SPECIFICATIONS:	Frequency Range	135 – 141MHz
	Input Sensitivity	0.223uV for 12dB SINAD -120dBm
	Bandwidth	1st IF 10.7MHz 230kHz BW @ 3dB 2nd IF 455kHz 30kHz BW @ 6dB
	Frequency Tuning	Varicap Tuned VCO with AFC circuit & Temperature compensation. Optional External PLL Synthesizer.
	Audio Output	Speaker Output 8 to 32ohms up to 500mW PC Audio Output Filtered for connection to a sound card 2v p-p
	Power	+12vdc 100mA

DESCRIPTION: Updated April 2011 to use the replacement BF998R MesFET. The complete Weather Satellite Receiver is built on a single 95 x 80mm size PC board & takes around 4 hours to construct. The receiver is designed around Motorola's MC13135P double conversion superhet receiver IC. The IC contains a complete receiver & has a dual conversion IF, two local oscillators & FM demodulator. The internal Varicap diode is used on the first local oscillator for frequency tuning. The circuit board has been designed for easy connection of an optional PLL Synthesizer for tuning, & 10.7MHz wideband FM IF demodulator for WEFAX reception on 1691MHz.

RECEIVER DESIGN: It took many months collecting information on Weather Satellite reception & receiver design, before I had some idea of what was required. The following is a wish list for a receiver design.

1/ Low cost single board design self contained re ceiver just plug in an antenna & connect to the computers sound card.
2/ Simple single chip FM receiver design with a low component count.
3/ PLL synthesizer to allow scanning of the Weather Satellite frequencies, & a mute circuit to stop scan ning automatically.
4/ Receiver IF Bandwidth of 40kHz @ 3dB.
5/ PLL FM demodulator to track the IF for Satellite doppler shift.
6/ Separate adjustable audio output suitable for direct connection to a computers sound card.
7/ Good receiver sensitivity but able to reject adjacent channel interference & overload from pagers & Orbcomms.
8/ Able to be used or modified for use with a 1691MHz downconverter for WEFAX.

Most of the above has been achieved except the use of a PLL Synthesizer which can be an additional option. A clever way of tracking doppler shift with a reduced IF bandwidth requirement has been adoptod, & will be explained in the circuit description. Most designs use either the dual conversion MC3362P or MC13135P Motorola chips as a complete FM receiver. I decided on a dual conversion FM receiver design using the Motorola MC13135P chip as the MC3362P was found to be obsolete. It seems that the MC13135P has recently suffered the same fate, but there are still plenty available worldwide. The most important design issue was the IF bandwidth requirement of the receiver. The only known problem with a dual conversion design is getting enough bandwidth from the second IF of 455kHz. Most articles indicated that a bandwidth of at least 30kHz @ 3dB was required, & preferably 40kHz @ 3dB to accommodate up to +/- 3kHz doppler shift. Suitable filters were looked at for 10.7MHz & 455kHz. The cost was the main consideration, so ceramic filters were the preferred over high cost crystal filters. After checking suppliers I finally found some 50kHz @ 3dB wide 10.7MHz filters in a large quantity. The 455kHz filters were found to be easier to obtain & the widest bandwidth available was 30kHz @6dB. This is possibly a little narrow but seems to be the widest available in 455kHz filters, & have been commonly used in weather satellite receiver designs for 137MHz. It was only found out when the prototype receiver was built, that the 50kHz filters were not usable due to the tolerance of the center frequency of the filters, & the 10.245MHz computer crystals. This caused the down mixed IF frequency to be slightly off 455kHz, & in combination with the 455kHz filter the 30kHz BW was much reduced. It was then discovered to get around the problem, most designs used a wide band 280kHz 10.7MHz filter for the first IF, which does not seem to affect the performance with the 455kHz filter doing most of the work. I have opted to use a slightly narrower 230kHz wide filter as these were easy to obtain.

CIRCUIT DESCRIPTION: Refer to the circuit diagram. The antenna input signal passes through the input tuned circuit & is amplified by the BF998R MesFET. The output is then filtered by a 3 stage 135 to 141MHz bandpass filter. The filter effectively removes unwanted signals outside the passband including pager interference on 150MHz before being input to pin 22 of the MC13135P IC. The input signal on 137.500MHz is mixed with a free running Voltage Controlled Oscillator, VCO on 148.200MHz to produce a 10.7MHz IF output on pin 20. The VCO consists of the

internal oscillator on pins 2 &3, along with the internal varicap diode on pin 23 & 24, & a number of external components including the VCO coil L5. The 10.7MHz IF output on pin 20 is filtered by a 230kHz BW @ 3dB 10.7MHz ceramic filter before going into Pin 18 to the second mixer. The 10.7MHz IF is then mixed with a fixed 10.245MHz crystal oscillator on pins 5 & 6 to produce a 455kHz IF output on pin 7. The 455kHz IF is then filtered by a 30Khz BW @ 6dB 455kHz filter before going into pin 9 to the FM limiter & demodulator. The demodulator consists of the 455kHz demodulator coil along with a 10kohm resistor across the coil to widen the demodulator BW. The raw audio is then output on pin 17 & goes both to the AFC & audio amplifier circuits. The AFC circuit is very effective in keeping the oscillator on frequency with temperature changes, & being able to track a Satellites doppler shift. The circuit consists of a high gain BC549C along with a 4k7 NTC thermistor & associated components. The 470ohm (Option 1) resistor sets the capture & hold in range. The capture range is around 40Khz, with the hold in range being much greater. The DC voltage on pin 17 will vary according to the doppler shift, or if the signal received is slightly off tuned. The voltage biases the BC549C & adds or subtracts a small amount of DC voltage across the tuning pot. The voltage variation is then fed back to the varicap diode to readjust the VCO frequency. When the AFC switch is in the normal position, the AFC circuit still adds some temperature compensation to the VCO, but cannot capture & hold in a signal. The tuning circuit consists of a 100kohm 25turn trimpot for course preset tuning, & a 20kohm trimpot for fine tuning. The 100kohm is set initially to the prefered receive frequency, e.g. 137.500MHz , & the 20kohm finetuning trimpot is used if the received signal cannot quite be captured by the AFC circuit. For extra receive channels a rotary switch along with more 100kohm 25 turn trimpots can be added as shown in the circuit diagram. The S meter & Squelch circuit uses the Receive Signal Strength Indicator, RSSI voltage on pin 12 along with the internal operational amplifier, pins 14, 15, & 16. The Offset2 trimpot sets the DC output on pin 16 to 0 volts when there is no received signal. When a signal is received, the DC on pin 16 of the MC13135P increases to drive the meter & squelch circuits. The 50kohm Squelch trimpot sets the threshold bias on the BC547 transistor that controls the operation of the MC34119 Audio Amplifier. As the voltage increases from pin 16 the transistor is biased on which lowers the voltage on pin 1 of the MC34119 effectively turning on the audio amplifier to drive the speaker. The 47uF capacitor on pin 1 slows the mute circuit for smoother squelch operation. The Mute output is used to control an optional external PLL Synthesizer to stop scanning frequencies when a signal is received. The audio circuit consists of a 2 stage operational amplifier to drive the MC34119 & PC audio output. The first stage of the TL072 IC is used to drive the MC34119 audio amplifier via the main Volume1 trimpot. The second amplifier is used to increase the audio level to a suitable level to drive a PC sound card. The Volume2 trimpot sets the audio level which is filtered by the 470ohm & 10nF capacitor on the output to cut audio frequencies above 3kHz. This effectively gets rid of high frequency noise that can degrade the quality of the Weather Satellite pictures.

CONSTRUCTION:

1. The PC Board supplied is a Professional plated through hole board. This makes it much easier to construct the Kit & avoid any potential construction errors. Most components except the BF998R & SMD 4k7 NTC resistor are soldered on the top groundplane side of the PC board.

2. Follow the PC Board overlay diagram and circuit carefully, when checking the components and placing them onto the board. The first part of construction is to fit the small EME180 PC board & the BF998R MesFET to the board. **It may be easier to solder the small PC board to the main EME117 board first before soldering the BF998R. One lead on the BF998R is fatter & this is the source connection, (S).** Next tack solder one lead of the BF998R to the small board, & check that you have the MesFET the correct way around before completely soldering into place.

3. Next fit the small 4k7 NTC SMD, (Negative Temperature Coefficient) resistor to the bottom side of the board.

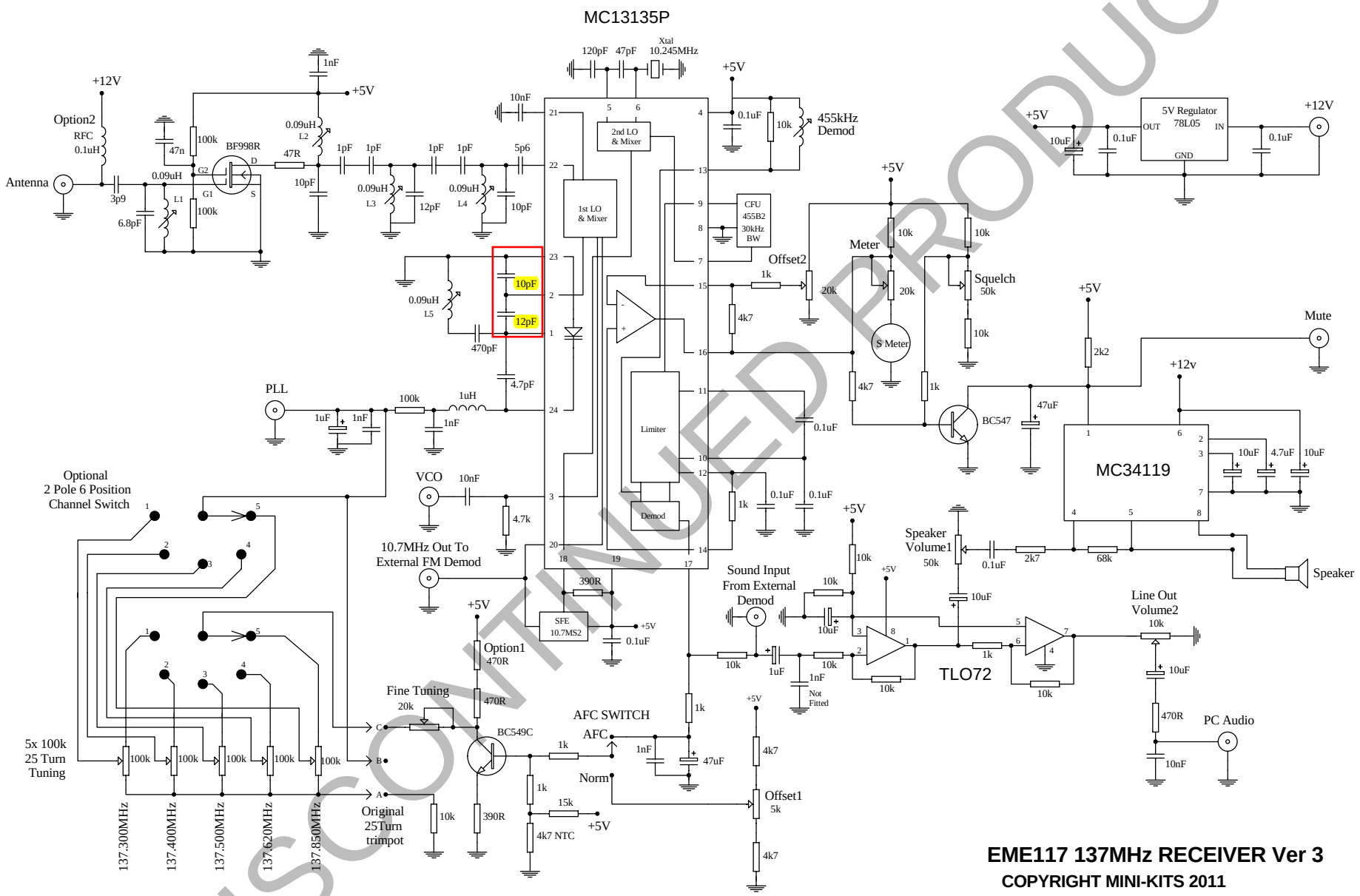
4. Next start fitting the smaller components to the board that include the resistors followed by the ceramic capacitors . **It is suggested that you check each resistor with a multimeter as the colours are getting more difficult to read due to poor paint colour before fitting.** There are many ceramic capacitors & care should be taken to make sure that the values are correct before fitting to the board.

5. Next install the transistors, Integrated circuits, & trimpots. **Be careful when fitting the MC13135P IC as they are static sensitive. IC sockets should not be used with the MC13135P as it can cause instability.** A 1uH SMD RF Choke is not supplied for the Option2 position on the board. Refer to the notes in the options section.

6. Next fit the Toko coils. **When soldering in the coils in the metal cans, make sure that you identify the cold earth end of the coil that is indicated by a small cut out in the metal can. This is the side of the can that has the printed writing stamped onto it.** The input coil L1 should face towards to BF998R, while the 3 coils L2, L3, & L4 after the BF998R should face towards the VCO coil L5. The VCO coil L5, should face towards the AFC/Normal link.

7. A Inline Header is supplied for the wire connections to the PC board. Simply cut the header to the lengths required & solder into the board. Alternatively Header Plugs & Sockets can be purchased & fitted to allow easier disconnection of the board from external circuitry.

8. 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 solder dags & incorrectly fitted component values.



EME117 137MHz RECEIVER Ver 3

TESTING & ALIGNMENT:

1. Alignment is straight forward, although some form of signal source or VHF signal generator is an enormous help. Set all 4 ferrite cores in the Toko coils to approximately 3mm below the tops of the cans. **The ferrite cores in the Toko coils are very fragile so only the correct plastic hex trimmer tool should be used. Metal screwdrivers etc will easily break the cores.**

2. Using a current regulated powersupply apply +12vdc to the board & check that the current is 100mA or less. Connect a suitable speaker to the board & turn the Volume1 trimpot up until noise is heard from the receiver. **Make sure that the Squelch trimpot is turned off, (Fully Clockwise).**

3. Put the AFC switch in the AFC position. Adjust the 100kohm 25 turn trimpot to the middle of its range. Set the fine tune trimpot to mid position. Short the antenna input to ground & measure the DC voltage at the AFC switch with a multimeter. The switch is now changed to the Normal position & the Offset1 trimpot is now adjusted to read the same DC voltage.

4. With the antenna input still shorted, adjust the Offset2 trimpot for 0 Volts on Pin 16 of the MC13135P.

5. The next lot of adjustments 5 to 7 are with the AFC switch in the normal position. We start with alignment of the first voltage controlled oscillator, VCO. For a receive frequency of 137.500MHz, the oscillator is tuned 10.7MHz higher to a frequency of 148.200MHz. The frequency can be measured by connecting a frequency counter to the VCO output pin on the PC board, or by monitoring the signal on a suitable FM receiver tuned to 148.200MHz. Adjust the oscillator coil L5 until the local oscillator carrier is on frequency. The tuning of L5 will be quite large with only a slight adjustment but just get it close to 148.200MHz. As the VCO is freerunning any movement of the board, or temperature changes will cause the VCO to change frequency. It is preferable that the board be mounted on 10mm or higher PCB spacers on each corner of the board in a suitable box. For initial alignment, the board can be supported with the PCB spacers on the workbench .

6. Next connect a signal generator tuned to 137.500MHz to the antenna input. Adjust the 100kohm 25turn trimmer if required until the signal is heard from the speaker.
Adjust Inductors L1 to 4 for maximum output on the signal meter. Modulate the signal generator with a 2.4kHz sinewave with 30kHz deviation & adjust the 455kHz demodulator coil for minimum distortion on the audio signal from the speaker. An Oscilloscope can be connected to the audio output & the demodulator coil adjusted for minimum distortion of the sine wave.

7. If you are using the optional channel switch with additional 100kohm 25turn trimmers, then set each one to the required frequencies of 137.300MHz, 137.500MHz, 137.620MHz etc using the signal generator to tune them in. **All frequency tuning should be done with the AFC in the normal position. When all frequencies have been tuned then the AFC should be turned on.**

8. Most alignment above can be made without test equipment by receiving a Weather Satellite signal.

RECEIVER BOARD CONNECTIONS:

1. The PC audio output is suitable for connection to a Sound Blaster or similar card. Use suitable shielded audio cable with a 3.5mm stereo plug on one end. Connected the center of the cable to the tab on the plug that corresponds to the far end of the 3.5mm plug. This is the left channel. Plug the 3.5mm plug into the microphone input of the sound card. With the software supplied with the sound card, set the mixer record volume level to +21, & the microphone input to about half level. Check that there is noise from the PC speakers. **The PC audio level trimpot on the Receiver should be turned fully clockwise.** For the recommended Software, refer to the separate Notes on Weather Satellite Reception.

2. The Antenna connection can simply be soldered directly to the board. An Optional F type R/Angle socket can be fitted to the board to allow the use of RG6 cable with F type connectors for the antenna cable.

3. Any 8 to 32ohm Speaker can be used on the Receiver. The Speakers Volume1 is independent of the Line Output Volume2.

4. For an S Meter any low cost surplus meter can be used. The S meter is not really required, but does give an indication on how strong the satellite signals are.

5. The AFC / Normal connection can be connected to an external toggle switch. The switch should be set to the normal position when tuning in a signal, before the AFC is turned on.

6. A PLL Synthesizer Option is currently not available. Spare holes are located in the PC board near the VCO coil L5 for the PLL loop filter components.

OPTIONS & NOTES:

1. The 470ohm **Option 1** resistor sets the capture & hold in range of the AFC circuit. The capture area with the 470ohm is around +/- 40kHz. The capture area can be lowered to around +/-15kHz by replacing the 470ohm with 0ohms.

2. The 1uH SMD Choke, **(L1.0u) Option 2** can be fitted to feed +12 volts up the antenna cable to power an optional preamplifier. **The choke should not be fitted if a preamplifier is not used.** An external preamplifier should not be required if low loss RG6 or similar cable is used to the antenna. An external preamplifier may cause overload of the receiver from strong out of band signals.

3. An optional PLL Synthesizer could be connected to the receiver for automatic scanning of the Weather Satellite

frequencies. The PLL input & VCO output connections on the board connect to the Synthesizer. The Mute output is used to tell the microprocessor when a signal is received to stop the PLL scanning the channels. **There is currently no plans to produce a PLL Synthesizer Kit to suit this receiver.**

4. An external 10.7MHz FM demodulator connection is provided on the board. This can be used for an optional external wideband 280kHz IF, for Japans geostationary GMS5 Satellite. The audio from the external demodulator can be fed back into the input of the TL072 as show on the circuit diagram. The 10kohm resistor on pin17 of the MC13135P would need to be lifted on the 1uF capacitor side & a switch fitted for switching between the two demodulators.

The MC13135P seems very sensitive to static so if you want to experiment with the Kit, make sure that the power is turned off before soldering anything on the board.

PARTS LIST:

RESISTORS

1 x 0R	1/4 Watt Resistor
1 x 47R	1/4 Watt Resistor
2 x 390R	1/4 Watt Resistor
3 x 470R	1/4 Watt Resistor
7 x 1k	1/4 Watt Resistor
1 x 2k2	1/4 Watt Resistor
1 x 2k7	1/4 Watt Resistor
5 x 4k7	1/4 Watt Resistor
11 x 10k	1/4 Watt Resistor
1 x 15k	1/4 Watt Resistor
1 x 68k	1/4 Watt Resistor
3 x 100k	1/4 Watt Resistor
1 x 4k7 NTC	**SMD 0805NTC Resistor**

TRIMPOTS

1 x 5k	TPV 5mm Trimpot Resistor
1 x 10k	TPV 5mm Trimpot Resistor
3 x 20k	TPV 5mm Trimpot Resistor
2 x 50k	TPV 5mm Trimpot Resistor
1 x 100k	25Turn Trimpot Resistor

CAPACITORS

4 x 1pF	Ceramic Capacitor
1 x 3p9	Ceramic Capacitor
1 x 4p7	Ceramic Capacitor
3 x 5p6	Ceramic Capacitor
1 x 6p8	Ceramic Capacitor
2 x 10pF	Ceramic Capacitor
1 x 12pF	Ceramic Capacitor
1 x 47pF	Ceramic Capacitor
1 x 120pF	Ceramic Capacitor
1 x 470pF	Ceramic Capacitor
4 x 1nF	Ceramic Capacitor **(102)**
3 x 10nF	Monolythic Capacitor **(103)**
1 x 47nF	Monolythic Capacitor **(473)**
8 x 0.1uF	Monolythic Capacitor **(104)**
3 x 1uF	Electrolytic Capacitor
1 x 4.7uF	TKR Electrolytic Capacitor
5 x 10uF	EB 63v Electrolytic Capacitor
2 x 47uF	TKR 35v Electrolytic Capacitor

SEMICONDUCTORS

1 x 78L05	5 Volt Regulator
1 x BC547	Transistor NPN
1 x BC549C	Transistor PNP High Gain >500
1 x BF998R	FET Dual Gate SMD
1 x TL072	Dual Operational Amplifier IC
1 x MC34119P	Audio Amplifier IC
1 x MC13135P	FM Receiver IC

INDUCTORS

5 x 0.09uH	Coil TOKO **100 073 Marked On Can**
1 x 455KHz	Demodulator Coil Xicon 7P **F201**
1 x 1.0uH	RF Choke (Brown Black Gold) Looks like a green resistor

FILTERS

1 x LTU/CFU455B2	Murata 455kHz (30kHz BW @ 6dB)
1 x SFE10.7MS2	230kHz BW @ 3dB **(L10.7S)**

MISCELLANEOUS

1 x PC Board	EME117C
1 x PC Board	EME180 (suit BF988R)
1 x Instructions	EME117C
1 x 10.245MHz	Computer Crystal
1 x Inline PCB Header	
1 x PCB 2 pin Header Link	

OPTIONAL NOT INCLUDED IN KIT

1 x Meter	Low cost for the S Meter
1 x Speaker	8 to 32ohms
1 x F Socket	R/Angle (For Antenna Connection)
1 x Switch	SPDT For the AFC / Normal selection
1 x 1.0uH	SMD RF Choke **Option2 Part # L1.0u**

For Product Support www.minikits.com.au

WEATHER SATELLITES: The notes below are to help the people that are new to Weather Satellite Reception. There are currently three Satellites on the 137MHz band that are operational 2/1/11.

Please check status on http://homepage.ntlworld.com/phqfh1/status.htm

NOAA 15 137.620MHz
NOAA 17 137.500MHz (On but No images)
NOAA 18 137.9125MHz
NOAA 19 137.100MHz

Only Infrared pictures are available when the Satellites are going over at night time. Picture quality can be rather grainy & dark with little colour at dusk or dawn.

ANTENNAS:

A circular polarized antenna like the Quadrifilar Helix or Turnstile is required to give acceptable signals. An omnidirectional antenna for the 144 to 148MHz band can be used, but signals are quite weak as the satellite gets higher than 20 degrees above the horizon due to the radiation angle of the antenna. Good noise free signals have been received on a quadrifilar Helix at only 3 metres above the ground. Signals however were only receivable from around 20 degrees above the horizon. Increasing the antenna height would improve this. With around 10 metres of low loss RG6 cable, a receive preamplifier should not be required. If a preamplifier needs to be used, then one with a tuned input filter is required to reject strong out of band signals like pagers on 150MHz. To receive low angle signals a circular polarized cross yagi, & azimuth / elevation rotator would be required.

COMPUTER:

A PC with a Soundblaster or similar audio card is required for the processing of the audio signal. Computer interference has been noted on 137.620MHz. The problem was radiation from the cables feeding a Scanner. The Scanner is now switched off when receiving NOAA 17 on 137.620MHz. Interference was also able to be minimized by rotating the antenna for a null. Antennas like the Quadrifilar Helix do still have nulls.

SOFTWARE:

1. The WX software suggested will allow you to get your Weather Satellite Receiver going easily & quickly. All software is available from the www.satsignal.net WEB site. There are other software packages available but the WXTRACK & WXSAT are free & easy to use. An additional audio record level program WXREC may also be useful.

2. Load the WXTRACK software & click the SETUP button & set your location in WXTRACK. The available Satellites are listed in the SETUP screen. Drag the required APT Satellites into the Active box. Select Noaa 15, 17, 18, 19, & Meteor 3-5. Update the satellite KEPS by clicking OPTIONS & then UPDATE KEPS. Your computer will connect to the NORAD web site & automatically download the latest KEPS. Make sure that it has downloaded the weather.txt, & noaa.txt files into the C:/wxtrack folder. While you are still on the WEB, go to a search engine & search for the current UTC time. Set your computers clock to this time.

3. For decoding & displaying the Weather pictures use WXSAT. It will allow you to display the picture from the Weather Satellite, along with being able record & playback WAVE files. Load the software & click on the PARAMETERS button & select either NOAA 4+4 or Meteor depending on the satellite you want to display when it comes into view. Click the PARAMETERS button & then the DECODING button & set the selection on the bottom RHS of the window to N-S or S-N depending on which direction the Satellite is traveling from. When you are just starting to receive the signal from the Satellite, click the RECORDING button & click PICTURE & WAVE FILE. WXSAT will then start recording the audio from the receiver as a WAVE file & start displaying the picture on the screen. A slight adjustment of the fine tuning on the receiver may be required when you first receive the signal.

4. The software WXREC can be used to check the audio record level into the soundcard. Load the software & click on the icon to start the program. The program will display a record level indicator that can be set with the mixers record level. When a satellite is received, set the record level to NOAA or Meteor depending on what you are receiving**. I have not found the record level to be accurate, & had to turn it down slightly.**

5. For any Software problems read the information on the satsignal WEB site as your computer may need extra files that can be downloaded from there.

REFERENCES:

www.minikits.com.au/down.htm

WxtoImg Software http://www.wxtoimg.com/

WXSAT Ver2.5 Christian H Bock

WXTRACK Ver 3.7.2 David J Taylor
http://www.satsignal.net/

WXREC Satlevel ver1.1.0 David J Taylor

ARRL Weather Satellite Handbook Dr Ralph E Taggart

137MHz Antenna
http://www.jcoppens.com/ant/qfh/index.en.php
http://www.qsl.net/kf4cpj/qha/

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