2403MHz with a 147MHz I/F Transceiver.** The receiver RF amplifier design consists of a MGA86563 low noise RF amplifier IC1 with around 20dB gain, followed by a 2441MHz SAW band pass filter FL1 with around 2dB loss, which is used to effectively reduce out of band signals. The input 15nH inductor L1 protects the MGA86563 amplifier from static damage, and has no measured effect on noise figure. A GALI-39 IC2 was chosen as the second stage receive amplifier due to its high gain and low noise figure, and further amplifies the signals by around +17dB. The signal is then filtered using another 2441MHz SAW filter FL2, and passes to the RF input pin 5 of the MCA1-42 +7dBm mixer IC3. The 2403MHz signal is then mixed with the 2256MHz L/O input pin 10 and appears as a 147MHz I/F output on pin 3. The I/F connection is terminated with a 50ohm 144MHz diplexer that allows all signals through that are tuned to the I/F frequency, and shunts signals outside the I/F across the 51ohm resistor R14. For I/F frequencies over 200MHz specifically a 432MHz I/F, the diplexer can be replaced with a simple 3dB attenuator. The 147MHz I/F signal then passes through an I/F switch Diode D2 to trim-pot VR2 allowing the gain of the receive converter to be attenuated if required, and then passes through D4 to the TRX connector. D4 blocks RF when in TX mode, and along with D3 adds some RF protection to the RX Gain trim-pot VR2. The overall gain of the receive converter is around 24dB, which is high enough to allow the 147MHz I/F to see most of the low noise figure of the MGA86563 amplifier. The gain and receive noise figure are typical of the prototypes tested.

TRANSMIT CONVERTER DESCRIPTION: The transmit up-converter uses the same SAW filter FL2, MCA1-42H mixer, and diplexer. The Transverter incorporates a 51ohm dummy load R14, and RF detector allowing Transceivers up to 5Watts to be directly used. The +7dBm mixer allows up to +10dBm at 147MHz to be fed into the I/F input pin 3, before distortion occurs, but this is limited to around +4dBm maximum when using 5 Watts for a cleaner RF output. In TX mode the 147MHz signal applied to the TRX connector is attenuated through the circuit consisting of R14, R13 and VR1 and is switched through D2 in TX mode and passes through the 144MHz diplexer to pin3 of the MCA1-42 mixer. The attenuation from the TRX connector to the mixer is around –38dB with the TX gain set to minimum and –18dB when set to maximum. The 147MHz signal is then mixed with the 2256MHz LO signal on pin 10 which produces various mixed frequencies at pin 5 of the mixer including 2403MHz, which is then filtered by a SAW filter FL2. The 2403MHz RF is then switched through D1 to the input of the TX driver IC5, GALI-39 and is amplifier by around +20dB. The 2441MHz signal is then further filtered by another SAW filter FL3 and is further amplifier by a GALI-84, IC6 to around +20dBm maximum output.

POWER SUPPLY: The circuit has been designed to operate on a +10 to +15vdc power supply. A 78M09 +9vdc regulator is used to supply a regulated supply for both the RX and TX circuitry, and resistors are used to reduce the voltage and

current to suit each RF amplifier. A number of bypass capacitors are used for decoupling and filtering.

RX/TX SWITCHING: The design incorporates a RF sensing circuit that is used to detect RF from the I/F Transceiver on either 144 or 432MHz to switch the Transverter circuitry from RX to TX mode. The RF sensing circuit is a compromise as it can drop out into RX mode when using SSB modes, but there is an optional 47uF capacitor C22 that can be connected with link LK1, to give some SSB Delay. The design can also be configured to detect a voltage from a modified IC202 or FT290R Transceiver with a TX DC output from the Antenna connector by linking LK2. This is a better solution than using the RF sensing circuit when using SSB or CW modes. A small level of 147MHz RF through C20 10pF is detected by D5, a Schottky Diode that produces a DC voltage to switch on Transistor T1 PDTC143. This then switches T2 BCX54 off disconnecting power to the RX circuitry, and turns on T3 FDN338P applying +9 volts power to the TX circuitry. In RX mode the opposite occurs as T1 is then off turning on T2 applies +9 volts power to the RX circuitry. On the A1 connector pin2 PTT low, allows sequencing of the Transverter if required. A1 pin1 +9V/TX and pin3 +9V/RX can be used to switch external amplifiers and relays for a simple Transverter application.

CONSTRUCTION:

1. **This Kit is for advanced constructors that already have experience with soldering SMD components. The Construction notes should be carefully read first before you start any construction.** To assist construction please refer to the pictures on the Kits webpage. **www.minikits.com.au/eme227**

2. Follow the component placement diagram carefully, by checking the components and placing them onto the board. **If you are constructing a 435MHz I/F version, then follow the PCB overlay and circuit diagrams on how to fit the 3dB attenuator instead of the I/F diplexer components.** Start with the small SMD components on the top of the board before fitting any components on the bottom side of the board. To solder in the chip capacitors, resistors, inductors, and Transistors, a pair of tweezers are used to hold them in place, soldering one side first then the other side. The bi colour Red/Green LED can either be mounted into the A2 connector on the top side of the board, or fitted externally.

3. When soldering in the GALI amplifiers, hold in place with tweezers, and solder one of its legs to the board and check alignment before soldering the other 2 legs and heat sink tab to the board. Plated through holes effectively ground the devices through the board to the bottom groundplane. The MGA86563 amplifier can be very difficult to solder to the board due to its small size, and a magnifier will be required to read the identification number for correct alignment on the board. Fit the MCA1-42 mixer to the board making sure that it is correctly aligned as it cannot be easily removed once soldered. Finally solder the 78M09 regulator to the top side of the PC board. The heat sink tab on the 78M09 is soldered directly to the top ground plane.

4. Fit the three SAW filters making sure that they are correctly aligned as per the board overlay diagram. A magnifier may be required to see the markings for correct alignment.

5. Next you can solder the remaining SMD components to the bottom of the board. With the 51ohm 5W resistor cut the leads so that it can sit flat against the PC board.

6. Finally Fit the Electrolytic capacitors and 2.54mm headers to the top of the board making sure that you check the correct orientation for the Electrolytic Capacitors before soldering in place.

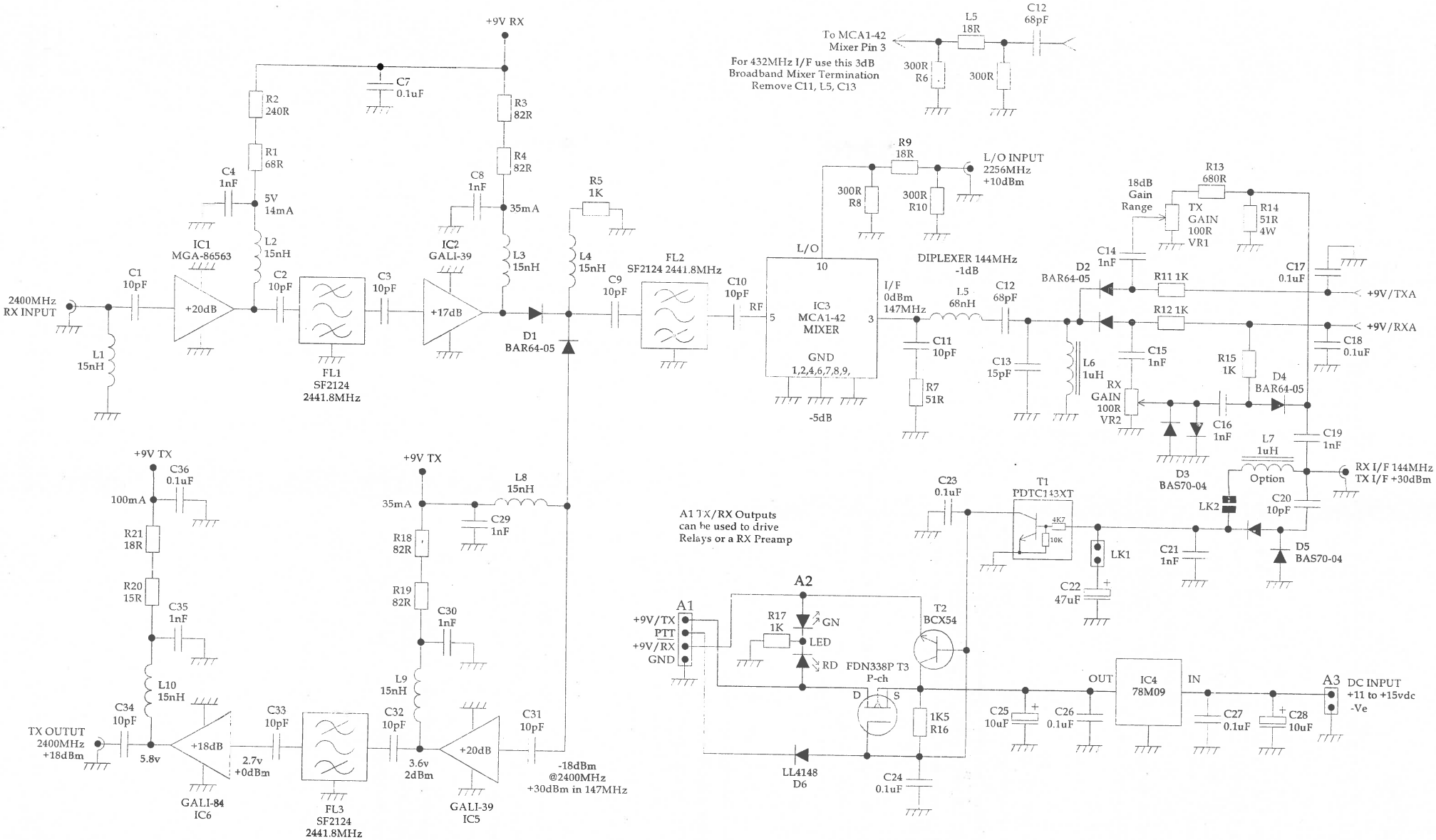
7. **The board is designed to use SMA connectors directly onto the board for the lowest loss.** Fit 1mm PCB mount SMA connectors to the PCB using a hot soldering iron with a large tip. RG316 coax cable could be used directly to the board but this has to be done using good microwave practice.

TESTING and ALIGNMENT

1. **Testing of the Transverter requires a +10dBm 2256MHz or 1968MHz local oscillator signal when using a 147/435MHz I/F for a 2403MHz output.** The EME228-1.8-2.6G Multiplier has been designed to be connected directly to the Transverter board, and provides the required +10dBm output for the L/O input.

2. Connect a suitable +11 to +15vdc current regulated power supply to the A3 connector on the board, and check that the power consumption in RX mode of the EME227 board is around 60mA @ +12vdc.

3. The design requires no tuning and is broadband. The noise figure and gain should be very close to the stated measurements that were made on a HP8970 noise figure meter and are very good for terrestrial use. Connect a suitable 2403.100MHz signal generator to the RX input connector and check that the signal can be received on a Transceiver tuned to either 147.100MHz with a 2256MHz L/O or 435.100MHz with a 1968MHz L/O. The RX Gain trim-pot VR2 can be used to adjust the receive gain to suit the Transcieiver being used. Alternatively a suitable 2400MHz antenna can be connected, and a local 2403MHz beacon can be used to check the converter.



EME227-12CM 2.4GHz TRANSVERTER

DRAWN	MINI-KITS
DATE	5-9-2017
PROJECT	12cm 2.4GHz Transverter
FILE	EME227-12CM-Rev1.1.SKF

4. To check the operation in TX mode apply up to 5 Watts of RF at 147/435MHz to the I/F TRX connector and check that the Transverter goes into TX mode. The TX Gain trim-pot VR1 can be used to set the RF output at 2403MHz to a maximum of +20dBm. With most boards the maximum output measured was around +19dBm using a 5 Watt +36dBm input on 147MHz, and +17dBm using a 1 Watt +30dBm input. The TX gain is useful when an external RF amplifier is used that may only require a low input level.

NOTES:

1. Any flexing of the PC board, including stress on the SMA connectors should be avoided, as this can easily crack chip capacitors. Cracked capacitors might show up as changes in either receiver gain, or low TX output power when the board is slightly flexed. The kit is supplied with a few extra 10pF capacitors as spare parts.

2. If the circuit does not work, carefully check your soldering first, and then check for any broken chip capacitors. The voltages on the receive and transmit circuits should be carefully checked with a multi-meter.

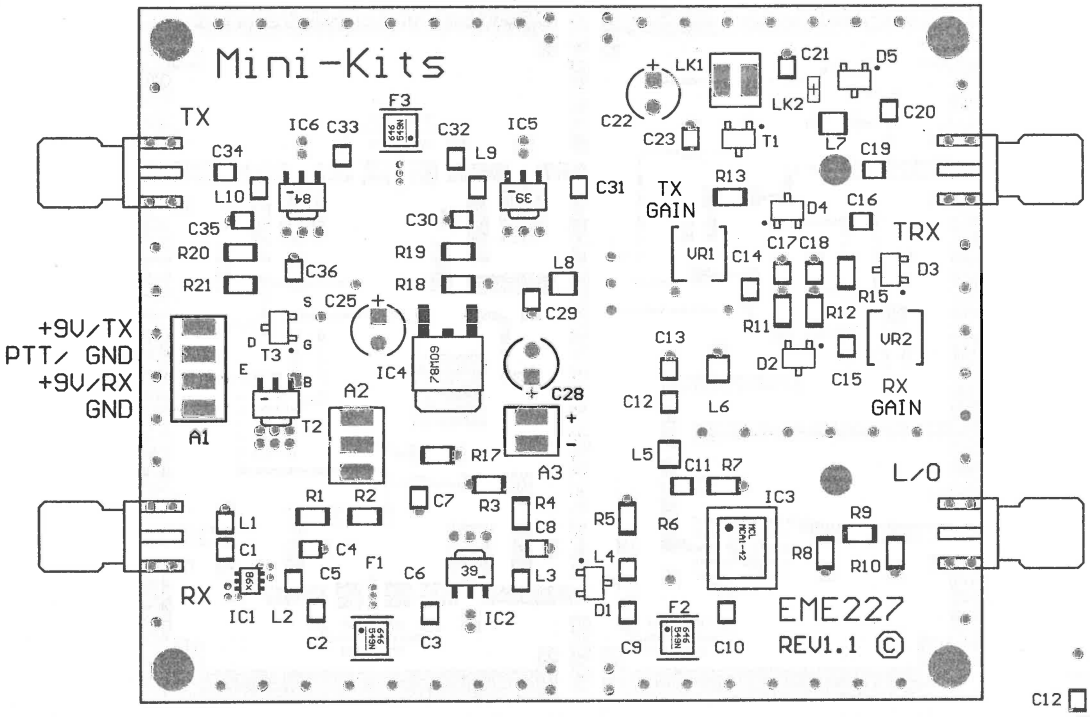
3. The MCA1-42 mixer has a maximum 1dB compression of +10dBm so anymore than this can cause distortion. The design of the input attenuator however limits the maximum input to the mixer to +4dBm when using a 5 Watt +36dBm input on 147MHz. This reduces the distortion giving a cleaner output especially in TX mode, but does reduce the maximum RF output to around +19dBm @ 2403MHz.

4. The RX to TX function of the Transverter can also be controlled using a DC voltage from a modified FT290R or FT817 or similar Transceivers. Linking LK2 with solder allows a DC voltage when present on the TRX connection to activate the TX mode.

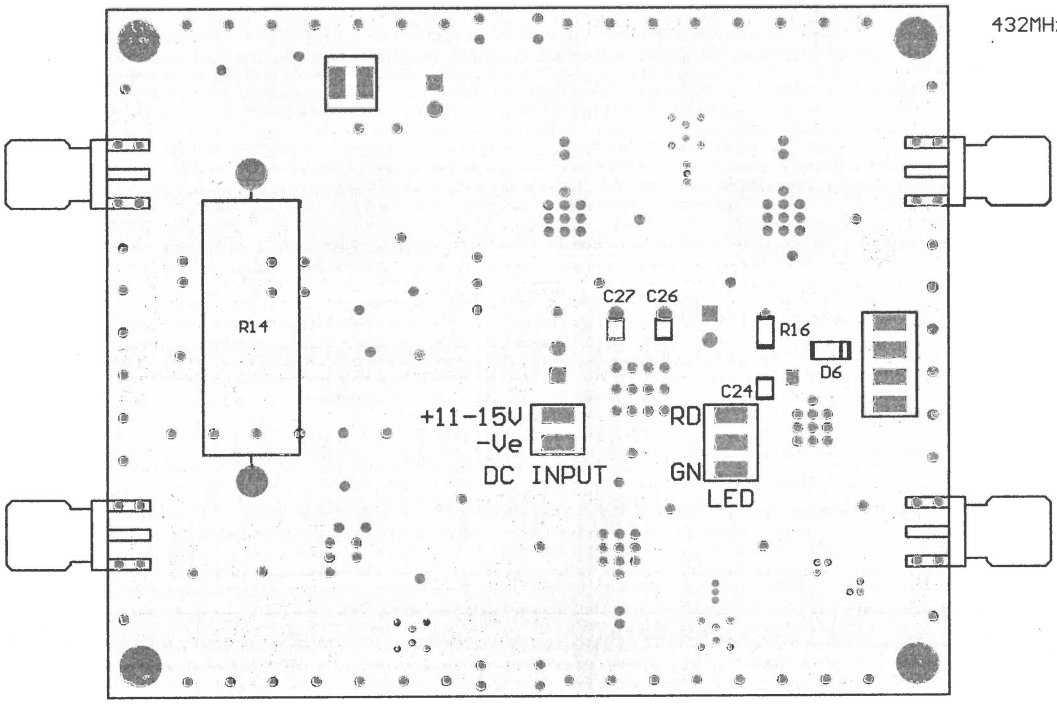
5. A complete Transverter block diagram showing the Kit modules and the wiring required can be downloaded from the Kits webpage **www.minikits.com.au/eme227**

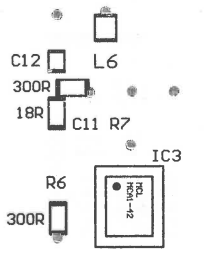
PARTS LIST			
QTY	**PART#**	**DESCRIPTION**	**BOARD #**
1	0R	SMD 1206 Resistor	**Not Fitted (R9 Option to use +7dBm L/O)**
1	15R	SMD 1206 Resistor	**R20**
3	18R	SMD 1206 Resistor	**R9, R21, (1x For Optional 3dB 435MHz I/F Attenuator)**
1	51R	SMD 1206 Resistor	**R7**
1	68R	SMD 1206 Resistor	**R1**
4	82R	SMD 1206 Resistor	**R3, R4, R18, R19**
1	240R	SMD 1206 Resistor	**R2**
4	300R	SMD 1206 Resistor	**R8, R10 (2x For Optional 3dB 435MHz I/F Attenuator)**
1	680R	SMD 1206 Resistor	**R13**
5	1K	SMD 1206 Resistor	**R5, R11, R12, R15, R17**
1	1K5	SMD 1206 Resistor	**R16 (PCB bottom side)**
1	**5C51R-MOS**	51R **5W** Metal Oxide Resistor	R14
2	PVG3A-100R	100ohm 4mm SMD Trim pot	**VR1, VR2**
14	10pF	SMD 0805 NPO 50v	**C1, C2, C3, C9, C10, C11, C20, C31, C32, C33, C34 (3x Spare)**
1	15pF	SMD 0805 NPO 50v	**C13**
1	68pF	SMD 0805 NPO 50v	**C12**
13	1nF (102)	SMD 0805 NPO 50v	**C4, C8, C14, C15, C16, C19, C21, C29, C30, C35 (3x Spare)**
10	0.1uF (104)	SMD 0805 X7R 50v	**C7, C17, C18, C23, C24, C26, C27, C36 (2x Spare)**
2	10uF	10uF 35v ELC10GA35	C25, C28
1	47uF	47uF 35v ELC47GA35	C22, (Must be >20vdc rated for 5W RF input)
3	SF2124E	Murata 2441.8MHz SAW Filter	**FL1, FL2, FL3**
8	L15nH	15nH 0805 SMD Inductor	**L1, L2, L3, L4, L8, L9, L10, (1x Spare)**
1	L68nH	68nH 1210 SMD Inductor	**L5**
2	L1uH	1uH 1008 SMD Inductor	**L6, L7**
3	BAR64-05	Dual PIN Diode SOT-23	**D1, D2, D4**
2	BAS70-04	Dual Schottky Diode SOT-23	**D3, D5**
1	LL4148	Diode Small Signal SOD-80	**D6 (PCB bottom side)**
1	**LED-RD-GN-3C-DIF**	LED Dual Red/Green 3mm C/Cathode	LED Fitted into the A2 position on the board
1	78M09	9v Regulator D-PAK	**IC4**
1	BCX54	Transistor NPN SOT-89	**T2**
1	FDN338P	P-Ch JFET SOT-23	**T3**
2	GALI-39	Mini-Circuits Amplifier	**IC2, IC5**
1	GALI-84	Mini-Circuits Amplifier	**IC6**
1	MCA1-42	Mini-Circuits +7dBm Mixer	**IC3**
1	MGA86563	Avago Broadcom Amplifier	**IC1**
1	PDTC143XT	Digital Transistor NPN SOT-23	**T1**
1	PC Board	EME227-Rev1.1 Board	
1	HDR-M2-1	Header Male 2way 2.54mm	For LK1
1	SHUNT	Header Shunt 2 way 2.54mm	For LK1
1	HDP-2P	Header 2 pin Male PCB	For A3
1	HDS-2P	Header 2 Pin Female	For A3
1	HDP-4P	Header 4 pin Male PCB	For A1
1	HDS-4P	Header 4 Pin Female	For A1
7	HDS-Pin	Header Pins	For A1, A3
	OPTIONAL		
4	SMA45	SMA Female PCB mount	Recommended for high Performance

EME227-12CM TOP OVERLAY



BOTTOM OVERLAY





432MHz I/F Option