
850 – 870 MHz PLL RF Oscillator

Overview

This is a project for a simple 850 – 870 MHz PLL RF oscillator. It is frequency agile, using DIP switch parallel programming to choose any frequency between 850 and 870 MHz, in 25,000 Hz steps. You can use an old cellular phone's RF power module and antenna to increase the RF output power to around 3 Watts ERP. You can also salvage old cellular phone's PC boards for SMT resistors, capacitors, and other useful components.

The VCO used in this circuit is a [Z-Communications V580MC05](#). This exact model VCO isn't made anymore, but a suitable model is the V580ME10 or V708ME01. The PLL frequency synthesizer IC is the trusty Motorola MC145152. This PLL synthesizer IC uses *parallel* programming, so it doesn't require any microcontroller for frequency loading, just some DIP switches. The dual-modulus prescaler which divides the VCO's RF output, is a Fujitsu MB501. This particular divide-by-64/65 prescaler can be hard to find. A suitable replacement is the Motorola MC12022B. The main reference crystal is a 12.8 MHz Temperature Compensated Crystal Controlled Oscillator (TCXO). This is a bit of overkill, but helps maintain the oscillator's stability during any dramatic temperature changes. The PLL's loop filter is based around a OP27 op-amp, the LM351 or MC33171 will also work. Also, the loop filter's component values are determined from the characteristic of the V580MC05 VCO. If you use a different VCO (with a different MHz/V value) you may have to adjust the loop filter values. E-mail GBPPR staff if you need any help doing that. The other support components are not really critical.

PLL Synthesizer Programming

Note: You'll want to study the datasheet for the Motorola MC145152 before reading this section.

Programming the Motorola MC145152 *Divide-by-N* and *Divide-by-A* counters looks complicated at first, but really isn't that hard. Here an example of what to do:

The VCO RF output frequency you want : 857.750 MHz

Your **Reference Crystal** is : 12.8 MHz

You want a **Reference Frequency** of 25,000 Hz, so you divide the **Reference Crystal** by 512 (see datasheet).

Now it is time to determine the PLL's **N-Counter** and **A-Counter** ratios.

Divide 857.750 MHz by 25,000 Hz:

$$857,750,000 / 25,000 = 34,310$$

This is the **Main Divide-by-Ratio** you will use during loop filter calculations (not covered here).

Now divide 34,310 by 64, the MB501 prescaler's divide-by-ratio:

$$34,310 / 64 = 536.093$$

Round 536.093 down to 536.

The **N-Counter's** divide-by-ratio needs to be set to: 536

Multiply 536 by 64, the MB501 prescaler's divide-by-ratio:

$$536 * 64 = 34,304$$

Subtract 34,304 from 34,310:

$$34,310 - 34,304 = 6$$

The **A-Counter's** divide-by-ratio needs to be set to: 6

Verify the math:

$$(N * PRESCALE) + A = \text{Main Divide-by-Ratio}$$

$$(536 * 64) + 6 = 34,310$$

$$34,310 * 25,000 = 857,750,000 \text{ Hz (857.750 MHz)}$$

Now, to actually program these values into the Motorola MC145152, all you need to do is toggle the pins on the MC145152 either *high* (1) or *low* (0). Since the MC145152's divide-by-ratio pins are already pulled-high, when they are left open, they will be a logic "1". When they are grounded, they will be a logic "0".

So, to program our example N-Counter value of 536 and A-Counter value of 6, the programming would look like this:

PLL's N-Counter Programming Inputs

	512	256	128	64	32	16	8	4	2	1
-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
536	1	0	0	0	0	1	1	0	0	0
-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----

or mathematically: $512 + 16 + 8 = 536$

MC145152 Pin #	N-Counter Programming Inputs	(Datasheet Label)
-----	-----	-----
11	1	(N0)
12	2	(N1)
13	4	(N2)
14	8	(N3)
15	16	(N4)
16	32	(N5)
17	64	(N6)
18	128	(N7)
19	256	(N8)
20	512	(N9)

In this example:

Pins 20, 15, 14 would be left "Not Connected" (high or logic 1).

Pins 11, 12, 13, 16, 17, 18, 19 would be "Grounded" (low or logic 0).

Now, for our example A-Counter value of 6, the same basic thing:

PLL's A-Counter Programming Inputs

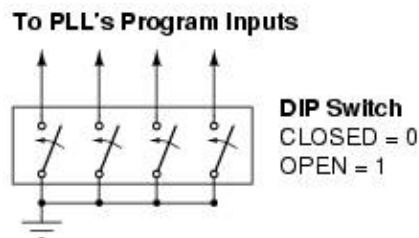
```
32 16 8 4 2 1
-----
6   0 0 0 1 1 0
-----
```

or mathematically: $4 + 2 = 6$

MC145152 Pin #	A-Counter Programming Inputs	(Datasheet Label)
23	1	(A0)
21	2	(A1)
22	4	(A2)
24	8	(A3)
25	16	(A4)
10	32	(A5)

In this example:

Pins 21, 22 would be left "Not Connected" (high or logic 1).
Pins 23, 24, 25, 10 would be "Grounded" (low or logic 0).



Here is an example of using DIP switches, or even regular SPST switches, to load the divide-by-ratio programming inputs on the MC145152.

Datasheets

12.8 MHz TCXO can be ordered from [Mouser](http://www.mouser.com), (<http://www.mouser.com>) or [Digi-Key](http://www.digikey.com) (<http://www.digikey.com>).

- [Z-Comm V580MC05](http://gbppr.digitaldropbox.com/mil/ccecm/V580mc05.pdf) (<http://gbppr.digitaldropbox.com/mil/ccecm/V580mc05.pdf>)
- [Fujitsu MB501 Dual-Modulus Prescaler](http://gbppr.digitaldropbox.com/mil/non/mb501.pdf) (<http://gbppr.digitaldropbox.com/mil/non/mb501.pdf>)
- [Motorola MC145152](http://gbppr.digitaldropbox.com/mil/non/MC145151-2.pdf) (<http://gbppr.digitaldropbox.com/mil/non/MC145151-2.pdf>)
- [Texas Instruments OP27 Op-Amp](http://gbppr.digitaldropbox.com/mil/non/op27.pdf) (<http://gbppr.digitaldropbox.com/mil/non/op27.pdf>)

Pictures



Picture #1

Overview of the entire oscillator assembly. It is built into an old Motorola "bag"-style cellular phone case. The stock cellular phone PCB is shown on top for comparison. The large black IC on the lower left is the MC145152. The large blue thing is the RF power module, with its shielding removed. The blue rectangle on the right side are the DIP switches. RF output is on the top right via the phone's stock mini-UHF connector and stock antenna.

Picture #2

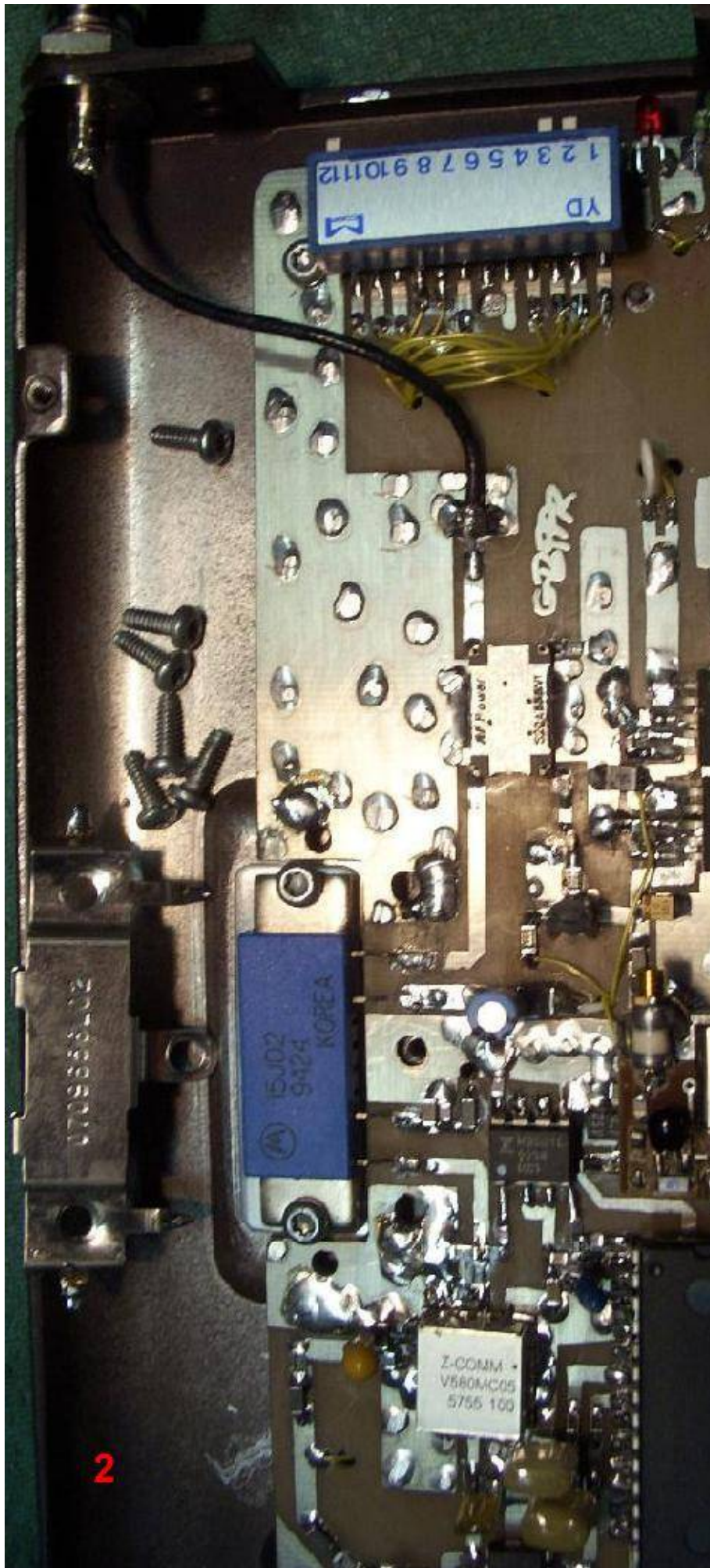
Close up picture of the RF power amplifier module and the RF output section. The RF output is going through an Anaren S20A888N1 20 dB directional coupler. The coupled side is then sent to a diode detector and transistor buffer to light an LED. This makes a useful "RF Output" detector, and is optional.

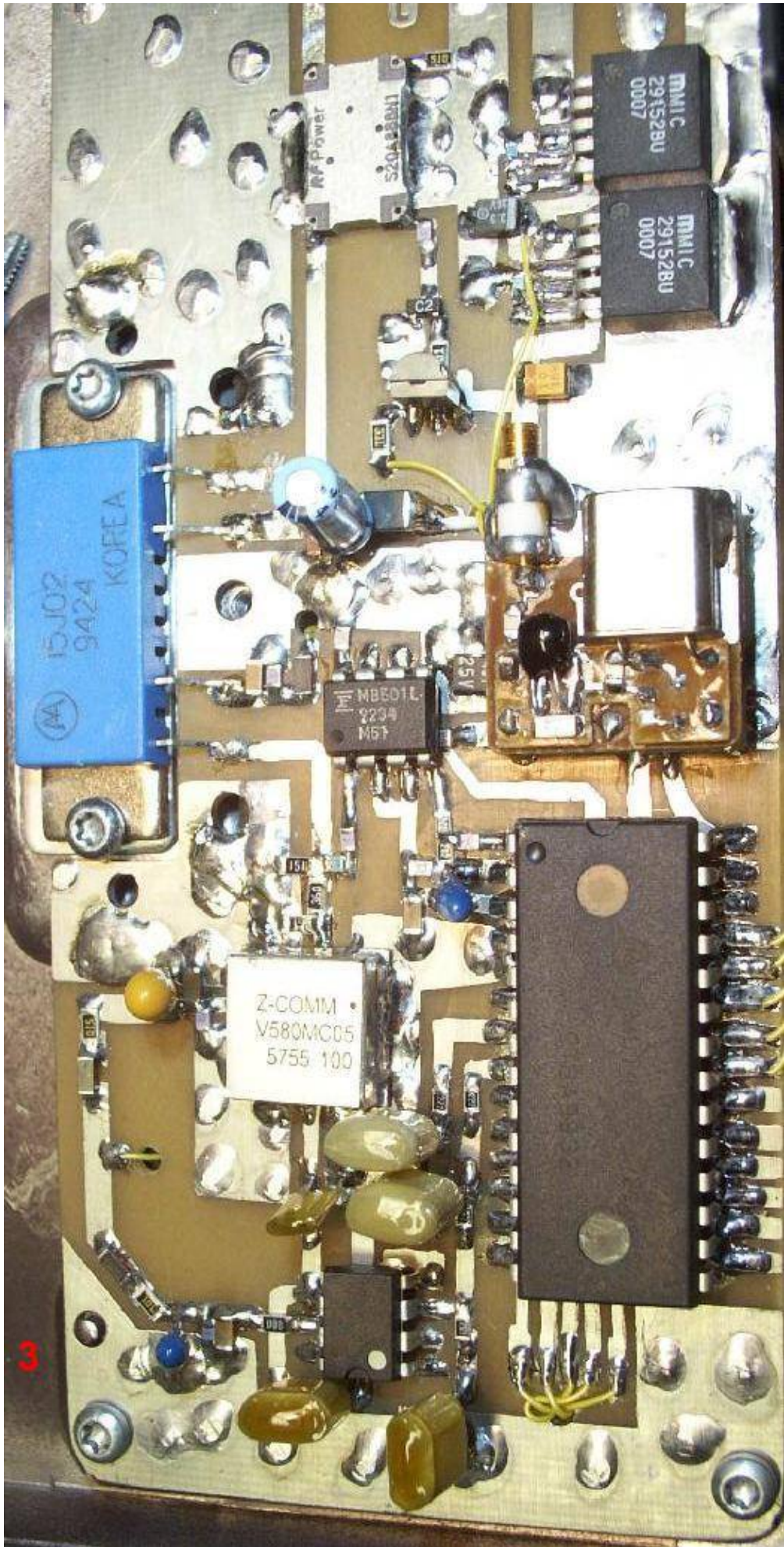
Picture #3

Close up of the synthesizer and VCO sections. Note that I took apart the TCXO to add a new, hi-Q variable capacitor. This also allows the frequency to be "tweaked" so the oscillator can tune inbetween frequencies. This modification is also optional. The two MIC29152s are the voltage regulators.

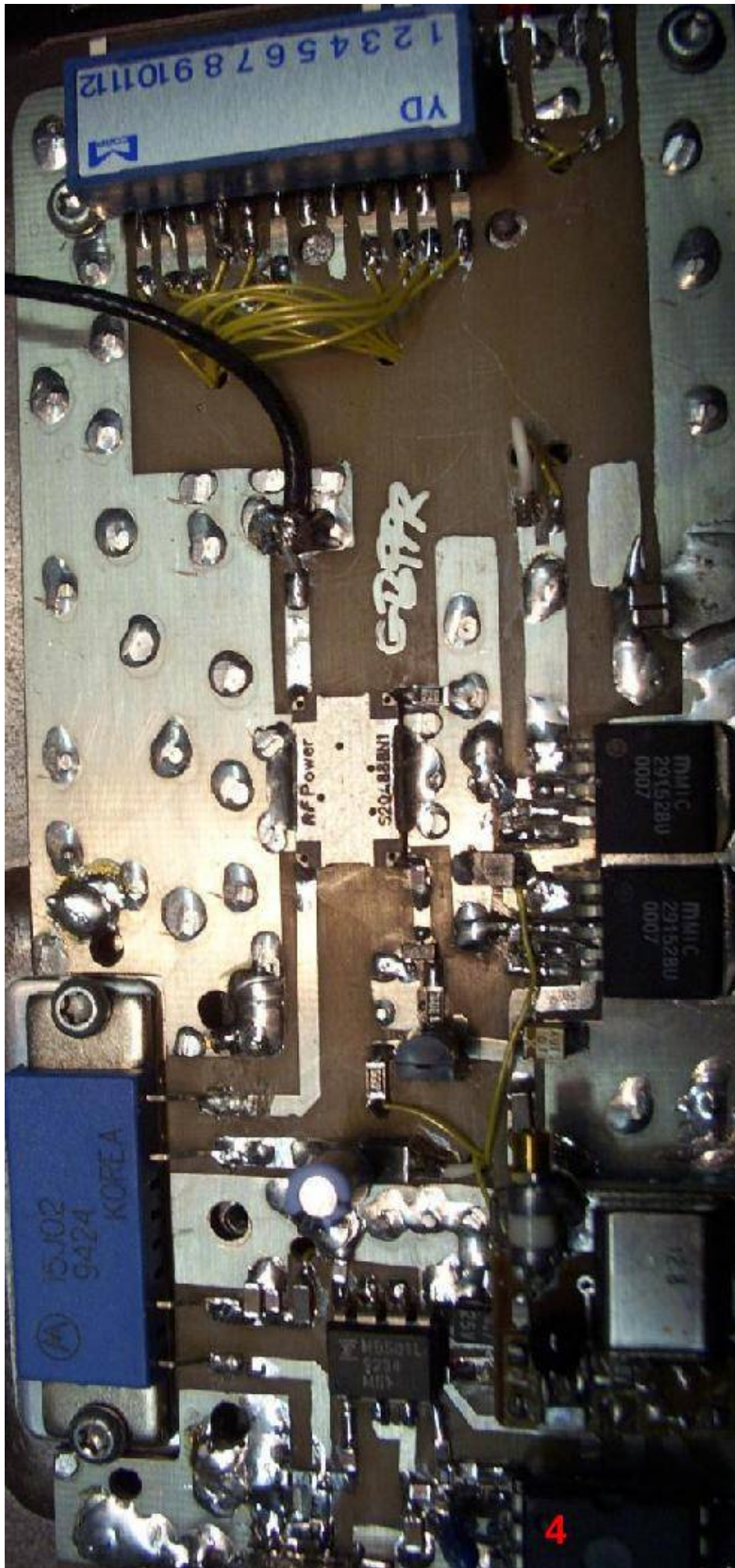
Picture #4

Additional picture of the RF output section, the programming DIP switches, and the "PLL Fault" and "RF Output" LEDs.

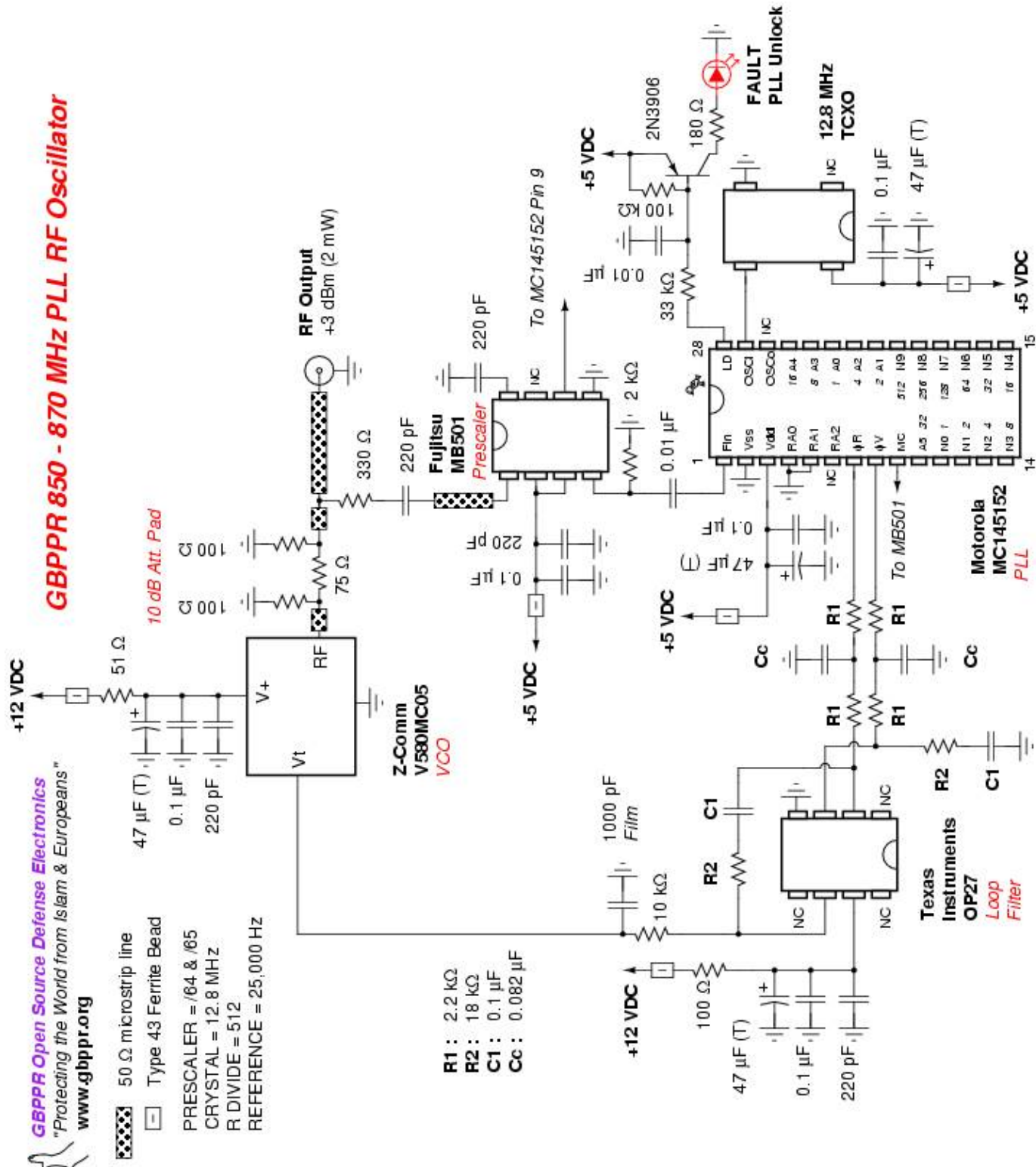




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GBPPR 850 - 870 MHz PLL RF Oscillator



- 50 Ω microstrip line
- Type 43 Ferrite Bead
- PRESCALER = /64 & /65
- CRYSTAL = 12.8 MHz
- R DIVIDE = 512
- REFERENCE = 25,000 Hz

- R1 : 2.2 kΩ
- R2 : 18 kΩ
- C1 : 0.1 μF
- Cc : 0.082 μF