430MHz AM VIDEO TRANSMITTER KIT

SPECIFICATIONS: EME44-Rev3 KIT

Frequency Range:	420 - 430MHz (Standard Frequency Range)
Modulation:	High Level Amplitude Modulation
Video Input:	1V P-P into 75 ohms
Audio Input:	Optional subcarrier input 5.5 to 6.5MHz
RF Output:	Up to +20dBm (100mW)
2nd Harmonic:	-25dBc M suffix (-35dBc M1 suffix)
Power Supply:	+12 to 15vdc (100mA @ +12vdc)
Size:	PC Board 70 x 98mm
Kit Webpage:	**www.minikits.com.au/eme44.htm**

DESCRIPTION: The complete video transmitter is built on a single 71 x 98mm size PC board and takes around 3 hours to construct. The Kit is very similar to the previous VK5EME44 design from 1996, but the PC board has been reworked in 2002 to replace the older RF transistors with surface mount types, as most of the older leaded types had become obsolete. The transmitter is basically a high level amplitude modulated transmitter for the 430MHz Amateur band, and has been developed from various other designs, and overcomes the difficulty of building and tuning a TV transmitter by using proven design and construction techniques. The transmitter has an excellent high frequency response which gives the transmitted signal good horizontal resolution and colour reproduction. It was decided to use high level modulation instead of low level, due to it being easier to successfully build a linear transmitter. There can be colour burst and sync problems in low level modulated designs, due to the poor high frequency response and linearity of the transmitter. The design features a sync stretcher and high level modulation to overcome the linearity problems encountered in transistors, and linear power amplifiers. Effectively the sync to video ratio can be set on the board to drive a high powered linear amplifier. The sync stretcher will pull the sync tip to maximum RF output to compensate for gain compression in a linear amplifier, this means if a high powered 100 Watt amplifier is used the sync tips will be pulled to 100 Watts, with an average power output of around 20 to 30 Watts. An optional Audio/Subcarrier, EME158 KIT can be added to the transmitter for the audio.

TRANSMITTER: The oscillator uses two BFR92A transistors in a two transistor Butler type design. Because of the light crystal loading, the Butler oscillator offers far better short term stability than the more common colpitts type oscillators. The second BFR92A transistor is driven into heavy limiting and hence a high output at the crystals harmonic frequencies. The collector is tuned to the third harmonic (213 / 222MHz). The third transistor a BFR93A doubles the output from the BFR92A to the final frequency, (426 / 444MHz). Double tuned circuits are used at both the multiplier stages, and output stages to reduce unwanted harmonics. The final frequency is then amplified by a BFQ19 to around 100mW, +20dBm output. Both the BFR93A and BFQ19 are high level modulated on their power supply rails to provide the linearity required for a television transmitter. It was discovered that past designs were difficult to build due to the amount of coils that had to be wound correctly, and the difficulty in tuning up. This design only needs two coils wound for the X3 multiplier, and uses printed tuned strip-lines on the PC board for the 400MHz stages. Even though there are 6 trimmer capacitors, tune up is relatively straight forward once the crystal oscillator is aligned. The use of the correct bypassing techniques was critical to the performance and picture quality of the transmitter. The transmitter uses 220pF bypass capacitors and RF chokes to effectively bypass the RF on the UHF Multiplier and output stages. The use of 220pF Chip capacitors on the UHF driver and output stages, effectively bypass UHF frequencies but have minimal effect on the 0 to 7MHz video frequencies providing good high frequency video bandwidth. Chip Capacitors were required as they are the only effective type of capacitors at 400MHz, providing a solid RF ground for the cold end of coils, L4 and L6. It was difficult to keep video from appearing on the 12 volt supply rail and getting into the Audio and transmitter stages, so a low leakage 100uF EXR capacitor has been used and was found to be the only effective bypass solution.

MODULATOR: The Modulator Transistor 2N2219A must supply all the current to the BFR93A and BFQ19 transistors, and must provide a very low supply impedance and very high slew rate. The low impedance is necessary for both full RF output power and control over possible parasitic oscillation tendencies in the transistor amplifiers. Also the Modulator drive from the emitter must have low capacitance to Video frequencies, i.e. up to 10MHz. 220pF chip bypass capacitors are used on the transistors supply rails to bypass the 400MHz RF, not affecting the lower Video frequencies.

SYNC STRETCHER: The sync stretcher consists of a sync separator to separate the sync from the video signal to drive the BC327 sync stretcher transistor. The BC327 provides +ve going sync pulses to drive the 2N2219A modulator transistor which pulls the output stages power supply rail up to almost full rail during sync periods. Without sync stretching, the RF power output would have to be set to a much lower output to maintain linearity of the video signal through the transmitter output stages.

CONSTRUCTION:

1. The PC board supplied is a professional plated through hole board, which makes construction much easier. The conventional components are mounted on the top ground plane side of the PC board, and the SMD components are mounted on the bottom track side.

2. **Refer to the Kits web page, (www.minikits.com.au/eme44.htm) for detailed construction pictures.** Follow the PC Board overlay diagram and circuits carefully, when checking the components and placing them onto the board. Make sure to keep the component lead lengths very short as required in UHF construction. It is best to start by installing all the conventional leaded components on the top of the board first, starting with the resistors and capacitors. **Leave the coils, crystal, semiconductors and SMD components until later on.**

3. Next Install the Toko coil and trimmer capacitors to the board. When installing the trimmer capacitors, they can be a bit tight in the boards holes, so don't apply too much downward pressure on the wiper, and jiggle them so that they sit flat onto the board. It is best to solder the trimmers earthed legs also on the top of the board for better RF grounding and to make adjustment of the trimmers smoother when tuning up. With a broad tip in the soldering iron the legs can be easily soldered to the top of the board without damaging the plastic trimmers.

4. Next install the leaded transistors and regulator on the top of the board. **Note when installing the 2N2219A transistor, mount it just above the PC board so that it won't short out onto the top ground plane. Be careful when mounting the 78L05 regulator, make sure that you mount it on the board the correct way around.**

5. Solder the SMD transistors and chip capacitors to the bottom of the board. To solder in the chip components, use a pair of tweezers to hold them in place, soldering one side first then the other side.

6. Next wind the two coils L2 and L3, **these are rather critical so should be carefully wound and measured when installing.** Both are 5.5Turns (6 Hoops) of 0.7mm ECW on a 3mm drill bit. Stretch the coils slightly to a length of approximately 6mm to fit the holes in the PC board. The coils are mounted 2.5mm above the PC board using a ruler for measurement before soldering into place. **The diameter and height above the board is rather critical to get the tuning range required with the trimmer capacitors.** The RF Chokes are made by winding 4 turns of 0.315mm ECW on FB -43-101 Ferrite beads.

8. **When installing the crystal,** it requires the outer case to be electrically connected to the top ground plane of the board. Use a short length of wire, (resistor lead off cut) and solder it to the crystals case near the base of the crystal, and then solder to the top ground plane of the board. **Use minimal heat on the crystals case so that you don't internally damage the crystal.**

9. Check your construction carefully, checking that you have no shorts, solder dags etc, before applying any power to the board. Most faults are caused by poor soldering, incorrectly wound coils, or chip capacitors that are not soldered on both sides. **Always use a current regulated power supply when initially applying power to the board.**

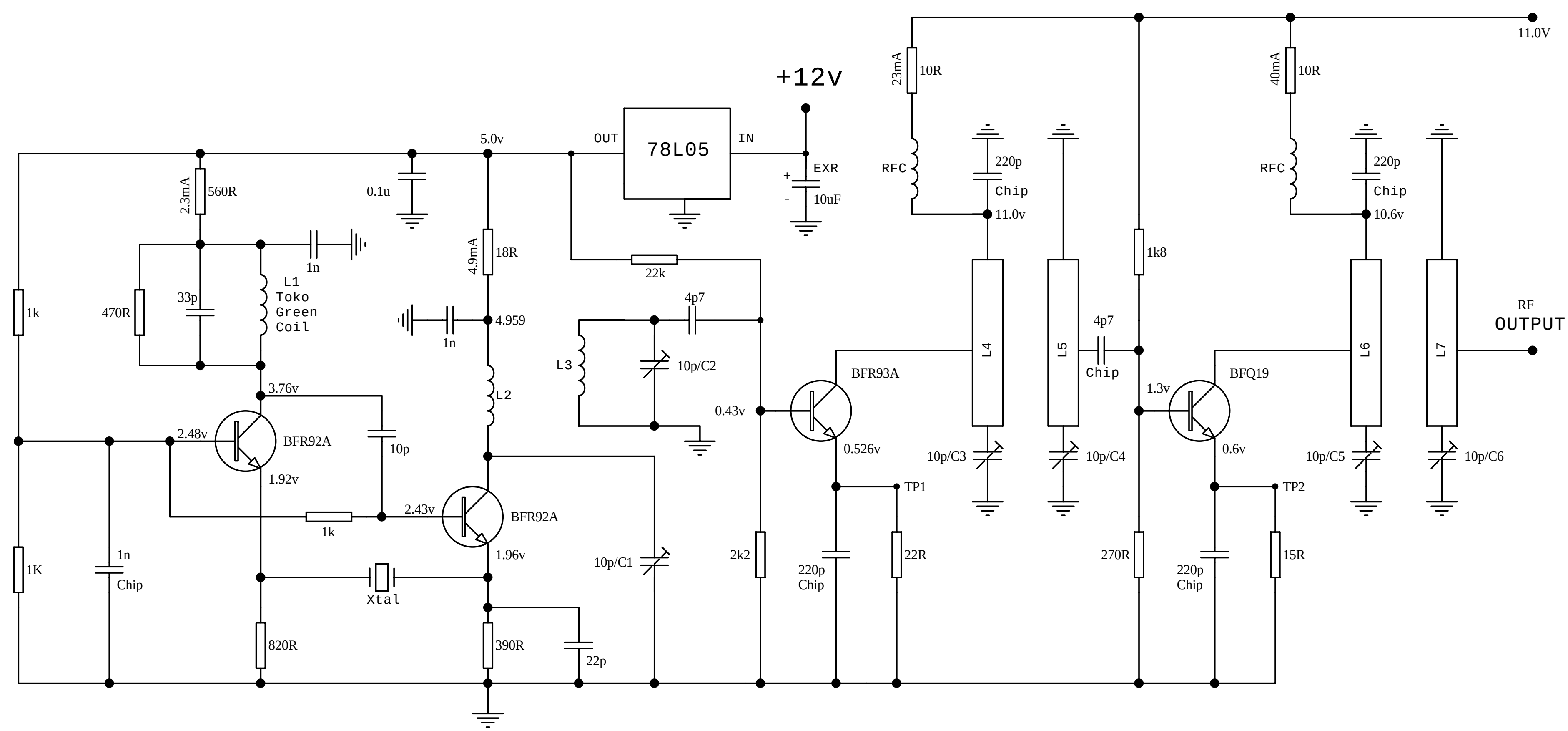
TESTING and ALIGNMENT:

1. Although alignment can be done using just a multi-meter and a scanner receiver, some form of wave-meter or spectrum analyzer is an enormous help as the trimmer capacitors have a large adjustment range. For the initial trimmer capacitor settings for 434.250MHz, set the trimmer capacitors to the positions shown on the PC board overlay diagram, and set the Toko coil L1 so that the core is level with the top of the coils can. Terminate the transmitter output into a 50 ohm load. At UHF frequencies, a 47 ohm resistor mounted on the rear of a BNC connector with a 1N5711 Shottky or 1N4148 diode can be used as a load, and will do as a RF indicator of relative power output.

2. Using a current regulated power supply, apply +12 volts to the transmitter, and adjust the 1K ohm Clamp level trim-pot fully counter clockwise to set the voltage rail to the RF output stages to maximum, there should be no video connected while tuning up. Check that the transmitter draws no more than 120mA.

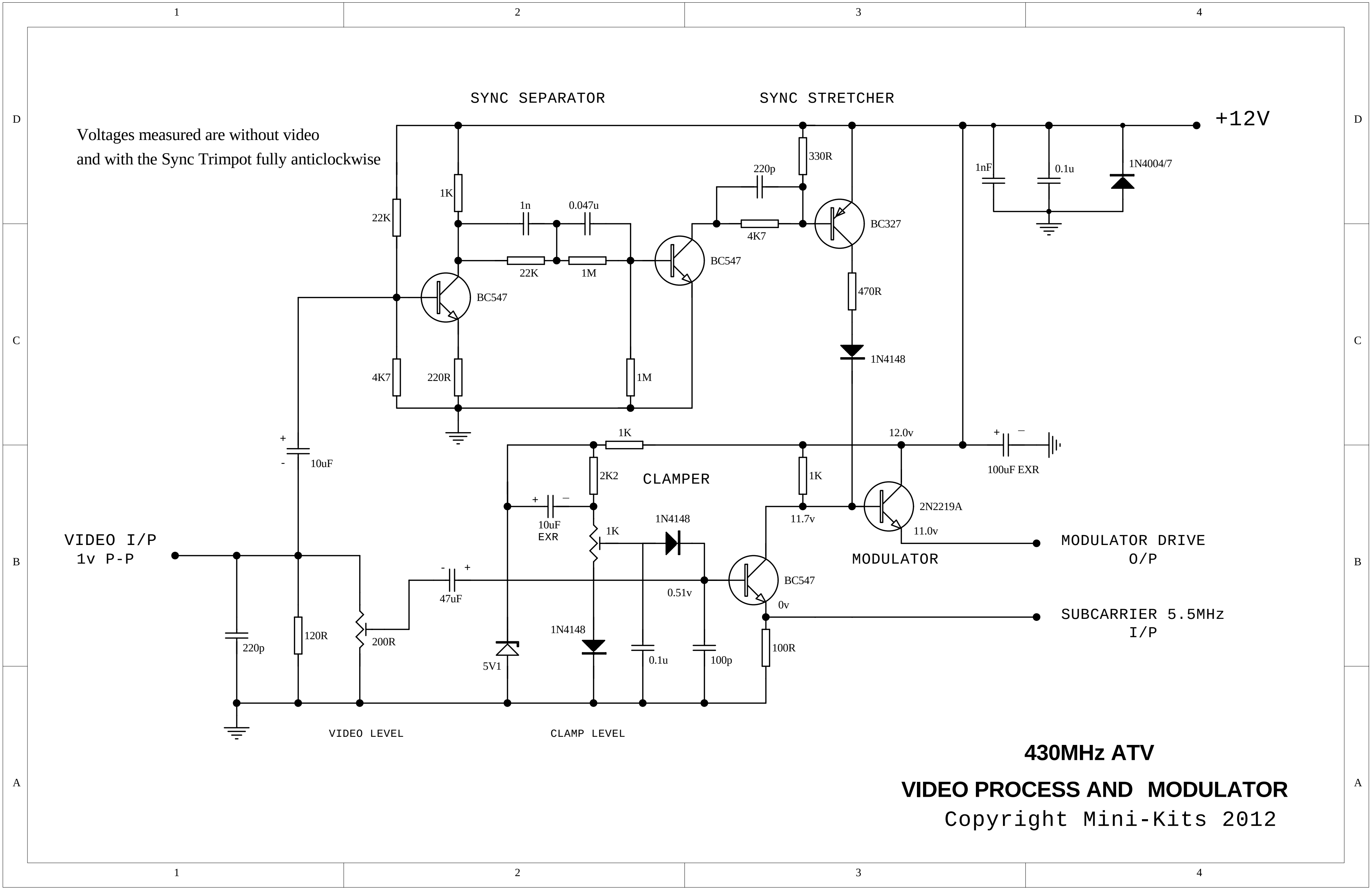
3. **First make sure that you have set the trimmers capacitors as shown on the PC board overlay diagram and set the core of L1 level with the top of the coils can.** Monitoring the signal on a either a wave-meter or a scanner receiver tuned to the crystal frequency, e.g. 72.375MHz, or

ALL CURRENT & VOLTAGES MEASURED WITH CLAMP SET FULLY ANTICLOCKWISE & NO VIDEO INPUT



430MHz ATV

100mW TX EXCITER


Voltages measured are without video
and with the Sync Trimpot fully anticlockwise
SYNC SEPARATOR
SYNC STRETCHER
+12V
22K
1K
1n
0.047u
22K
1M
BC547
BC547
4K7
220R
1M
220p
330R
4K7
BC327
470R
1N4148
1nF
0.1u
1N4004/7
10uF
1K
2K2
CLAMPER
10uF
EXR
1K
1N4148
12.0v
100uF EXR
1K
11.7v
2N2219A
11.0v
MODULATOR DRIVE
O/P
MODULATOR
VIDEO I/P
1v P-P
47uF
0.51v
BC547
0v
SUBCARRIER 5.5MHz
I/P
220p
120R
200R
5V1
1N4148
0.1u
100p
100R
VIDEO LEVEL
CLAMP LEVEL
430MHz ATV
VIDEO PROCESS AND MODULATOR
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74.0417MHz, adjust the oscillator coil L1, (Toko Coil) until you hear the signal. There is some interaction with trimmer C1, so you may have to adjust C1 slightly and then readjust L1 until you can hear the signal. **Refer to the Notes section 1 if you cannot hear the crystals signal.**

4. Using a wave meter or Spectrum Analyzer tuned to the 3rd harmonic of the crystal, e.g. 217.125MHz for a 72.375MHz crystal, tune the C1 and C2 trimmer capacitors corresponding to coils L2 and L3. **If you have minimal test equipment then connect a multi-meter to TP1 (18R resistor emitter second BFR92A).** Tune C1, C2, and L1 for maximum voltage across the resistor**.**

5. Then tune trimmers C3 to C6 for maximum 400MHz RF output from the transmitter. **If you have minimal test equipment then connect a multi-meter to TP2 (15R resistor emitter of the BFQ19 transistor).** Tune C3 to C6 for maximum voltage across the resistor. When the trimmers have all been peaked, some output should be evident from the transmitter. Then readjust all trimmers again until the maximum output power is reached.

6. After initial alignment, install the board in its final position and fully realign the transmitter as in sections 4 and 5 above. Some instability and Spurious output has been noted from this oscillator design when it has not been aligned correctly. This can only be seen on a Spectrum Analyzer, and can be cured by careful peaking of the trimmers C1 and C2 for maximum output. Output from the transmitter board on a schottky diode RF probe, should read about 2.5v DC when connected to a digital multi-meter, or +20dBm on a suitable Microwave Power -meter, or Spectrum Analyzer.

7. Adjust the clamp level trim-pot to about 1/2 way, which is around 50mW O/P (+17dBm) with no video input signal. Connect a video signal (1V p-p) to the input of the transmitter and adjust the video and clamp level trim-pots for best picture on a TV set, (i.e. No white or sync crushing). The normal setting of the clamp level trim-pot is half way, but will depend on the linearity of the Power Amplifier used on the transmitter. The transmitter will show much less output power when a video signal is applied, but the output power is still 50mW (+17dBm) sync tip power.

8. Increased picture quality, (higher frequency response and colour) can be obtained by slightly stagger tuning the C3 to C6 trimmer capacitors to broaden the bandwidth of the transmitter using high frequency and colour test charts. The clamp and video level trim-pots will need adjustment as the settings interact. **Do not adjust L1, C1 and C2 after the alignment in section 5 above as they do not improve the video and or colour quality**. Using a camcorder of 400 lines resolution, the transmitter was capable of being aligned to pass up to 300 lines resolution, (probably the limitation of the TV set used) with excellent colour reproduction. Excessive high frequency peaking may also cause interference to other users in the 430MHz band if incorrectly aligned.

NOTES:

1. If the oscillator fails to turn on when power is applied, then coil L1 is probably not adjusted correctly and will need to be adjusted slightly to start the oscillator. Retest to make sure it always starts when applying power. If you are having problems getting the oscillator stable or working correctly, then it can be made to free run without the crystal to test the resonant frequency of L1 and the 33pF capacitor across it. Disconnect the crystal by either removing, or cutting a track, and connect a 47 ohm resistor across where the crystal would be connected. This effectively will allow the oscillator to free run at the resonant frequency without the crystal. Carefully adjust L1 to determine what frequency it is operating on and see if you can hear it on a scanner receiver, or see it on a Spectrum Analyzer. If you cannot get the frequency close then check that you have the correct Toko coil, (0.13uH) and capacitor, (33pF) combination for 400MHz. When you are sure that you have it correct, then disconnect the resistor and solder in the crystal to the board. The adjustment of the core in L1 was found to be around 1mm below the top of the coils can for 72.375 and 74.0417MHz crystals.

2. The standard double sideband EME44B AM transmitter has at least 11MHz bandwidth when using a 5.5MHz sound subcarrier, compared to 7MHz bandwidth for a standard VSB, (Vestigual Sideband) Television broadcast signal. **When using the transmitter on 444.250MHz in urban areas of Australia, It is suggested that an interdigital filter be constructed and fitted to the output of the power amplifier. Under the WIA band planning, it is mandatory in Australia to only use VSB when operating on 444.250MHz. The problem that exists, is that AM television transmitters do have lots of harmonics from the video and audio subcarrier that spot across the band, and can open the input of FM repeaters or cause interference to simplex users if the signal is strong enough.** Some years ago I was able to hear a local Hams 70cm 444.250MHz ATV transmitter audio, on our 438.450MHz FM frequency when mobile at 5kms away. Tuning across the 70cm band his transmitters had video spots across most of the 70cm band.

3. An alternative is to use a low cost Toko helical filter between the transmitter and linear power amplifier, but it will not be as effective. The filter can be tuned in conjunction with adjusting the trimmer capacitors to reduce the lower sideband by around 20dB at -8.5MHz below the carrier, without affecting the carrier and upper sideband of the signal. The tests done recently have indicated that the helical filter skirts are marginal in reducing the lower sideband in the 438MHz area of the band when operating on 444.250MHz. A spectrum analyser is a great help when tuning the transmitter and filter. The helical filter can be wired between the transmitter and power amplifier using small RG316 cable soldered directly to the pins. Connections should be kept very short using good UHF construction techniques.

4. Further filtering of the video signal using a 5MHz low pass filter on the Video input of the transmitter will also help to reduce harmonics of the video frequencies.

5. The older M57716 modules were able to produce around 15 watts sync tip power which measured around 4 Watts average on a RF power meter. I expect that the newer RA30H4047M modules could produce close to 20 watts sync tip, 6 watts average when the transmitter is adjusted correctly. **Quality of the picture, (high linearity) should always be the priority over poor quality by trying to get more output power. Poor sync on a received signal is normally a sign of poor linearity of the transmitter or power amplifier.**

6. An optional Audio/Subcarrier KIT EME158 KIT can be added for audio. Only 5.5MHz should be used in Australia for compatibility with analogue TV sets, and to keep the bandwidth to a minimum. The subcarrier is fed to the **(Sub In**) connection on the transmitter board via a short length of small diameter coaxial or shielded audio cable.

PARTS LIST

CAPACITORS

1 x 4p7	NPO 50v Monolithic Capacitor
2 x 4p7	SMD 0805 Chip Capacitor **(1 spare)**
1 x 10pF	NPO Ceramic Capacitor
1 x 22pF	NPO Ceramic Capacitor
1 x 33pF	NPO Ceramic Capacitor
1 x 100pF	NPO Ceramic Capacitor
2 x 220pF	NPO Ceramic Capacitor
5 x 220pF	SMD 0805 Chip Capacitor **(1 spare)**
5 x 1nF	X7R Monolithic Capacitor
2 x 1nF	SMD 0805 Chip Capacitor **(1 spare)**
1 x 0.047uF	Monolithic Capacitor
3 x 0.1uF	Monolithic Capacitor
3 x 10uF	63v Radial Electrolytic Capacitor
1 x 47uF	35v Radial Electrolytic Capacitor
1 x 100uF	25v Radial Electrolytic Capacitor
6 x 10pF	Yellow 808 Trimmer Capacitor

RESISTORS

1 x 0R	1/4 Watt Resistor
2 x 10R	1/4 Watt MF Resistor
1 x 15R	1/4 Watt Resistor
1 x 18R	1/4 Watt Resistor
1 x 22R	1/4 Watt Resistor
1 x 47R	1/4 Watt Resistor **(alignment aid)**
1 x 100R	1/4 Watt Resistor
1 x 120R	1/4 Watt Resistor
1 x 220R	1/4 Watt Resistor
1 x 270R	1/4 Watt Resistor
1 x 330R	1/4 Watt Resistor
1 x 390R	1/4 Watt Resistor
2 x 470R	1/4 MF Watt Resistor
1 x 560R	1/4 Watt Resistor
1 x 820R	1/4 Watt Resistor
6 x 1k	1/4 Watt Resistor
1 x 1k8	1/4 Watt Resistor
2 x 2k2	1/4 Watt Resistor
2 x 4k7	1/4 Watt Resistor
3 x 22k	1/4 Watt Resistor
2 x 1M	1/4 Watt Resistor

TRIMPOTS

1 x 200R	TPV 5mm Trimpot
1 x 1K	TPV 5mm Trimpot

SEMICONDUCTORS

1 x 78L05	Regulator
1 x 1N4004/7	Power Diode (Black Silver Band)
3 x 1N4148	Signal Diode (Orange Black Band)
1 x 5v1	Zener Diode (Orange 5v1 on body)
3 x BC547	Transistor NPN
1 x BC327	Transistor PNP
1 x 2N2219A	Transistor NPN
2 x BFR92A	Transistor NPN RF
1 x BFR93A	Transistor NPN RF
1 x BFQ19	Transistor NPN RF

INDUCTORS, RF CHOKES, FILTERS

1 x E526HNA**100114L1**	Toko MC120 0.13uH Coil
2 x FB43-101	Ferrite Beads **(RFC)**

MISCELLANEOUS

1 x PC Board	EME44B
1 x Instructions	EME44B
1 x 200mm	0.315mm Enameled Wire
1 x 200mm	0.7mm Enameled Wire
4 x 1mm	PC Board Pins

OPTIONAL NOT INCLUDED IN KIT

1 x Crystal	426.250MHz (71.0417MHz) AUD
	434.250MHz (72.3750MHz) EU
	435.500MHz (72.5833MHz) USA
	444.250MHz (74.0417MHz) AUD
	5th Overtone HY-Q QC49 GJ05S

TOP PC BOARD OVERLAY EME44B

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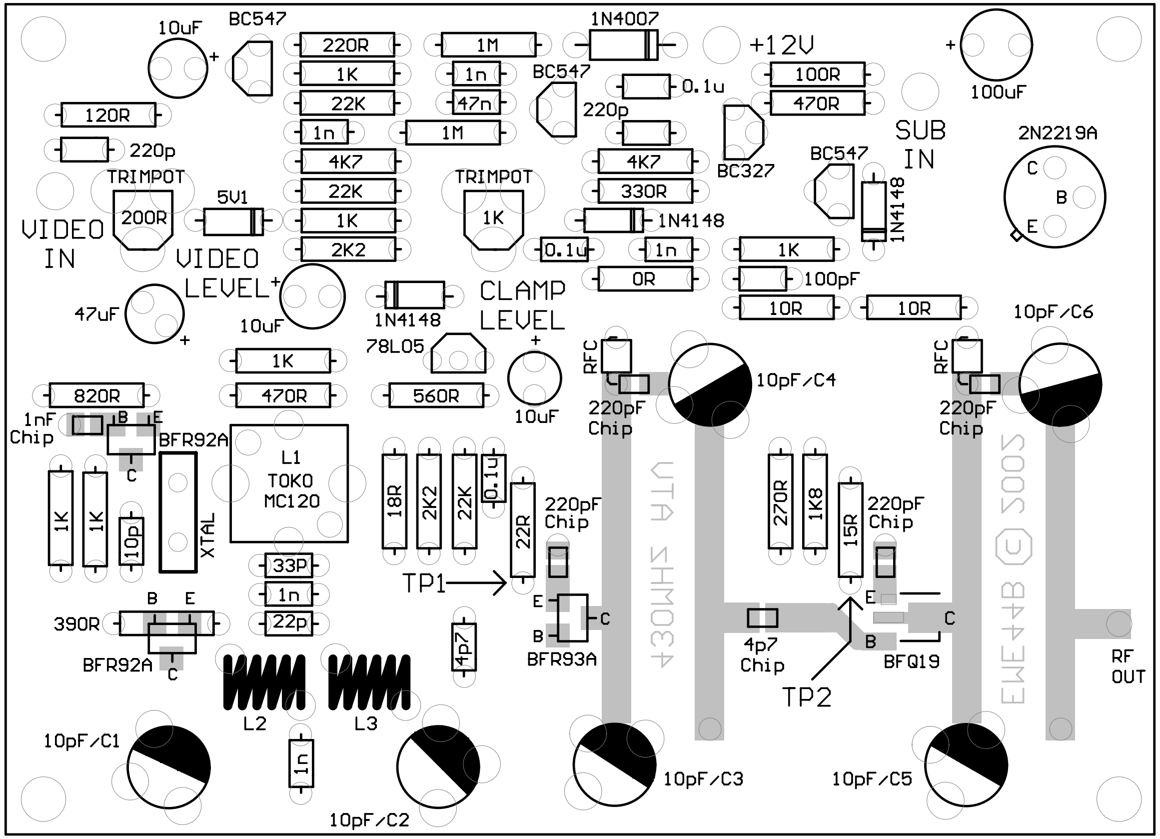

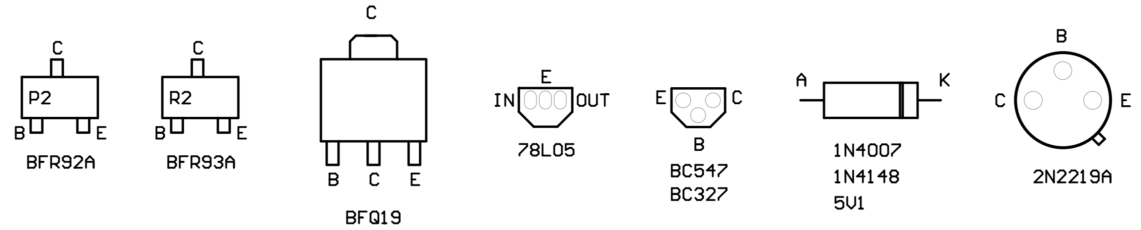

COMPONENT PINOUTS
TOP VIEW

L2 & L3 6.5Turns wound on a 3mm dia drill bit

Coils are spaced evenly to a length of 6mm to fit the PC board

Mount the bottom of the coils 2.5mm above the PC board

RF Chokes (RFC) are made by winding 4 turns on FB-43-101 Ferrite beads