FRG-7 *Digital*

Installation Manual

Manual Version 1.2
Software version 1.4x
Marcel Jacobs
PA8MA

Introduction

The Yaesu FRG-7 is a communications receiver, produced in the late 1970s and early 1980s. The range is from 500 kHz to 29.99 MHz. The FRG-7 is a triple conversion super heterodyne receiver. The tuning is based on the Wadley Loop principle, which was revolutionary at the time.
In addition to Yaesu, it was also sold under the name Sommerkamp and Sears.
The frequnecy readout is based on an analog scale.

It is still a nice receiver that is worth the money. Due to its analogue structure and good documentation, a lot can be done yourself, such as modifications and repairs.

An option that was released at the time by the Gilfer company, among others, was a digital readout. This replaced the drum of the analogue readout, which was a big modification.
Since this is no longer available, many hobbyists have made their own internal or external readout.
Nowadays you can also have a frequency counter from China for little money.
Because these counters still have their limitations, especially when using SSB, I designed the FRG-7 *Digital* . This is based on an Arduino Nano.
The goal is to keep the FRG-7 as original as possible without major mechanical interventions.
The modification must also be easy to undo, so that it can be returned to its original state.
The readout should indicate the correct frequency for AM, LSB and USB. This also applies to receivers with an extra narrow SSB filter and a modified BFO.

That's why I chose to place the readout at the position of the S-meter. Because there is no longer an S-meter, the readout has also been given a digital S-meter in addition to the frequency.
For readability, a high-contrast color TFT screen was chosen.

This manual describes in steps how the FRG-7 Digital can be installed and adjusted.
The existing mounting points in the FRG-7 are used.
In principle, no additional measuring instruments are required for installation. Because the clock frequency of each Arduino Nano may differ slightly, the counter is equipped with a calibration routine. The ready-made readouts are pre-calibrated to a very stable and accurate reference. This is stored in the EEPROM.
The S-meter routine includes the AGC characteristic of the FRG-7. It is calibrated on this basis. A signal generator with a defined output level would be helpful. This will be described in more detail.

NB!

The housing of the radio was removed during installation and adjustment. This means there is a possibility that one could come into contact with the mains voltage. One must always be aware that one is working well-considered and safely.

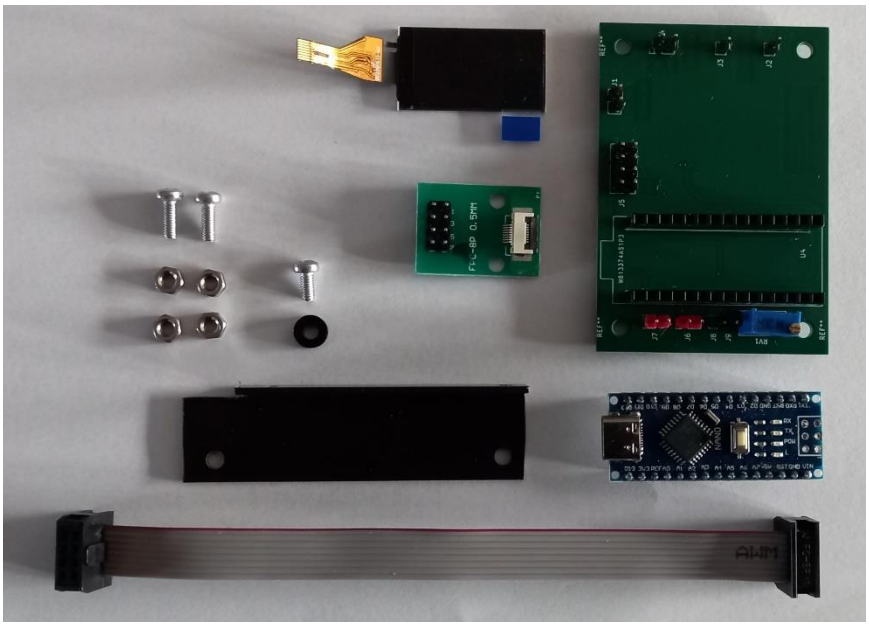
Contents

1 Built-in FRG-7 Digital

1.1 Package Contents FRG-7 Digital

The package for creating the digital readout on the Yaesu FRG-7 consists of the following parts:

- Double sided PCB with pre-programmed and calibrated Arduin Nano
- 8-way flat cable with FC8 Pin Idc socket connectors on both sides
- 1.14 inch TFT display with FPC flat cable connection
- FPC adapter PCB
- Screw M3 6mm long
- Screw M3 8mm long, 2 pieces
- Nut M3, 4 pieces
- Spacer M3, 2mm high
- L-shaped profile, 70mm long



Picture 1 : Package content

You only need to add yourself some wires for power supply, S-meter signal, mode select and a piece of shielded audio cable for the VFO signal.

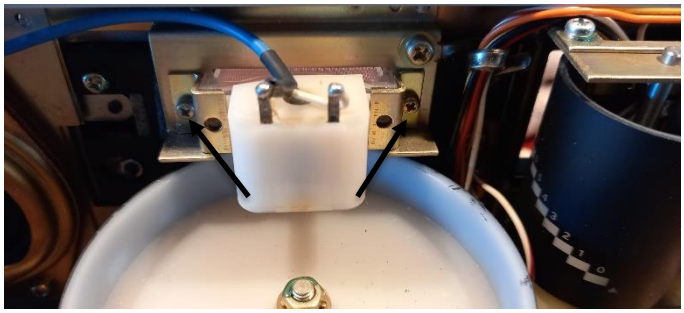
1.2 Disassembling S-meter

Unscrew the screws at the top, side and bottom (9 in total) and slide the chassis forward out of the housing. See picture 2 and 3.

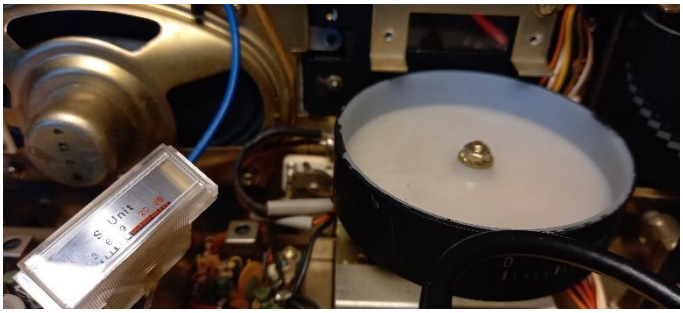
Picture 2 : Screws

Picture 3: Chassis

Now the S-meter must be removed. Unscrew the 2 small screws on the left and right of the meter. Keep the screws well. These will be needed again later.



Picture 4 : S-meter mounting



Picture 5 : Disassembled S-meter

The S-meter can now be removed. Leave the cabling in place.

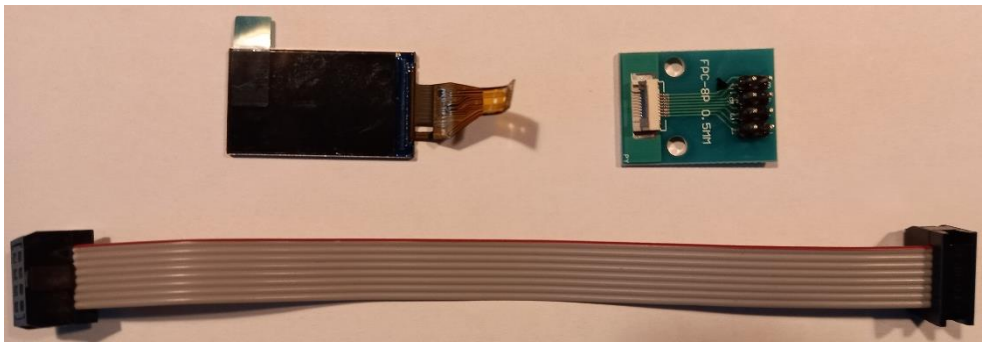
1.3 Digital display assembly

The digital display replaces the S-meter. Because there are no displays with sufficient resolution available with the dimensions of the S-meter, a larger 1.14 inch TFT display was chosen. This

causes part of the display to sit above the opening in the front. This has been taken into account in the display. There is enough space left to clearly display both the frequency and the S-meter.

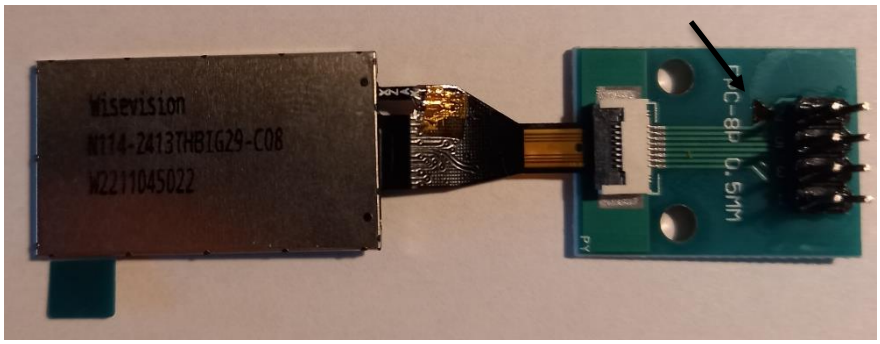
The display consists of 3 parts:

- 1,14 inch TFT display
- FPC adapter
- 8-way flat cable



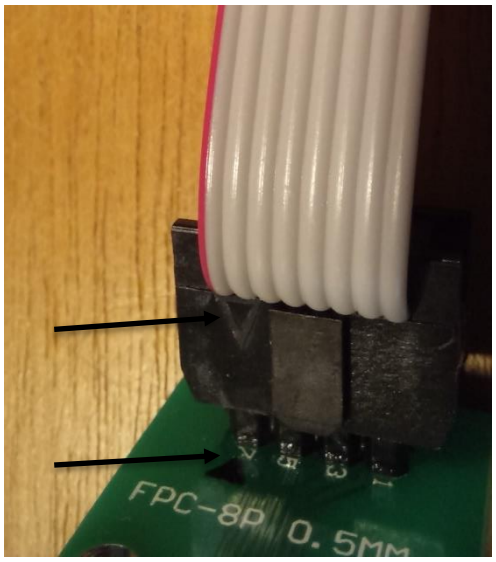
Picture 6 : Parts display

The display now needs to be connected to the FPC connector.
Carefully raise the black tab and slide the flat cable from the display with the contacts facing the PCB into the connector. Close the connector. The display is now face down. See picture 7.



Picture 7 : Display with FPC adapter

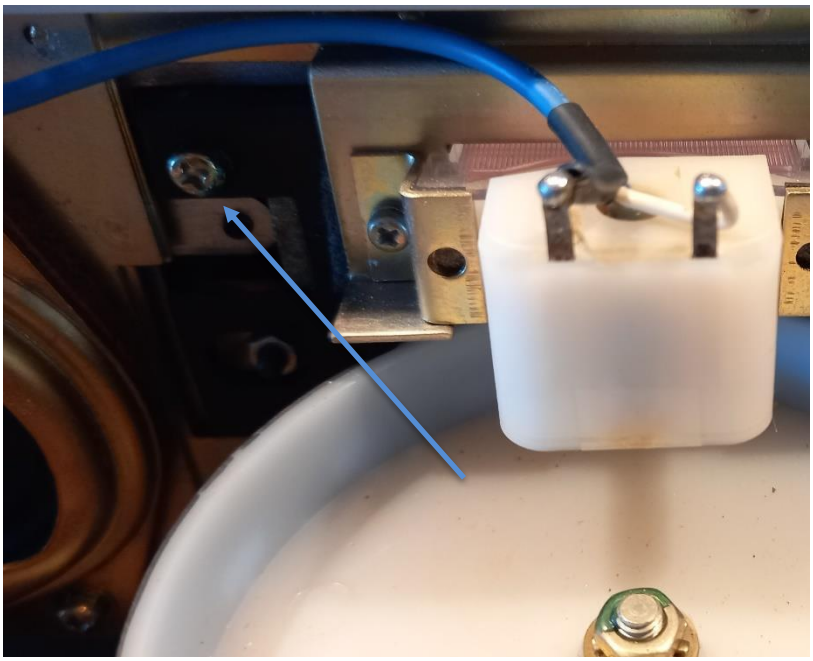
Now the 8-way flat cable can be connected. Note the marking, the black triangle (see arrow), near the connector on the FPC adapter. Such a mark can also be found on the connector of the flat cable connector. These must match.
You can also connect the flat cable after the PCB has been mounted.



Picture 8 : Flat cable with FPC adapter

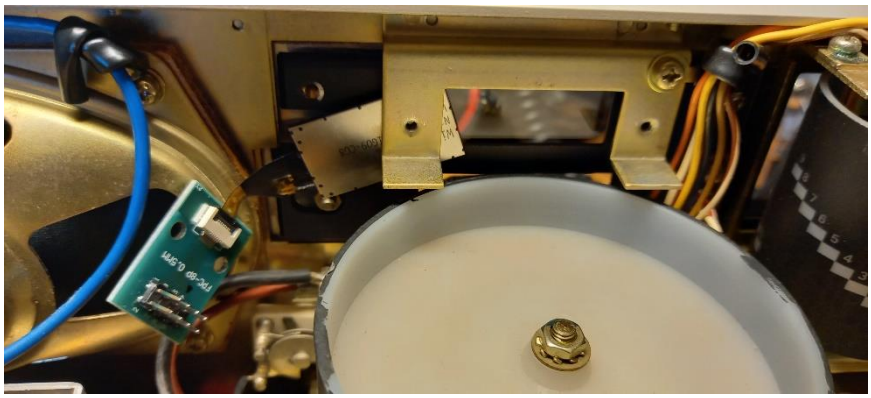
1.4 Placement of TFT display

The display can now be placed in the window of the S-meter.
First a screw must be removed (see picture 9) for mounting the FPC adapter.


Picture 9 : FPC mounting positie

This M3 screw cannot be reused because it is too short. Replace this with the supplied 6 mm long M3 screw. The supplied plastic spacer of 2 mm thickness must also be used for mounting. This will be described shortly.

First remove the screen protector from the TFT display.
Slide the display from the left between the S-meter holder and the window.


Picture 10 : Mounting display


Picture 11 : Position display

Because the display is higher than the opening of the S-meter, the bottom of the display must be placed on the black edge. This will cause the display to tilt backwards slightly. However, this does not disturb the reading.
Now make sure that the display is in the middle of the window. This is best visible at the front. Then fix it with a piece of adhesive tape, as shown in picture 12.


Picture 12 : Display with adhesive tape

The adapter PCB can then be secured. Place the relevant plastic spacer under the PCB, so that no contact is made with the chassis.
Turn the PCB in such a way that the flat cable of the display has as little mechanical resistance as possible.

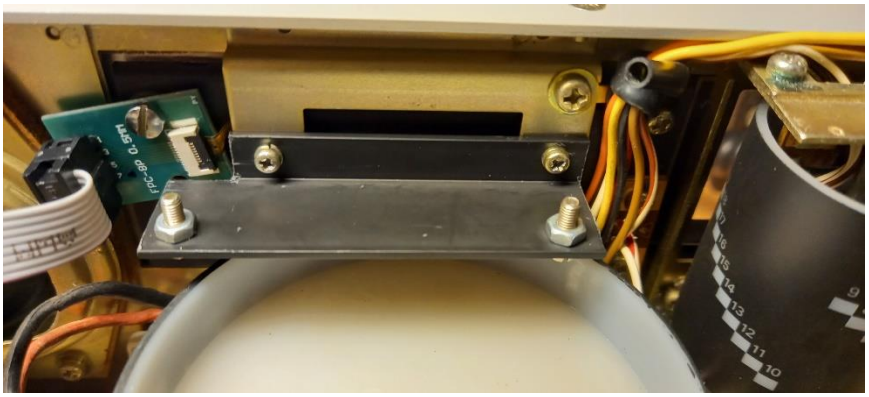
Picture 13 : FPC print assembly

If the 8-way flat cable was not yet connected, this can now be done. Pay attention to the marking on the PCB and the connector of the flat cable. See picture 8.

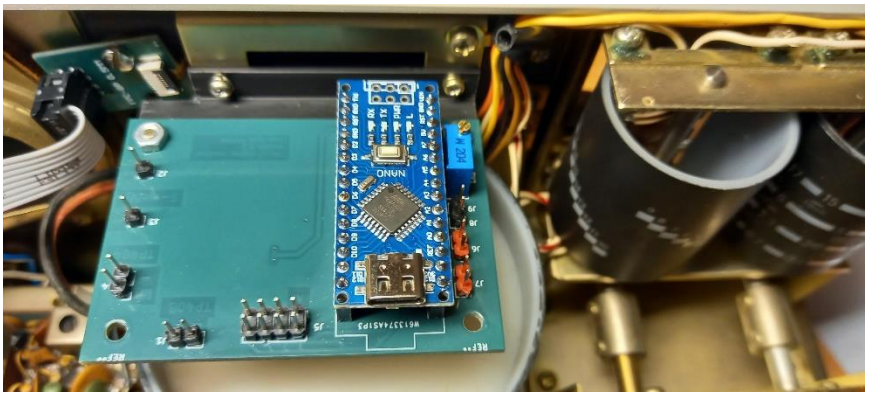
Because the display does not cover the entire opening of the S-meter, some light from the scale illumination will remain visible in the window. If necessary, this can be covered by placing a piece of black paper the size of the window behind the display. This can be stuck to the back of the display with double-sided tape.

1.5 Arduino nano and board assembly

Place the Arduino Nano carefully in the socket, as can been seen in picture 15.
The Arduino PCB will be mounted in place of the S-meter using the supplied L-profile.
Remove the top nut from both M3 bolts. These will be used to secure the Arduino board.
Now mount the L-profile in place of the S-meter using the original screws of the S-meter.


Picture 14 : Mounting L-profiel

Then mount the Arduino PCB on the 2 bolts and secure them with the nuts.



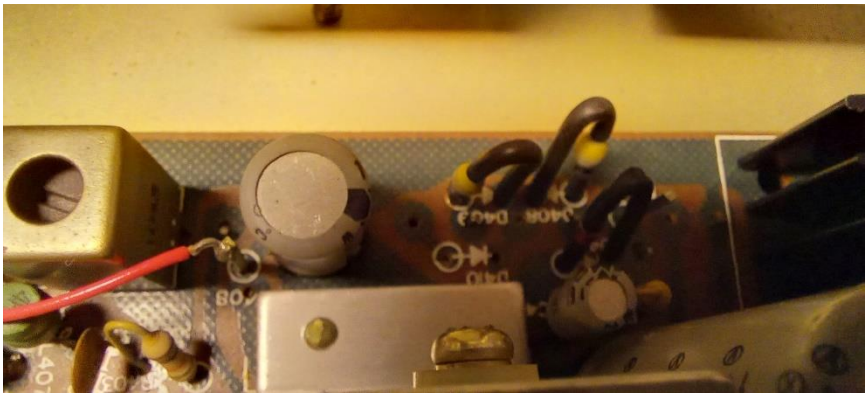
Picture 15 : Mounting PCB

The mechanical installation is now complete. You can then start making the necessary connections.

2 Wiring

2.1 Power supply

The readout uses the power supply within the FRG-7. This power supply point can be found on the IF-AF unit with reference TP408 (on the edge near the cooling profile). This is approximately 10.6V.

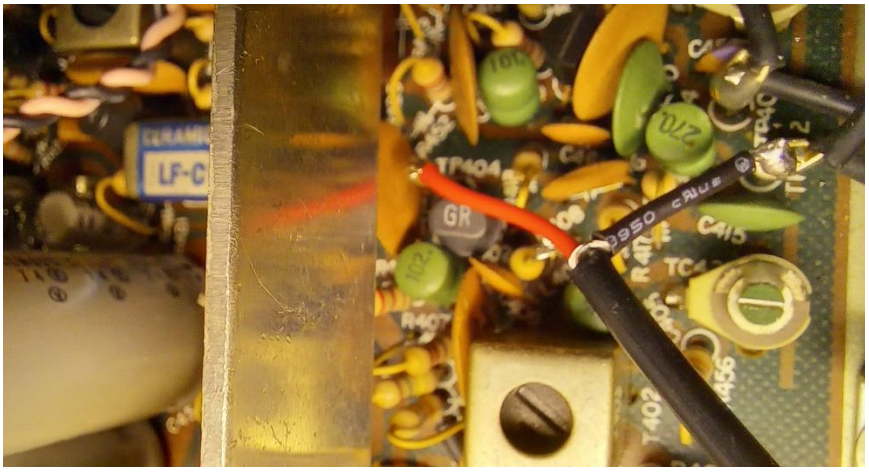


Picture 16 : Power supply FRG-7 TP408

Now make a connection between TP408 and the + of J1 on the PCB. The ground may also be connected (- at J1), but is not necessary, because the ground is also connected to the input of the frequency readout and the S-meter.

2.2 VFO signal

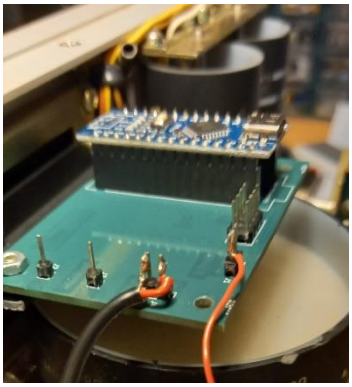
For the correct reading, the signal from the VFO is taken from the IF-AF unit at a test point. This is test point TP404.



Picture 17 : VFO signal TP404

Because this is a high-frequency signal, the connection must be made with a piece of shielded cable. This can be a shielded audio cable. The shielding can be connected to TP402. This is a ground point to which several cables are connected.

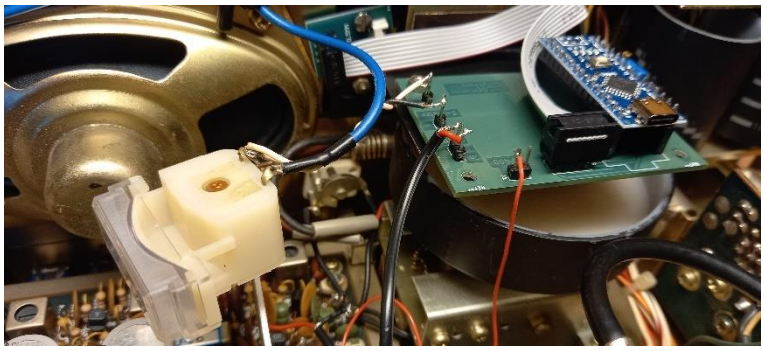
Connect the shielded cable to J4. Note the + and -.



Picture 18 : VFO on J4

2.3 S-meter

Because the display replaces the S-meter, the uC must ensure the correct reading. For this purpose, the signal from the S-meter is connected to the PCB at point J2 (signal) and J3 (ground). Leave the S-meter connected and connect the PCB and the S- meter with 2 cables. This is necessary to adjust the S-meter of the digital readout.

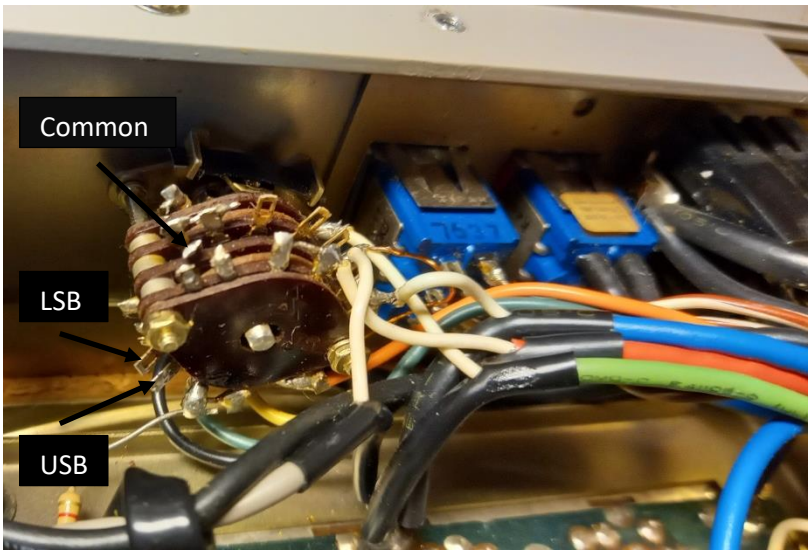


Picture 19 : S-meter connection

2.4 LSB and USB readout

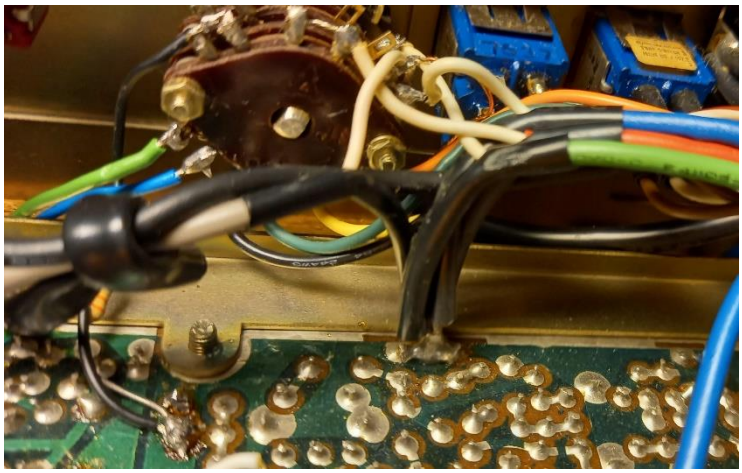
Modern receivers take into account the frequency shift when switching from AM to LSB or USB. In order to have the correct reading on the FRG-7, this is arranged by the uC. In addition, you can set the required offset yourself. This will be described later in the adjustment.
This frequency shift is optional. Without this application, the display will always show the AM frequency.

If the frequency shift is used, it must be detected which mode has been selected. A free position on the MODE switch S2 can be used for this purpose.



Picture 20 : MODE switch S2

The COMMON connection must be connected to earth. There are plenty of options for this on the bottom of the IF-AF unit.
The LSB tab is connected with a cable to J8 on the PCB of the FRG-7 Digital. The USB tab is connected to J9 on the PCB.

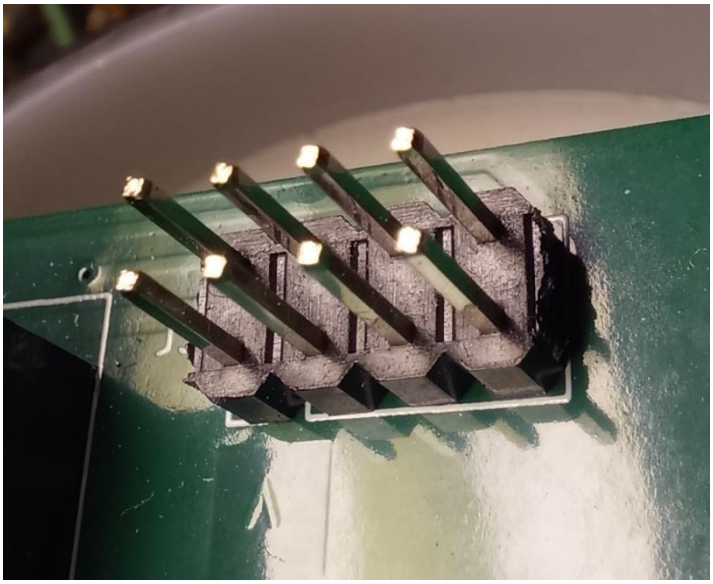

Picture 21 : S2 connected

Picture 21 shows the connections. Black for ground and green and blue for LSB and USB respectively.

2.5 Display

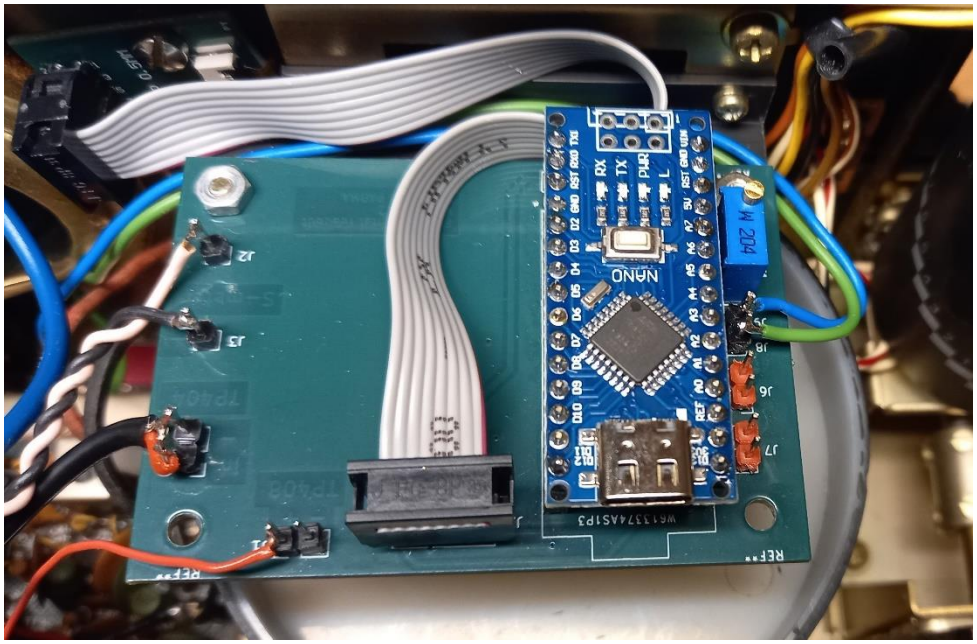
Once all previous connections have been made, the display can be connected to J5.
There is again a marking on the print. This triangle must correspond with the triangle on the

connector of the flat cable.



Picture 22 : Connector marking

If everything is connected correctly, the total will look like this.



Picture 23 : Total overview

3 Using FRG-7 *Digital*

Once everything is connected, the radio can be turned on. Once again, make sure that you do not come into contact with the mains voltage.

The display will start up with the logo and then show the frequency and S-meter.
Since the frequency counter has already been calibrated, this is immediately the correct frequency.
This may differ slightly from the analogue display. Especially because you can move the indication with the “dial” button. The frequency progression is also not exactly linear over the entire range.
Because no offset for LSB and USB has yet been set, the MODE will not be visible on the display.

You can now start further adjusting and setting the digital readout.

3.1 S-meter adjustment

The analog S-meter has now been replaced by a digital S-meter. Because an analog S-meter has a certain inertia, this has been incorporated into the digital version. The characteristic of the AGC of the FRG-7 has also been included. As a result, the S-meter values will better correspond to the correct voltages on the antenna input.

Adjusting the S-meter can be done in two ways. Using a strong signal from a broadcast transmitter or using a signal generator.

3.1.1 Adjustment with a broadcast transmitter

Tune to a strong shortwave broadcasting station so that the analog S-meter reads at least S9.
Try to get the needle to S9 by turning the PRESELECTOR.
Now use a thin screwdriver to adjust the ten-turn potentiometer RV1 such that the digital S-meter is at S9.

3.1.2 Adjustment with a signal generator

Connect a signal generator to the PL-259 connector. Set this around 15.5 MHz. Do not use exactly 15 MHz or another whole frequency, because then a problem arises with the harmonic of the generator in the FRG-7.
Set the signal to -73dBm (50.2uV @ 50 Ohm) without modulation. This is the signal strength of S9 at an HF receiver.
Tune in to this in AM mode and peak the PRESELECTOR on this signal. The analog S-meter will now also read approximately S9.
Now use a thin screwdriver to adjust the ten-turn potentiometer RV1 such that the digital S-meter is at S9.

3.1.3 Replacing analog S-meter

If desired, the analog S-meter can be left in the FRG-7 and secured with a cable tie.

If you do want to remove it, the S-meter must be replaced with a 640 Ohm resistor. This can be done, for example, by connecting 560 and 82 Ohms in series. This resistor should be soldered over J2 and J3.

3.2 Display brightness

The TFT display has a very high contrast and brightness. Since such brightness is not always desired, it can be dimmed.
To do this, close jumper J6. After the version information, a completely white screen will now be visible.

Picture 24 : Display setting

By briefly closing jumper J7 you can choose a bright or dim display.
As soon as jumper J6 has been removed, this choice will be stored in the EEPROM.

3.3 Offset AM

The FRG-7 is based on a very stable Wadley-Loop system. After mixing several signals, the last IF frequency of 455 kHz will be generated. Sometimes this frequency is not exactly 445 kHz, but a few kHz off. With the analog scale, you probably won't notice this. But with the digital readout you will see that when the VFO is set to the frequency of an AM station, the signal is not in the middle of the IF filter. You have to change the frequency of the VFO maybe one or two kHz to get the signal in de middle of the filter. This is due to deviation in the oscillator signals in the FRG-7.
By varying the tuning up and down around the AM station, you can hear where the middle of the filter is.
Therefor an offset for AM is available in this digital readout. It will compensate this deviation.

Notice :
You only have to do this when you notice that the AM station is a little bit of the centre of the IF filter. Otherwise you can leave the AM offset to zero.

This offset will be used also for the correct LSB and USB indication.
It is advisable to do this before you start the offset procedures for LSB and USB.

To set the offset for AM, the following procedure should be followed carefully.

- Tune to a strong AM shortwave broadcast station. These are in a 5 kHz grid. Make sure the frequency readout ends with XX0.0 or XX5.0.
- The MODE switch should be on AM. The station is audible but not in the middle of the filter
- Switch off the FRG-7
- Place jumper J7
- Switch on the FRG-7
- After startup the following screen will appear

Picture 25 : Start AM offset

- Close jumper J6. The display will now show the offset

Picture 26 : AM offset at start

- Now tune the station to the center of the IF filter.

Picture 27 : AM offset during setting

- When done, remove jumper J6
- This setting is now stored in EEPROM
- Next, the display shows that jumper J7 must be removed.

- Once removed, the correct frequency for the AM station, tuned to the middle of the filter, will be shown on the display.

3.4 Offset SSB

To use the offset setting for LSB and USB, this option must first be wired as described in chapter 2.4.
As long as this option has not been activated, no MODE indication will be visible in the display.

Picture 28 : Display without MODE indication

Because the BFO in the FRG-7 can be set for both LSB and USB, the offset can be different. Therefore, there are separate procedures for both SSB modes.

Important !!!

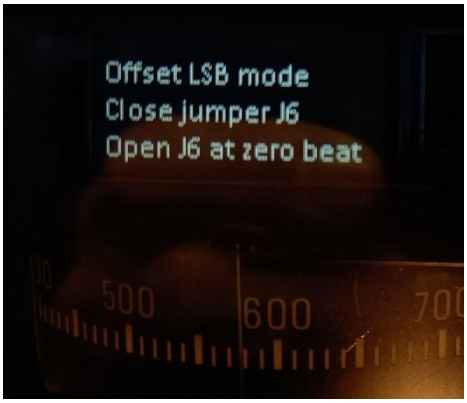
Before setting the offset, it is important that the FRG-7 is properly warmed up. The BFO is known for not being very stable. Make sure the FRG-7 is turned on for at least half an hour before doing this.
The offset will be stored in EEPROM after setting. It is possible to do this again at any time.
If you want to abort the procedure, first switch off the FRG-7 and then remove the relevant jumpers. Then turn the FRG-7 back on.
DO NOT leave jumpers in place during power-up. This can lead to unwanted situations.

3.4.1 Offset LSB

To set the offset for LSB, the following procedure should be followed carefully.

- Tune to a strong AM shortwave broadcast station. These are in a 5 kHz grid. Make sure the frequency readout ends with XX0.0 or XX5.0.
- Set the MODE switch to LSB. A tone will be heard.

- Close jumper J7. The following text appears on the display.



Picture 29 : Start LSB offset

- Close jumper J6
  The display will now show the offset.

Picture 30 : LSB offset at start

- Now adjust the tuning to zero beat on the broadcast station.

Picture 31 : LSB offset during setting

- Remove jumper J6
- This setting is stored in EEPROM
- Next, the display shows that jumper J7 must be removed.
- Once removed, the correct frequency for LSB will be shown on the display. The selected MODE will be shown as well from now on.

3.4.2 Offset USB

To set the offset for USB, the following procedure should be followed carefully.

- Tune to a strong AM shortwave broadcast station. These are in a 5 kHz grid. Make sure the frequency readout ends with XX0.0 or XX5.0.
- Set the MODE switch to LSB. A tone will be heard.
- Close jumper J7. The following text appears on the display.

Picture 32 : Start USB offset

- Close jumper J6
  The display will now show the offset.

Picture 33 : USB offset at start

- Now adjust the tuning to zero beat on the broadcast station.

Picture 34 : USB offset during setting

- Remove jumper J6
- This setting is stored in EEPROM
- Next, the display shows that jumper J7 must be removed.
- Once removed, the correct frequency for USB will be shown on the display. The selected MODE will be shown as well from now on.

After setting the offset, the mode is now also visible in the display.

Picture 35 : AM mode

Picture 36 : USB mode

3.5 Offset removal of AM, LSB and USB

Sometimes it can be necessary to remove all the offset values, stored in EEPROM.
The next procedure will make them all zero again. Also the mode indication on the display will disappear, because no LSB or USB offset has been programmed.
The brightness setting of the screen and the calibration value will remain in EEPROM.

To make these values zero, the following procedure should be followed carefully.

- Switch off the FRG-7
- Place jumper J6 and J7
- Switch on the FRG-7
- After startup the following screen will appear

Picture 37 : Reset offset

- After 4 seconds this text will disappear and jumper 6 must be removed
- Next jumper 7 must be removed

Now the offset values are set to zero and stored in EEPROM.

4 Counter calibration

The accuracy of the frequency display depends on the crystal frequency of the Arduino Nano. Since this can differ per copy, a calibration routine is included in the software. This will calculate a calibration factor, based on an expected accurate reference signal and the measured value and store it in EEPROM.

Each Arduino Nano of the FRG-7 Digital is already calibrated, based on a highly stable and accurate signal generator from Rohde & Schwarz. So it is not necessary to perform this routine again.
If you want to do this, you must have the correct equipment. An incorrect calibration will lead to an incorrect frequency display.

If you have decided to perform the calibration again, the following procedure must be followed.

- Make sure the FRG-7 with the FRG-7 *Digital* option is turned on for at least 30 minutes
- Turn off the FRG-7
- Disconnect the input signal on J4 from TP404
- Connect an accurate signal generator at this point
- Set this exactly to 3,000,000 MHz, -10 dBm output power and no modulation
- Close jumper J7
- Turn on the FRG-7

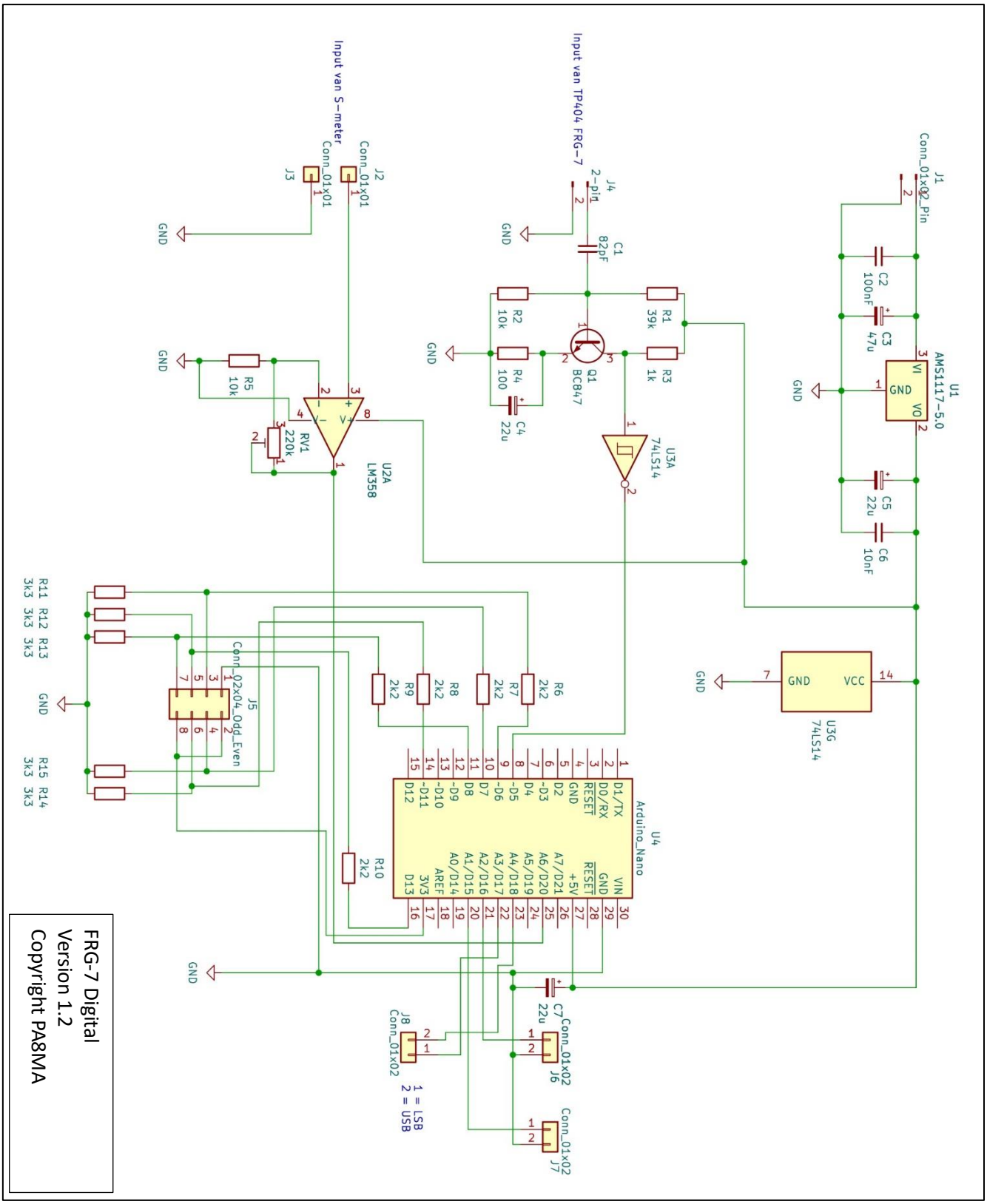
  The following text appears on the display

Picture 38 : Start calibration

- Close jumper J6 for a short time
- The counter starts the calibration routine.
- The display shows when it is ready and what the calibration factor is
- Calibration factor should be close to 1.00
- Once the routine is completed the frequency will be visible
- If “455.0” is displayed, the calibration has been carried out successfully
- Turn off the FRG-7
- Remove jumper J7
- Disconnect the signal generator from J4
- Reconnect the signal cable from TP404 to J4
- Turn the FRG-7 back on

The calibration routine described above can be cancelled at any time by switching off the FRG-7. If this is done after closing J6, the new calibration factor is already stored in the EEPROM.

5 FRG-7 *Digital* schematic



Picture 39 : FRG-7 *Digital* schematic