4 GHz Counter Pre-scaler Project

22nd June 2011

If you are like me, you already have a frequency counter that reads up to about 1GHz. I have started to explore the lower microwave frequencies (2.4 & 3.4 GHz) so this limit is a bit of an issue. The solution is to use a pre-scaler that has a high enough toggle frequency to cope with your new upper limit requirement and place it in-line with your existing counter input.

There are various pre-scaler chips with varying toggle rates around, and they have been around for some time. The bit that enthused me to move ahead with this project was the availability of some low-cost ($AUD8.30) HEL-33 chips from Rockby Electronics (http://www.rockby.com.au/searchres.cfm?searchkey=hel33&imageField.x=0&imageField.y=0) and these being listed as having a 4 GHz toggle frequency. The other equivalent part numbers are the SY10EL33 and MC10EL33, with a ZC or similar suffix, or the equivalent parts in the SY100EL/MC100EL series . These are in an SOIC-8 package, also described in the various documentation as a Z-8 and SOP-8 (3.9mm) format.

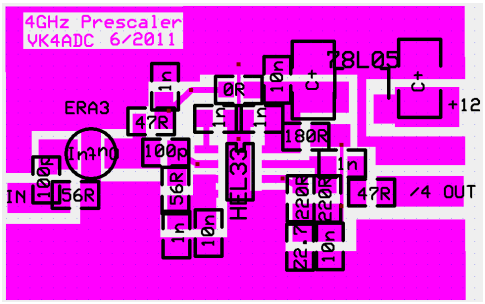
Data sheet here : http://www.micrel.com/**_PDF**/HBW/**sy10-100el33-l.pdf** (http://www.micrel.com/_PDF/HBW/sy10-100el33-l.pdf)

These chips are an ECL series, and this particular chip was designed to run from -5V. A negative polarity voltage at around 30mA to 50mA is not hard to achieve but my thought processes led me to contemplate running the chip from a conventional +5V supply in lieu. In reality this is not hard to do. A special note about one difference between this type and conventional TTL and CMOS logic is that the "pullup" resistor has to be connected to ½ supply rather than full supply or ground. This isn't hard to achieve either and my implementation uses a small 2.7V zener to generate this (effectively) half-voltage point..

My first prototype was built up and successfully did a divide by 4 - and, yes, a calculator on hand makes it easier. Unfortunately it is a choice between using a calculator when using the pre-scaler **or** not being able to measure the higher frequencies.

A signal known to be on 2403.150 MHz read as 600.7875 MHz on my 1GHz counter display but the sensitivity of the pre-scaler was not quite good enough for general purpose use. The basic chip specs suggest 150mV, or about -5dBm, as a minimum sensitivity at a typical frequency up to 4.2GHz.

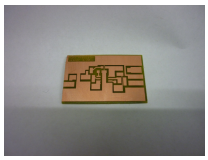
A revised layout was created and incorporated a ERA3 MMIC broadband amplifier to provide a sensitivity lift of up to 20dB. Other type MMICs (in the same style package) could be substituted by changing the bias resistor and / or running it from the (known : eg +12V) input supply voltage instead of from the +5V on-board regulator.



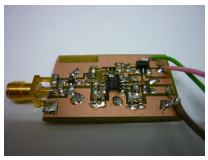
The regulator on this board will accept any supply voltage from around +7.5 to > +16 volts although the higher end voltages should be avoided to reduce regulator heat generation.. My general application tends to run everything from a nominal +12V supply so that is the way the PCB layout is marked.

The full size PCB is 40mm x 25mm and has been set up to utilize SMA-sized coax connectors.

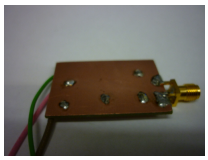
Mouse-over to see larger detail :



This is what the above artwork translates into as a bare copper PCB.



With all parts mounted & functional. A few wired-vias were added to the board to ensure that the layout was RF-stable.



The underside view shows the "wired-through" vias.

I can only test the actual sensitivity at frequencies up to 1040 MHz so the revised version was evaluated that way. The board required an input RF level of -23dBm at 1040.000 to give a 260.000 MHz reading. One word of warning : it will not reliably operate (if at all) with an input frequency below 400MHz (so giving a 100MHz output) so if you plan to use it in front of a lower-than-1GHz capable counter, be prepared for that.

It was "boxed" to make it mechanically stable and to provide shielding but that has been done in a manner to suit my personal needs. Anyone who makes up one of these will have their own mounting preferences anyway.

I used a diecast box around 100 x50 x 25mm in size, and it has a BNC male socket (yes, an unusual version but I found one in my junkbox) on the output end and a SMA female bulkhead on the other for the microwave input. I used BNC for the output as my counter has a BNC female on it so the prescaler box just clips onto the front of it. The external power comes in via a through-connector on one side, with a LED added to show when power is present.

Internal view.

The copper "tube" is UT-141 50 ohm coax as used at microwave. The power feed plus green LED are visible on the far side of the box.

The black diode at image centre is a simple reverse polarity diode arrangement, one end to the input power pin (cathode) and the other to the PCB ground (anode).

Slightly different view to show the input connection to the PCB.

The tinplate grounding piece was fashioned to shape with scissors before being soldered in place to the PCB and the jacket of the UT-141.

The PCB is not actually screwed down to the diecast box - the physical mounting is arranged through the end of the board being soldered to the end of the 3mm screws holding the BNC plug in place. All holes were tapped with a 3mm thread.

The SMA bulkhead male plugs are a bit unusual but a conventional BNC female could be used if a short low loss 50 ohm BNC-BNC male-male (or other type to suit the counter input terminal) coax lead is used.

The opposite side view showing the power indicator LED and the input power feed-through insulator.

The input connector is a SMA female bulkhead style.

The finished project : a repeat of the photo at the top of the page.

The diecast box was spray etch-primed then painted in a metallic charcoal spray finish.

The label was printed on A4 paper then bonded to the box with a piece cut from a sheet (with an extra 3mm overlapping border all around) of the self-adhesive Marbig Quick Laminate.

It may not be the "be-all" and "end-all" of useful projects but for those who need to make their counter work to a higher frequency point, it is one solution. Total basic board cost is around $25 in parts, plus coax connectors, mounting box etc.