

A PIC16F876 based, automatic 1.8 – 60 MHz SWR/WATTmeter

a project from "Il Club Autocostruttori" of the Padova ARI club

The project in short

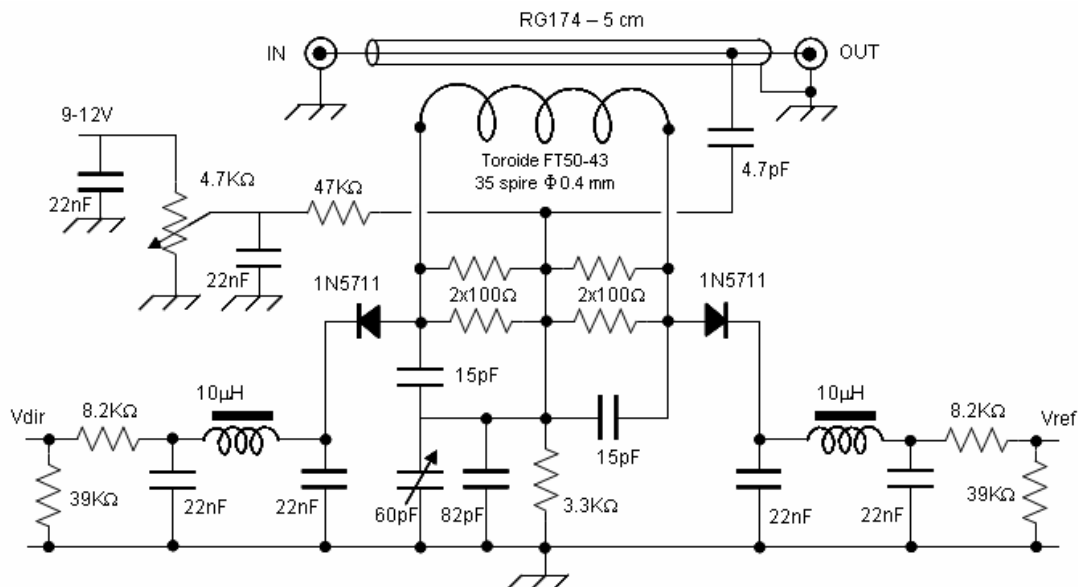
This project was developed by a little group of HAMs operating at the local ARI club in Padova. The software was developed by Danilo (IW3EGT), who manages the "microprocessor group", while I (IK3OIL) took care of the directional coupler and PCB design.

Our target was to build a digital, totally automatic, version of the classic SWR meter, capable of displaying both the SWR and P.E.P. power values, with a bar graph on the second line tracking the instantaneous power.

The reading is quite precise in the whole HF band, up to 50 MHz, covering the power range from 5 to 120 W, therefore usable also in the QRP range.

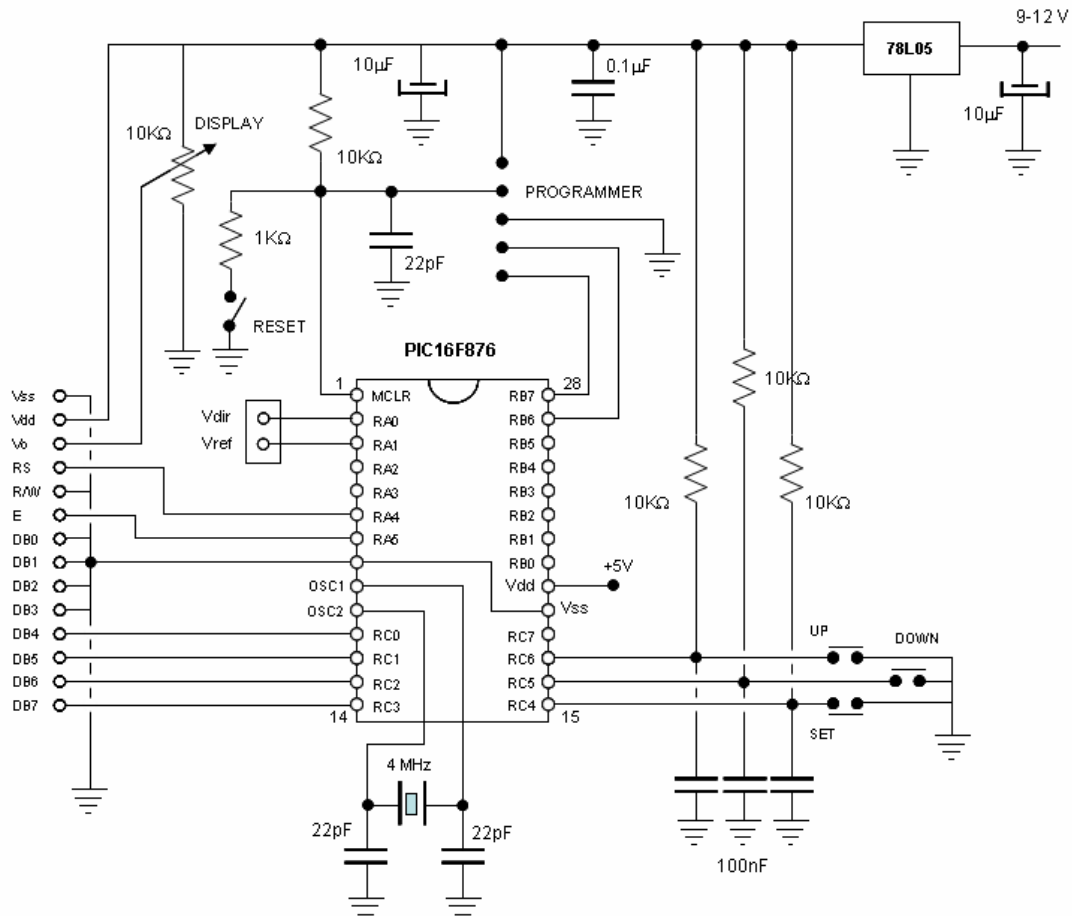


The directional coupler circuit



I tried several arrangements for this circuit, using both single and three wire coils, with and without central tap. Finally the simplest solution revealed to be also the best one. So I chose a single wire, no tap coil, wound on a ferrite FT50-43 toroid. The bridge balancing is done with a common 60 pF trimmer, adjusted for the lowest SWR reading on a matched 50 Ω dummy load. Two little 15 pF capacitors, parallel coupled to the 100 Ω resistors, allow to enhance the linearity and balance of the RF bridge. Please note that the 4.7 pF capacitor connected to the output line must be suited for high voltage (200 V). I chose two 1N5711 Schottky low barrier diodes as detectors, so as to improve the frequency linearity and power range of the coupler, spanning from 5 to 120 W (even a 3W power may be measured, but with a lower precision).

A little forward bias to the diodes is required to improve the dynamic range, this is obtained by adjusting the 5K Ω trimmer for a few mV voltage reading at the Vref point with no input signal.

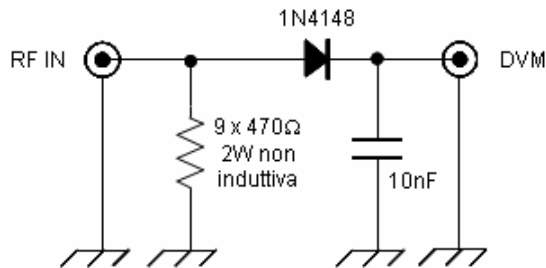


The software also compensates the diodes voltage drop, so as to obtain a more precise reading. The power measurement is updated every 2 seconds, registering the higher value read during this period. So doing the displayed value is stable enough, also with a modulated carrier. The power shown is a p.e.p. value.

Calibrating the instrument

This is the only “one time” manual operation required initially, remember that the whole instrument precision depends on this calibration.

It may be divided in two phases : *directional coupler adjusting* and *microprocessor system calibrate*. Both these phases require a 50Ω dummy load. This may be easily built according to following drawings :



Use only non inductive resistors, do not exceed 15 W TX power with 2W resistors. A digital, high impedance DVM should be connected to the “DVM” output.

Directional coupler adjusting

- Place the DVM at the Vref output, and a 9-12 V source to the 4,7 KΩ trimmer. Adjust the trimmer so as to read about 5mV.
- Now connect the transmitter and dummy load, select 28 MHz band and 10-15 W output in CW or AM mode. Place the DVM at Vref pin and adjust the 60 pF capacitor for the minimum reading (should be very near to zero).

Calibrating the microprocessor system

This calibration requires a TX operated in the range 10-15 W and a dummy load. The TX must be set for CW or AM operation, and the power can be derived from the following formula :

$$\text{Power (Watt)} = (V_{\text{out}} + 0.5)^2 / 100$$

where the 0.5 V term compensates for the diode forward voltage. Choose a frequency in the 14 - 21 MHz range and activate the calibration function by pressing the SET button. The microprocessor will ask for the actual power. Calculate it with the upper formula, reading the voltage on the dummy load, and insert this value by using the two < and > buttons. The microprocessor will ask to confirm and then will save this value in its internal EEPROM; later on it will use this value as a reference while computing other power values.

The directional coupler PCB and components layout

This PCB is built on a two layers copper board. All the components, except the two SO239 connectors, are placed on the same side, together with the tracks. The whole opposite side is left covered by copper, it is employed as a surface for all ground connections. The SO239 connectors are placed on this side, and kept in place by 3 screws. Some components (like trimmers) require drilling through the PCB, so you should countersink the holes on the opposite side using carefully a 4 mm drill.



