FMT MK4   Feature rich CW Trainer

This is new version of the FISTS Morse tutor project, this time after many requests it is offered as a cased kit. I addition a number of new features have been added too.

Now the FMT will support BOTH Paddle and Straight keys in practice mode and an additional fixed low level SINEWAVE output is provided. This output can be connected to a PC for use in a number of ways, the first is when its used with a software package such as CWGet, FLdigi etc you can check your own sending in practice mode, the FMT does NOT have a Morse decoder built in but this way you can see how good (or Bad!) your sending really is. Another useful use for this output is to use the practice oscillator over Zoom or other internet streaming type services.

The kit is easy to build and due to coming with pre-punched front and back panels a better finished product is assured (no more cutting out holes for the large LCD display)

Designed originally for the FISTS CW Club this tutor offers a wide range of features that you will find hard to beat. The FMT Now has had a BIG addition to its feature list, it now has all the tutor features you would expect but also as a 39 lesson Koch trainer built in too, I believe that this is the best way to learn the code and is great for someone completely new to this mode.

Of course you also get all the original FMT Tutors features.

The Standard tutor modes are:

Random Letters, Random Numbers and Mixed Modes which is the standard from the old type of tutors, but this tutor also much more;

Random Prosigns, Random Callsigns, Random common words and abbreviations, Contest mode (More on that later) and even a practice oscillator (Straight key, Iambic paddle, and Cootie mode too) and a 10-minute practice session timer.

The tutor is very simple to use, no pages of menus to navigate your way around, just one push button that changes the mode and 3 knobs, one for character speed, one for the gap between characters and finally a volume control.

Learning the code can be hard and you do need to stick to it, but don't spend too long per session, it's not beneficial. I suggest keeping to a 10 min session once a day, every day. To help you know when a session is up the tutor will illuminate a LED for 10 secs every 10 Minutes. This is a sign that you may need to take a break.

Now a note about the contest mode, ok what is contest mode? Well, the tutor will send a typical contest type 'Over'. It will send a random callsign followed by a three digit serial number, finally a short random message ending such as 'GD DX', a 4 digit locator (Not necessarily the one for the callsign !), RST Report, or 'QRZ' etc.

That's all well and good but to add to the realism as much as possible the pitch between overs and also the speed will change randomly if you select the 'ACM' (Advanced Contest Mode) on the tutor's board (a two pin jumper enables it). You may want to start with the standard contest mode but you can change to ACM at anytime. (I activate it all the time on mine)

The tutor will generate code from about 12 to nearly 30 wpm, if this gets too tame for you then you can push the tutor up to above 50WPM, another jumper on the main PCB selects this 'Hyper' mode.
In addition, the user can change the default tones pitch to their own liking. (See users guide)

Select practice mode and plug either a straight, Paddle, or Cootie key in and you have a practice oscillator to play with too. (Paddle and Cootie key options are new in this MK4 version)

The FMT will now allow you to select Iambic A or B mode and also gives the option for left or right handed paddle use

In Koch Mode the tutor will allow the user to select 1 of its 39 lessons and is the best way to learn Morse, a great addition to the FMT.

The finial mode is the Prisoner of war Tap Code trainer /emulator, read the user guide for full details of this historic code.

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How to build the FMT?
Read ALL the following instructions BEFORE you start.
Check you have all the parts before you start.

FMT PCB ☐
Mini Controls PCB ☐
Hammond RM2015M case ☐
Front and Back Punched/Screen Printed Panels ☐
4 x Stick on feet ☐
DC Power Socket ☐
3 x 3.5mm PCB Sockets ☐
PCB 8 Ohm Speaker ☐
9V Battery holder ☐
3 x Battery holder fixing screws ☐
4 x PCB fixing Screws ☐
D1   IN4001 Diode ☐
R1, R5   2K2 Ohm ¼ watt Resistor ☐   (Coloured Bands Red, Red, Red)
R2   39 Ohm ¼ watt Resistor ☐   (Coloured Bands Orange, White, Black)
R3   10K Resistor Network ☐   See Instructions
R4   1K ¼ watt Resistor ☐   (Coloured Bands Brown, Black, Red)
R6, R7, R8, R10   10K ¼ watt Resistor ☐   (Coloured Bands Brown, Black, Orange)
R9   1K8 ¼ watt Resistor ☐   (Coloured Bands Brown, Grey, Red)
C1, C2, C3   0.022uF disk Capacitor (Marked 223) ☐
C4, C7, C8   0.1uF disk Capacitor (Marked 104)   ☐
C5, C6   22pf disk Capacitor (Marked 47) ☐
T1   2N2222 (OR 2N2222A) ☐
IC1   ATMEGA328 Processor Chip ☐ Keep on antistatic foam till needed (ESD protection!)
Socket   28 Pin IC Socket ☐
VREG   78L05 Regulator ☐
2 x   10K potentiometer ☐
1 x   10K potentiometer with integrated switch ☐
1 x   PCB Push Button ☐
3 x   Control Knobs ☐
1 x   3mm Alarm Blue LED ☐
1 x   4 Core connecting cable ☐
1 x   5 Core connecting cable ☐
6 x   2.54mm jumpers ☐
6 x   2.54mm 2 Pin Headers ☐
1 x   2.54mm 4 Pin Header (to be fitted to main PCB for display wiring) ☐
1 x   2.54mm 5 pin straight Header (fitted to main PCB for Control board) ☐
1 x   2.54mm 5 pin 90 degree Header (fitted to small control PCB)   ☐
1 x   Mounting Spacers/Hardware pack ☐
1 x   2 line LCD Display ☐
1 x   I2C Board ☐ (This may already be fixed to the display)
1 x   16Mhz Crystal ☐

The build of the Morse Tutor is straight forward and shouldn't present much in the way of problems. Many people have built the MK1, MK2, MK3 FMT's as a first project and this new version should be just as easy to build.

First Let's fit the IC socket, on the socket you will see a small notch on one of the ends, also on the PCB layout the socket will be shown with a notch on the silk screen, makes sure you put the socket on the board to match the silk screen layout, then solder all pins in place making sure the socket is pushed down onto the board.

The Colour bands on each resistor tell you the value, use the colour chart to identify them if you can but I have detailed the colours for each resistor in the parts list above.
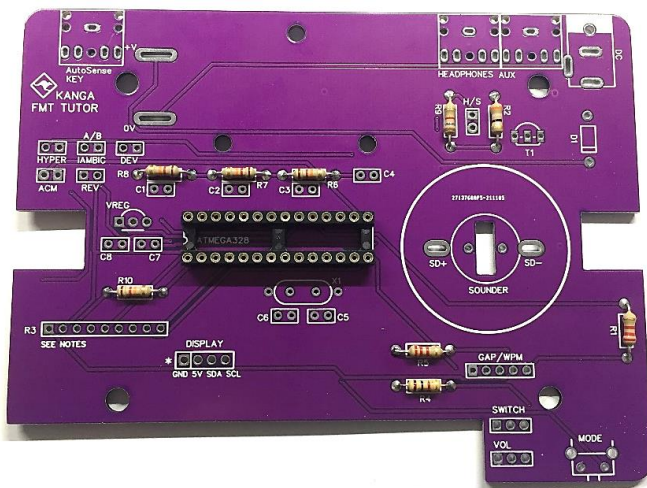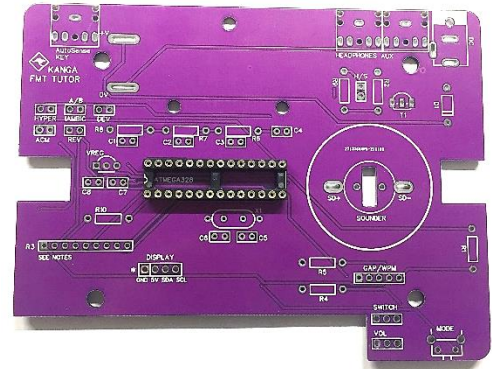
Now we need to move on to the resistors.
In this stage we will fit all the resistors apart from R3 (the resistor network).
Start with R1 and work though all up to R10, we are not fitting the large resistor network R3 at this point. Resistors can be fitted either way round. Make sure they are sitting flush with the board and that the correct value is fitted in each location. Use the parts list and the silk screen printing to locate each parts location and value, do not try and use the colours of the resistors in the photo here as this board is just the prototype, the values in the parts list are correct for your version.

Next we will fit the capacitors, there are less of these than the resistors, again these capacitors can be fitted either way round but of course the right value must be in the right place. Take care as most of the capacitors look the same, the value is printed on one side of the capacitor (See parts list for what the markings should be)
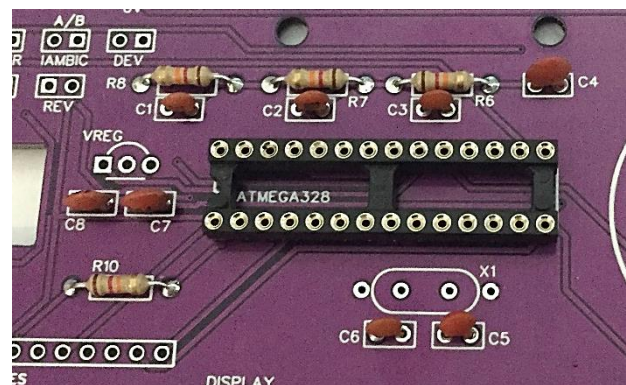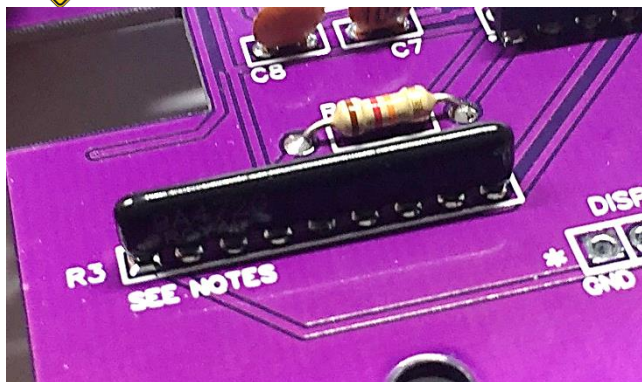
Now previously we missed fitting R3, R3 is a resistor network that acts as logic pull-up network for the processor. The value is not too critical, a 10K network is specified in the parts list but any network between 4k7 and 20k could be supplied and will make no difference. There is one very important point you MUST be careful of with this part. Unlike the other resistors this can only be fitted one way round, if you look very carefully at the sides of this part you will see only one side has an identification mark/text. This side must be nearest to the '**SEE NOTES'** text on the PCB, double check that you have the part that way and then solder in place.

The next stage is fitting the header pins, there are 6 x 2pin, 1 x 4pin and 1 x 5pin. Make sure these are nice and vertical when you solder them, I solder just one pin of the header and check its straight, when happy I solder the other pins.
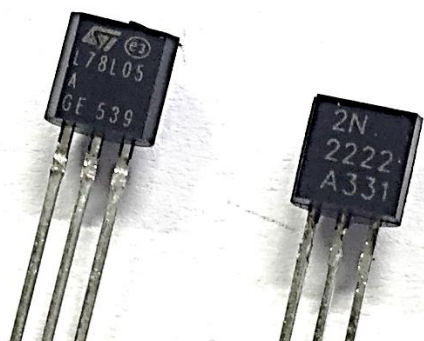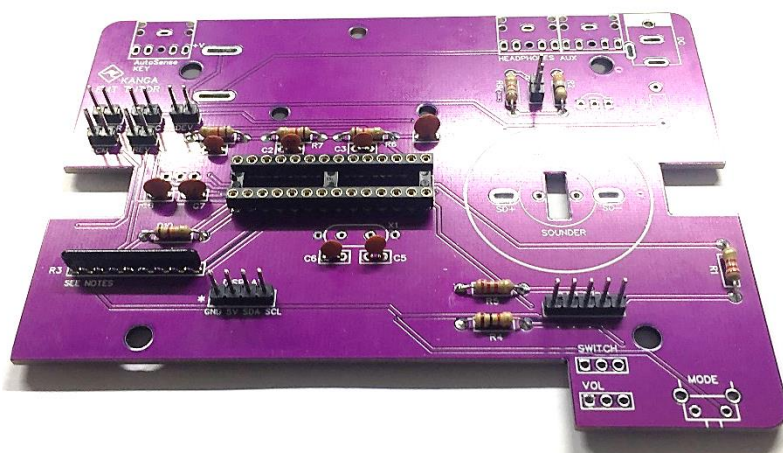
Now we have had a little practice soldering we can move onto the more sensitive parts, we will fit the voltage regulator and the audio amplifier transistor next. Both these parts look the same but they are VERY different, they must be fitted the right way round and in the right place. The only visible difference is the writing on the flat side of the part.

The regulator (VREG) is marked 78L05 and the transistor is marked 2N2222. Carefully identify these two parts and fit as shown on the PCB. T1 = 2N2222 and VREG = 78L05. Only push these down to a comfortable height of around 5mm of lead showing, do not try and push them right down on the board or you will damage them.

VREG   2N2222

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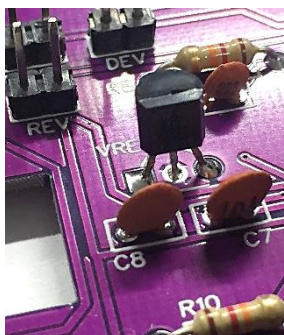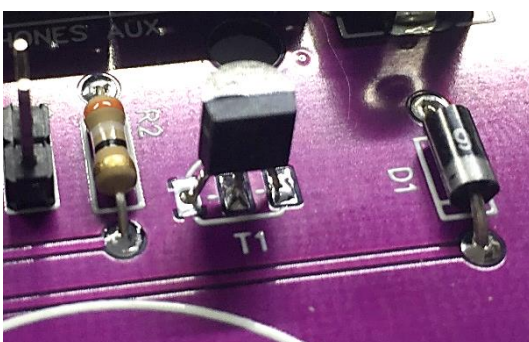
Now fit D1, the 1 amp diode as shown in the second photo above. Make sure it's fitted the right way. Check the band on the diode points towards the front of the board.

The next part to fit is the small quartz crystal, this is used to give accurate timings for the processor. The processor is running at 16Mhz. The crystal can be fitted either way round.

You will see two small holes either side of the crystal, these are grounding points for the crystal but in this circuit extra grounding is not needed, if you feel happier doing so feel free to add soldered ground wires to the top of the crystal to one or both of these points. BUT this is not necessary !
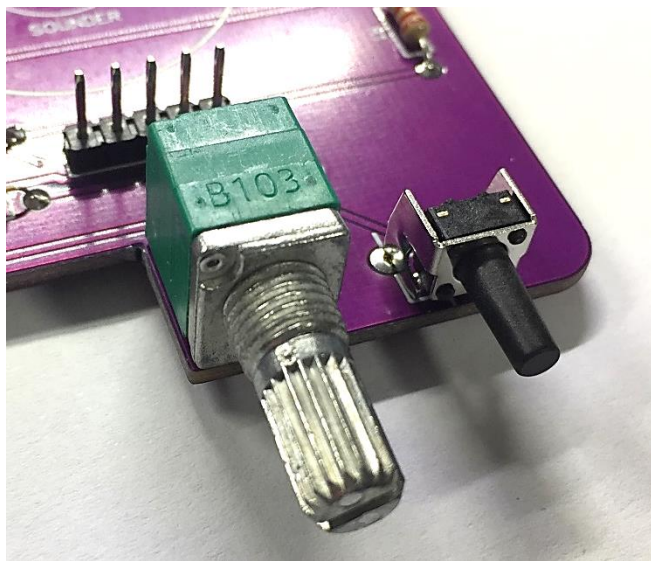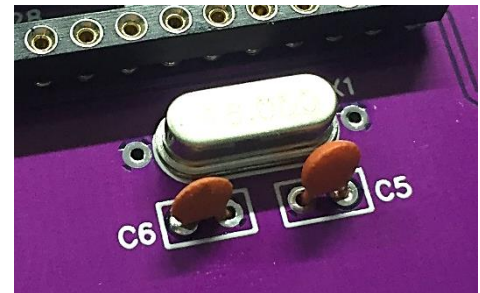
Now we can fit the power control and the small mode push switch. IMPORTANT NOTE Follows

The combined volume and power switch should be fitted onto the main PCB but before you do you will need to remove the Tab from the body of the pot, it will snap off easy, I use my cutters and try and bend the tab, it will snap off without much effort.
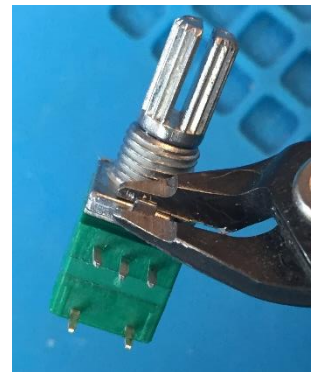
Now fit the mode switch, this fits next to the volume control on the PCB. Make sure it is sitting nice and flat onto the PCB.

We next can fit the 3 x 3.5mm jack sockets and the DC power socket on the rear edge of the board, these sockets can only be fitted one way, just make sure that they are all pushed down flat onto the board and sit nice and square. Take care you do not form solder bridges between any pins as some are rather close to each other.

The battery holder is next, cut the leads from the holder to about 20mm, strip the ends of the wires by 3 mm and twist/ tin the ends, solder the wires in place
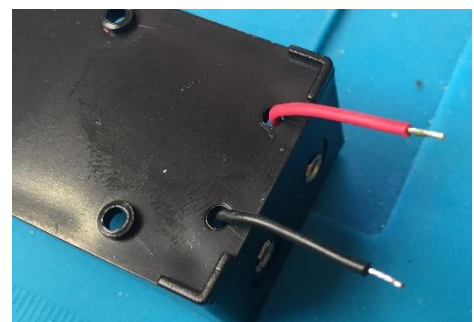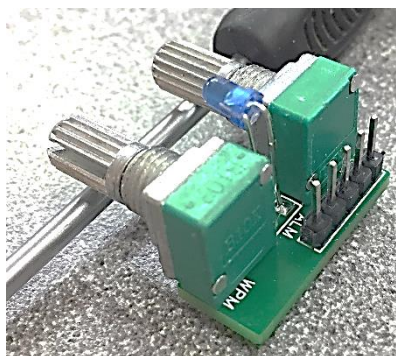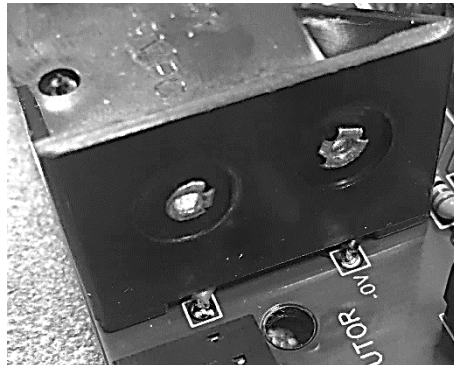
Follow the layout silk screen shows where each wire needs to go.
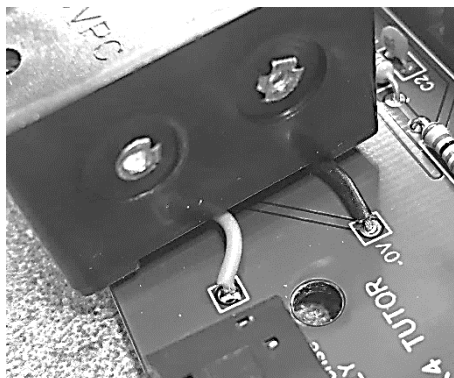
Then position the holder so the wires are under it and secure in place from the BOTTOM of the board with the three small black self-tappers provided.

Now we need to build up the small control PCB board.

Fix the 5 Pin Header to the board, you will have a new 90 degree bent pin version. Make sure the bent pins are pointing towards the back of the board NOT towards the position for the two controls or you will not be able to plug a cable onto them.

Next fit the two 10K control potentiometers on the board, You **MUST** break off the small tag on each of these controls as you did for the volume control before. Finally, the blue LED. It may be worthwhile NOT fitting that just yet as it needs to be the right height to fit into the hole on the front plate, we will come to that in a moment.

Next move onto the front panel. These are the parts you will need for this stage

Fit the LCD module as shown below. Make sure that you put the small white spacers between the panel and the LCD display or the display will not sit correctly. Before fitting the display module you will see its 4 connection pins are bent over by 90 degrees. You will need to straighten these pins. Use a pair of pliers and **carefully** bend the pins back to the upright position. Make sure they are nice and straight and all the same distance apart.

Now attach the small PCB to the front panel. Bend the LED so that it can protrude through the small hole between the GAP and WPM controls. The LED as two leads, one longer than the other, the long pin goes into the ROUND pads hole. Once your happy with the position and height of the LED solder it in place and trim the leads.

Note the pins on the display module in this picture. They are sticking out straight. Are yours??
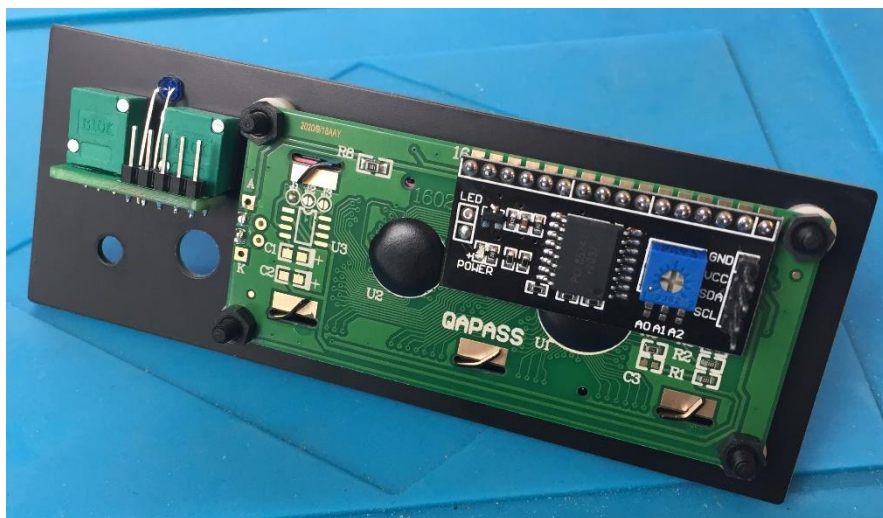

Now fit the front panel loosely to the main PCB, don't tighten this up at this time.

If all looks good it's time to fix the speaker. We have left it till now because the speaker attracts just about every bit of off cut wire it comes near, the magnet inside causes this. So before you fit it have a clean-up on your work bench!

The speaker has Positive side (look at the bottom of the speaker) this side should go nearest to the processor Chip. Find the bottom part of the case and the back panel. Hold the back panel in place next to the back of the PCB and lower the lot into the case base. Now use the 4 small self-tappers to secure the PCB into the case.


Now is time to fit the Processor chip, it will be on an anti-static foam pad. Look carefully at the chip and you will see a small dot near one pin. This is Pin 1, make sure this end of the chip is nearest to the small voltage regulator.
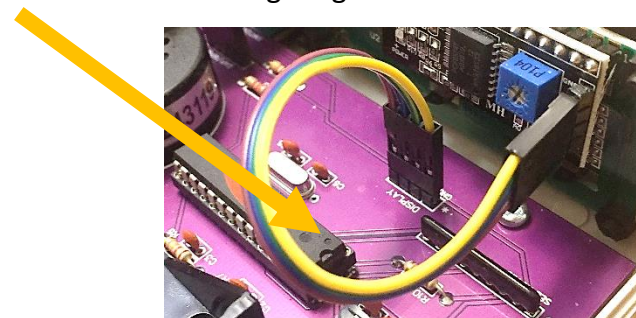
Next we need to fit the cables between the board and the front panel. The first is for the display, take the 4 way cable that came in the kit and plug it onto the main PCB.

The other end of the cable connects to the piggy back board on the display, it will only work one way round. Look at the pictures above to show you the correct way to fit the cables.
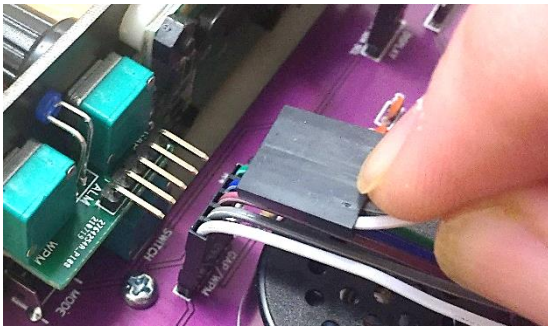
Then you need to fit the control cables to the GAP/SPEED PCB use a 5 core cable for this.

Fit the 9v Battery and turn on the tutor, the blue LED should flash briefly and the display will light up. The text on the display may be faint (or even not there at all!) or just a row of black squares. Adjust the small blue trimmer on the back of the display board to set the display to your liking.

By Now you should also be hearing the sweet sound of Morse Code. Press and release the mode switch should allow you to move from one mode to another, the volume, gap and speed controls should also be working.

If the display is not working check you have put the 4 way display cable the right way round. Same for the controls. If all ok turn off and fit the top case and use the two long case screws to fix the two half's together. Use the 4 stick on feet on the bottom of the case

You have completed the Tutor, good job!

Using the FMT

Now How to use it. Most of the controls do not need any real explanation, the only thing you may have a problem with is the practice oscillator.

You can leave a key plugged into the tutor at all times if you wish, but to activate the practice mode you will need to turn off the tutor and depending on the key type (Paddle or Straight) you will hold down the straight key (or press the left hand paddle) and turn on the tutor, continue holding the key until you see the sign on message. The tutor will then read the key input and switch to practice mode. There are no options in straight key practice, press the key and the unit will emit tone as you would expect, if it's a paddle key the display will show the approx. WPM rate it is set to (adjusted by the WPM control on the front panel) .

When finished using this practice mode turn off the tutor, next time you turn it on it will just return to tutor mode unless you are holding the key at power up.

The MK4 also has a fixed low-level output. This output is a sine wave so it sounds better when fed into a separate amplifier or computer (your choice) this will allow you to use software such as CW get, fldigi or many others (links on my website on the 'Links' page) to decode your own sending as the tutor does **not** have a built-in decoder. Also, this can be used over the internet for CW train via Zoom etc.

The only other options you may want to play with are the jumpers on the main PCB.
The jumpers are labelled as HYPER, ACM, H/S, IAMBIC, REV and DEV.

The Hyper jumper will control the max speed of the tutor, not for the faint hearted! About 50 WPM max with this enabled.

The ACM jumper is for the Advanced Contest mode. In this mode the tutor will randomly adjust the speed and pitch when in contest mode to make things more realistic.

Next is the H/S jumper, The AF output socket on the rear of the tutor can drive an external speaker at much higher volume levels than the built in one. That's fine but with headphones it's very loud. The Jumper here when removed reduces the max volume at the socket and is more suitable for headphones, if you intend to only use the socket for headphones its worthwhile removing this jumper (if fitted).

The Next jumper, IAMBIC selects Iambic A or B mode in the practice oscillator, jumper on is Iambic 'B' off is 'A'. The jumper marked REV is to switch from standard right handed paddle use to left handed, the finial jumper marked DEV (for development) is currently not used. If I add more features later this may be needed (features can be added by changing the plug-in chip at some later time)

One thing I get a number of emails about is the Blue LED, 'it doesn't stay on' that's what I keep getting told. This LED will come on after 10 mins of tutor use. It will come on and remain on for only 10 seconds. After that it will go off again until another 10 minutes as past. It's an indicator that it's time to take a break not a power on LED. It will also come on when you turn on the tutor as a power on check and also

when you press the mode switch to show it has accepted you change mode request just before the mode changes.

There is a sperate USER GUIDE that gives much more information on how to use the tutor and all the other features it has (like a built in 39 lesson Koch tutor and Prisoner of War Tap Code emulator/Trainer)

I hope you enjoy building the new FMT tutor and that you find it helps you learn the Code. The Koch mode is particularly good for beginners.

Consider joining FISTS CW Club you will get a warm welcome and encouragement/support to help you to learn the code.

73 Paul M0BMN