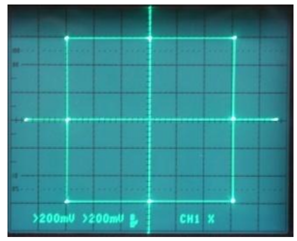
X – Y TEST PATTERN GENERATOR FOR OSCILLOSCOPE CRT GEOMETRY TESTING & ADJUSTMENTS.

H. Holden Sept 2013.



Introduction:

Most good quality CRT based oscilloscopes, such as those made by Tektronix, have adjustments for the geometry of the CRT display. This adjustment usually interacts with the trace rotation control. It is easy to align the horizontal trace to be parallel with the CRT's graticule, but the vertical or Y axis is harder to adjust while seeing its interaction with the overall scan geometry everywhere on the screen display in all four quadrants. Ideally a "box shaped" scan is required for the best adjustment possible.

This brief article describes an X – Y scan generator based on the PIC12F509 from Microchip to assist oscilloscope adjustments & repairs.

Operation:

The PIC12F509 was programmed using Microchip's MPLAB IDE v8.83. The IC was configured so that all of its available outputs were used. The program uses the bit clear and bit set instructions to set the outputs of the GPIO port high and low in a sequence with appropriate delays called in from a simple delay subroutine with a parameter passed in w. The nop instruction was placed between adjacent bcf and bsf instructions to prevent any possible read-modify-write problems.

Each of the digital outputs, GP0, GP1, GP2 & GP4 of the GPIO register were assigned to a quadrant to deflect the CRT beam into. The outputs are all positive logic levels. Negative deflection is required for the –x and –y deflections of the CRT beam. Therefore the outputs are passed via a unity gain differential amplifier (an OP295) running on a split power source to create the negative and positive going signals required to deflect the CRT beam into its 4 quadrants. This amplifier also serves another useful purpose (see below).

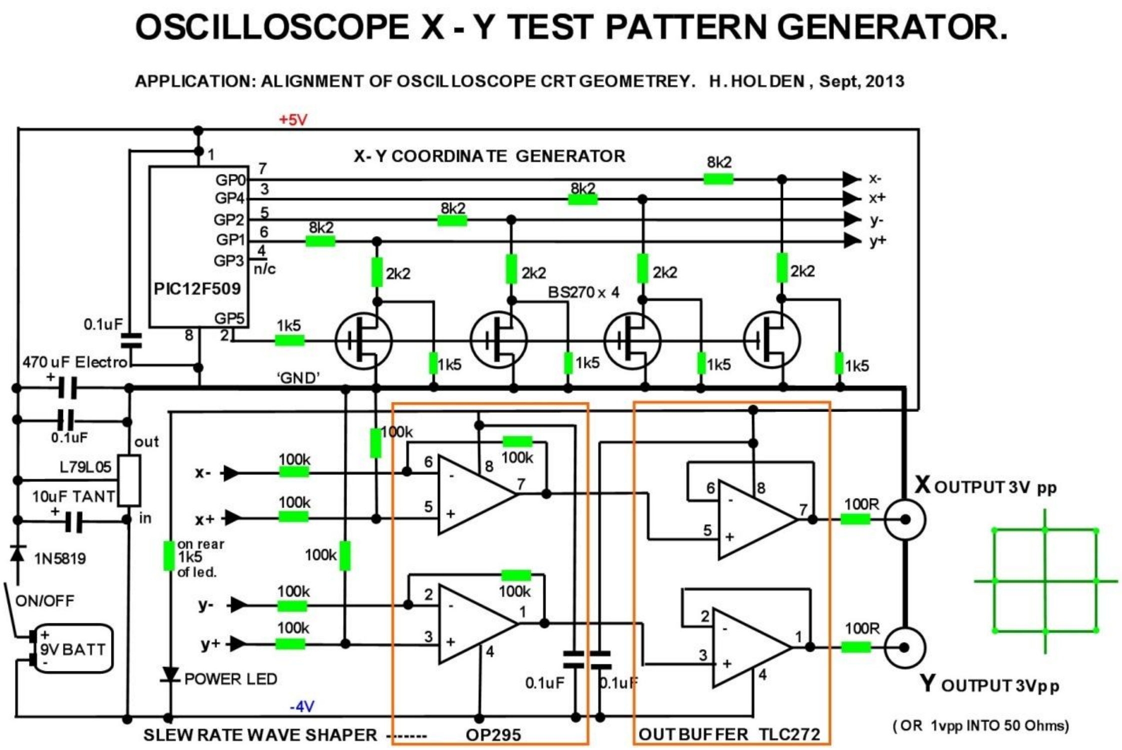
The switching signals march the beam around the screen in a clockwise direction. The time to complete a full scan is close to 2mS (500Hz rate) so there is no visible scan flicker. At the time in the scan where the Y deflection is zero (or X zero) GP5 is used as a gain control signal which acts on the four BS270 mosfets to elevate the signal output and produce the over-scan. This generates the appearance of the two lines on the X and Y axis crossing each other in the centre of the square.

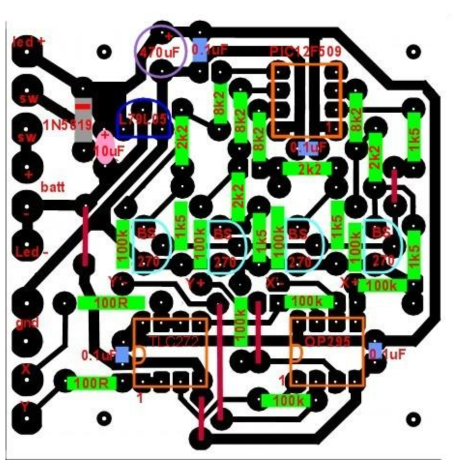
The signals generated by the PIC12F509 are digital so they have very sharp (fast) rising and falling edges. This means that these signals, on their own, do not produce an easily visible line on a CRT face (in X-Y mode) and could only generate dots which would be seen in the pauses where the CRT beam was deflected into each quadrant during the time that the digital output was in a stable state.

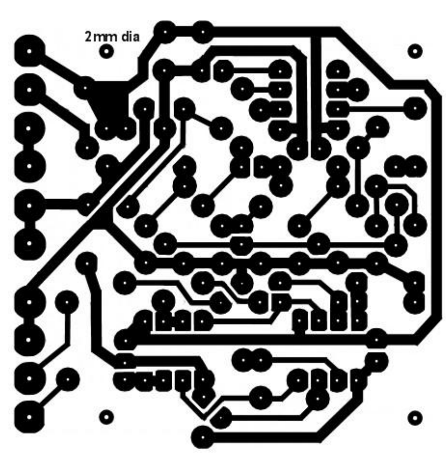
However, if an OP amp is driven with a signal with a rise or fall time faster than the frequency response of the OP amp, then the OP amp goes into a slew rate limited mode. In this condition its output voltage changes at a fixed number of Volts/uS. In other words the OP amp becomes a very convenient linear ramp generator. The differential amplifier selected is an OP295. This is a very low speed OP amp typically for servo use with a very low slew rate of only 0.03 V/uS. In this application with the outputs buffered, the measured slew rate is 0.022V/uS. This essential slow slew rate function slows down the scan between the quadrants and results in a “pseudo-analog” scan waveform. This makes the CRT beam visible as it traverses its pathway.

The OP295’s outputs are not suitable for driving cables and current sinking/sourcing from its outputs affects the slew rate, so the outputs are buffered with a TLC272 dual OP amp.

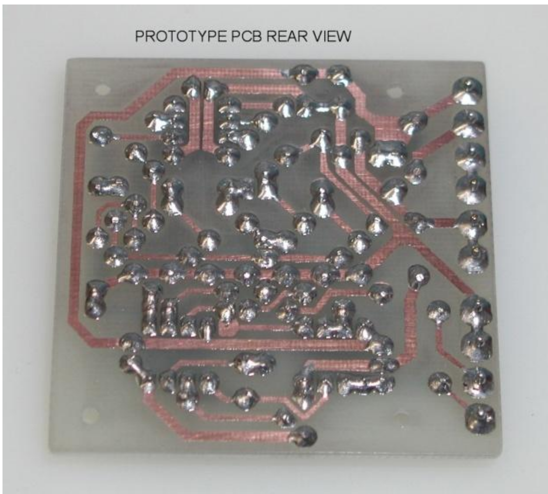
The schematic & PCB top view:

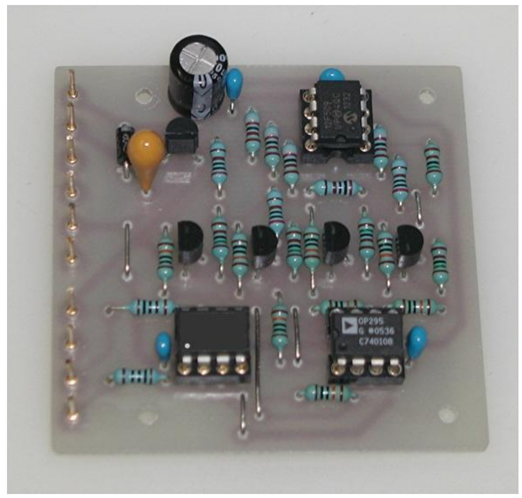






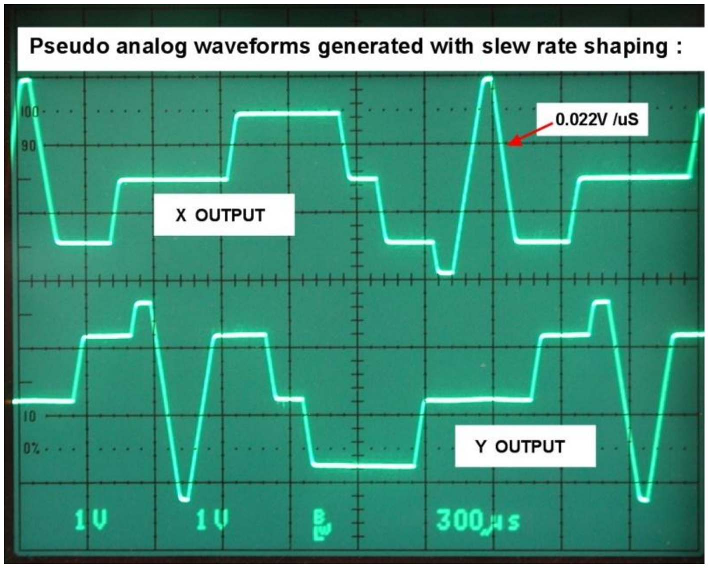
The components were placed on a 2.54 x 2.54 mm grid. The pcb was drawn in *Microsoft Picture It* over the 2.54 mm grid and printed with a laser printer to iron on pcb film from Jaycar. The film was applied to the pcb with a 140 Deg C clothing iron for 3 minutes. It was then etched with Ferric Chloride. After soldering the flux was cleaned off with contact cleaner and the tracks sprayed with clear automotive lacquer.



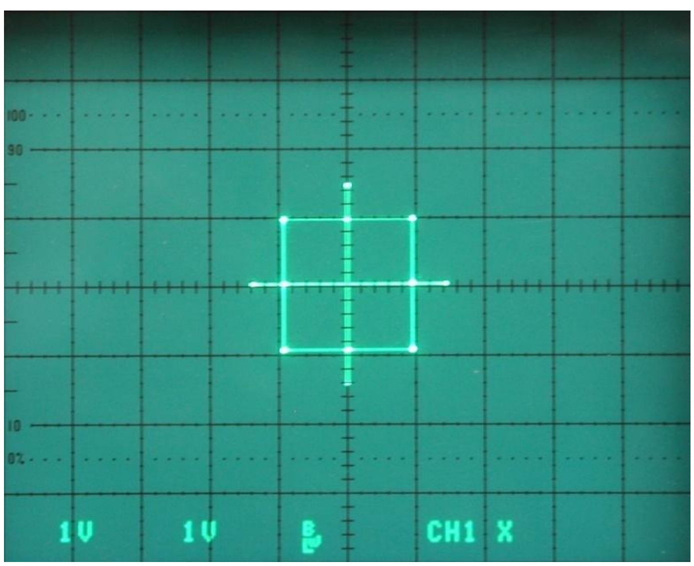


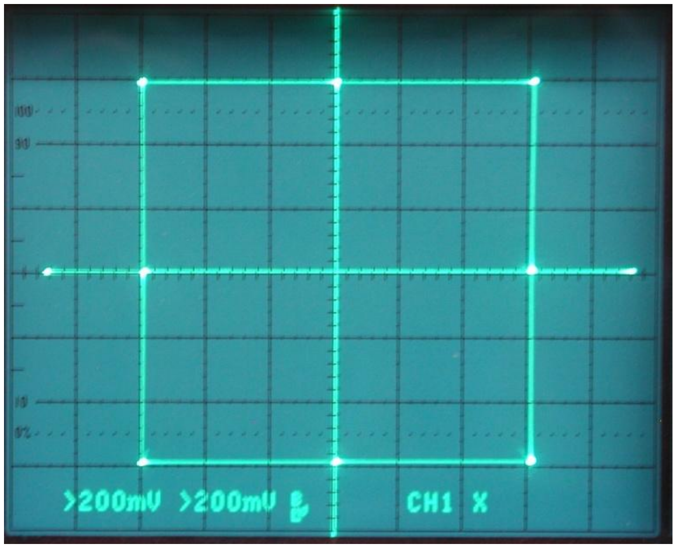
This assembly was placed in a Jaycar enclosure with a battery and the board connected up with Jaycar 0.9mm pins and sockets. The board was mounted on four 2mm diameter posts.

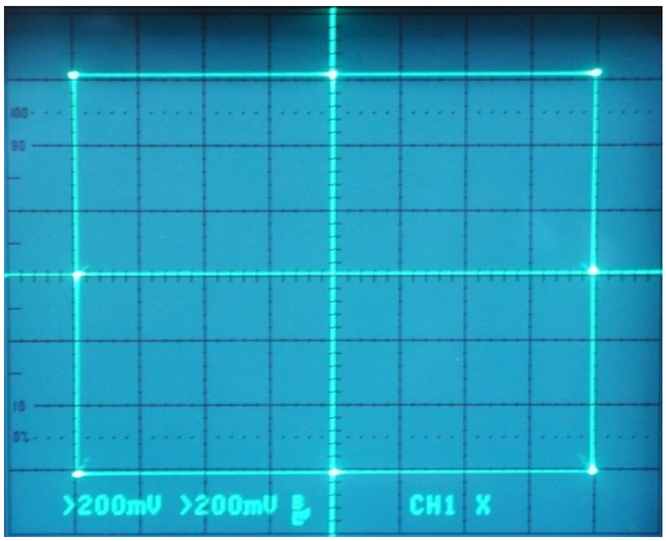
The following scope screen photo shows the X and Y signals displayed on a scope on Ch1 and CH2. It can be seen how the slew rate shapes the resulting waveform into a pseudo analog format:



Switching the scope over to X-Y mode produces the following pattern which can be any size depending on how the scopes X and Y gain settings are set and if the outputs are terminated into 50 Ohms or not . (Terminating into 50 Ohms drops the output voltage to 1/3 the unterminated value)







In the photo above the scope's X gain was simply set higher than the Y so the scan box becomes a rectangle.

As noted in the schematic a 1N5819 diode was placed in the battery circuit as it is easy to reverse touch the battery terminals by mistake at a battery change and damage the IC's. The unit's total current consumption is 8.70mA and when terminated into 50 Ohms about 12.7mA. 4.6mA of that is the power LED.

Battery Voltage:

The output waveform stays stable and produces a normal X-Y scan until the battery voltage drops to 6.85v. This is because at that point there is only -1.5 to -1.6 available for the negative rail of the OP amps (the 1N5819 diode drops about 0.25v) and the OP amp's output clips. At that point the battery is ready to be replaced as indicated by an abnormal X-Y scan.

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