Unpacking the kit:

The kit arrived in a modest sized cardboard box, with sufficient foam packing protecting the enclosed bagged items. All items were laid out and inventory was taken of the supplied parts with the parts list in the supplied documentation.

Photo 1: Complete kit of supplied parts (no heatsink, no RF connectors and no housing were supplied with the basic kit – available as options, if required, for additional cost.)

All items listed were found to be present and correct and were then checked off the parts list.

Photo 2: Most of the leaded components and hardware was in this bag.

Photo 3: Some semiconductors in this anti-static bag.
Photo 4: Some of the leaded and SMT components were supplied taped to a sheet, indicating both quantity, part name and circuit designator. A good idea, when having to handle some of this small componentary.

Photo 5: Something that is not usually supplied – a DC power cord!

Photo 6: The single double-sided PCB. Looks well laid out and well labelled, both top side and underneath.

The documentation supplied is quite extensive and contains the circuit specifications, descriptions, schematics, testing and alignment procedures, additional notes and references.

To assist with kit construction, references are made to the Minikits’ web pages for additional construction notes and photos.

My documentation had a few spelling errors and other mistakes that, hopefully, will be corrected before the next release, along with some minor errors found on the website.

If you require assistance or clarification on any part of your construction of this kit, suggestion is made, to contact Minikits via the email as found on their website.

Photo 7: The necessary documentation.
Components on the PCB:

Well, I can say, it was fun building this kit. Most parts went on the board with no problems.

It is recommended that you have a good light to see with, a clean area to work on and to lay out parts for easy access. A good soldering iron is essential along with some good quality resin cored solder (not supplied). A magnifying headset will aid in producing good, clean, solder joints. (A microscope is not needed for these few SMT parts.)

As per instructions, it is recommended to start installing the few components to the underside of the PCB first.

Note: Leave the FET till last – as per recommended instruction method. (You have read the instructions, haven’t you?)

Photo 8: This photo shows the underside of the partially completed PCB. (No RF connectors mounted/soldered and TF2 not installed.) [This PCB has been mounted prior to the FET being soldered and has been removed for photo clarity.]

Photo 9: This photo shows the topside of the partially completed PCB. (No RF connectors mounted/soldered and TF2 not installed.)
As can be seen from the above photos, after two evenings’ construction effort, the kit can be built to look like the one on the Minikits website. Let’s see if it works …

**Switch on:**

Initial current draw: 119mA @ 13.8 VDC. The green Rx came on and no smoke! I left the unit on for about half an hour and the current did not change. Good start.

I had to confirm which pin was the green Rx and the red Tx LED connections, as the board was not labelled, before tack soldering the bi-coloured led temporarily to the header pins.

![Photo 10: A3 header with Rx and Tx labelled.](image)

**Setting the 3.2MHz crystal oscillator level and frequency:**

The requirement was to adjust the oscillator output (mixer input) to be $+7$dBm. Measuring the crystal oscillator output by removing the link at LK6 and connecting for both output level, using a DSO and frequency calibration using a spectrum analyser. (I didn’t bother using a RF power meter.)

![Plot 1: Crystal oscillator output as measured on DSO at LK6.](image)
Plot 2: Crystal oscillator output level as measured by spectrum analyser at LK6.

4MHz Cheby-Chev Low Pass Filter response:

The output of the filter used between the crystal oscillator and the mixer was measured using a spectrum analyser.

Plot 3: Plot shows the output of the filter at LK6 link position.

The results are almost identical to the plot on the Minikits website. (I’ve also included an additional measurement at the 12MHz frequency.)
I have noticed frequency stability issues when touching the crystal case or simply blowing air across the case. As the crystal is not grounded, I decided to scrape away some of the resist layer on the topside of the PCB and solder the case to the ground plane. This minimises stray capacitance effects.

Supplied with the kit, is a crystal PTC heater. This item is used to raise the crystal temperature above the ambient temperature so that any minor temperature variations at ambient have little to no effect on the frequency stability. This item is wired to the incoming 12 VDC supply. (Separate ground return is used, rather than relying on the crystal case!)

![Photo 11: Soldering the crystal case to ground. Photo 12: Crystal heater installed.](image)

With the crystal heater installed, the Rx current went up from 119 mA to about 165 mA.

Initially, upon switch on, the Rx current started at 275 mA (@13.8 VDC) but quickly fell to 193 mA. After 5 minutes it went to 174 mA. Over the next two hours, it had already stabilised at 165 mA and was noted the same for another hour later.

**FL1 Bandpass Filter response:**

Getting the desired response from this filter proved to be a little tricky.

1. The schematic shows some obvious component value errors (printed). Supplied parts were correct.
2. Using the procedure to tune L12 and L13 by sweeping the filter by connecting a tracking generator to LK2 and measuring the output on a spectrum analyser at the pin 3 of the mixer – didn’t quite work.

Explanation:

1. Quick analysis of the parallel components of the band pass filter, as shown in the supplied schematic, gives the self resonance of the 1uH inductor and the 10pF capacitor connected in parallel, to be in the order of 50MHz! This can’t be right?? The circuit must be wrong! It is. Why? The Yellow IF transformer used, have an inductance of around 680uH coupled with a 180pF capacitor which, as we know, tunes to resonance around 455kHz. If we add an additional capacitor of 10pF, we can tune the inductor to 475kHz – the frequency of interest! So, L12 and L13 are actually adjustable 680uH cores with 180pF. C26 and C30 help tune up to 475kHz.
2. As C26 is part of the filter circuit, we can’t omit it while adjusting L12 with LK2 removed. If done this way, L13 can be adjusted, adjusting L12 seems to do nothing, but the output level at pin 3 of the mixer is about 20 dB down! It is better to leave the link LK2 in place.

So, what I have managed to do, is to place two IDC header pins at strategic points and take my measurements from them and tune the input band pass filter.
Photo 13: Tracking generator input pins made to underside of PCB. Upper pin (GND) is connected to ground leg of L12. Lower pin (TG) is connected to junction of D1 and C25. (Refer to kit supplied schematic and component overlay for component locations on the actual PCB.)

Photo 14: Spectrum analyser input pins. Right pin (GND) is connected to ground (pad). Left pin (SA) is connected to pin 3 of the mixer, IC3, via convenient top side pad.
These are the “custom-made” connectors to the IDC header pins.

(These items are not supplied with kit.)

So, once the IDC headers were in place, I took some measurements with the custom made connectors.

Plot 4: Plot showing the FL1 Band Pass Filter response

This compares quite favourably with the plot on the Minikits website.

I then took another measurement to see how it looks through the AM broadcast band segment.

After the measurements were completed, the IDC connectors were simply unsoldered and removed from the board.
Plot 5: Showing the **FL1 Bandpass Filter** response further in the AM broadcast band.

**Output Low Pass Filter response:**

The schematic for the output low pass filter was input into a filter program to verify the calculated response matched the one measured and presented on the Minikits website.

![500kHz Output Low Pass Filter](image)

**Schematic 1:** Output low pass filter
Plot 6: Using ELSIE to give an indication of what the likely response could look like and to compare with that as measured on the Minikits website.

The easiest way to check this low pass filter was to remove the jumper at LK4 position and insert the tracking generator of the spectrum analyser. (Check pin orientation for correct connection of the filter and ground connections!) The input to the spectrum analyser is then simply connected to the A1 output connector.

Plot 7: Plot shows the Transmission loss of the 500kHz output low pass filter.
When comparing the shape and the measured values with those on the Minikits website plot, it is reasonably close in all respects.

**NOTE!** As you can see, via the schematic, there is no afforded protection of the output FET, T3, from possible large static discharges other than a 100 volt capacitor. A much better solution would be to put a large value static drain resistor (or resistor string) permanently on the output of the filter to ground. Then there is no possibility of any discharge building up to damage either C12 on the RF output FET nor on C11, the pre-amp input capacitor. Be warned.

This concludes **Part 1** of the EME223-630M Kit evaluation. Stay tuned for **Part 2**.