The simple man's Spectrum Analyser
Sweep Generator

{gallery}sasweepgen/1{/gallery}

The sweep generator produces a sawtooth waveform (below left) which sweeps the oscilloscope beam from left to right via its X input, and simultaneously the VCO frequency (1st Mixer module). A quad op-amp type TL084 is used (the type would not be critical). This module was built on perforated matrix board and mounted behind the front panel potentiometers. Frequencies in this circuit are low so screening was deemed unnecessary.

IC5a forms an integrator and would produce a triangular waveform were it not for the diode between pins 1 and 2 which causes very rapid charging of the capacitor, compared to the slow discharge through the "SWEEP RATE" potentiometer.

The resulting sawtooth waveform is amplified by IC5d so that it is almost rail-to-rail, allowing maximum voltage range across the varicap diode in the VCO . The 20K multiturn potentiometer at pin 13 of IC5d controls the amount of amplification. The ideal is for maximum voltage range of the waveform, and this potentiometer should be adjusted by observing the sawtooth waveform on the oscilloscope and adjusting for maximum height. Too much amplification will cause clipping, see right.

{gallery}sasweepgen/saw{/gallery}

The amplified sawtooth waveform drives the oscilloscope "X" or "Horizontal" input. Adjustment of the oscilloscope's horizontal controls (X position and sweep gain) is required to centre the sweep nicely on the oscilloscope screen.

Note than an analyser where the sweep waveform is triangular does work. But hysteresis in the response of the oscilloscope X input circuits, and most probably also in the analyser itself, results in two analyser images appearing slightly displaced on the oscilloscope screen. Early attempts to remove the image by using a transistor to switch off the analyser output for half the waveform did work, but reduce the display brightness by a factor of two.

Op-amp IC5c produces the sawtooth which sweeps the VCO . The amplitude of the sawtooth is determined by the "FREQUENCY SPAN" potentiometer, and the "CENTRE FREQUENCY" potentiometer applies a DC offset. IC5b generates the +6V reference voltage for the other 3 op-amps.

{gallery}sasweepgen/2{/gallery}

On the subject of sweep rate...

In theory, a lower sweep rate is required the lower the final filter bandwidth (higher resolution). In this analyser there is currently only one filter resolution available. However the sweep rate is still important when using a cheap and simple oscilloscope such as my 5MHz Kenwood model CO-1305. When the sweep rate is too high, the display duration of the frequency peaks is too fast for the slow input circuits of the oscilloscope, and the display sharpness suffers giving the illusion of less resolution. The three images below illustrate the problem.

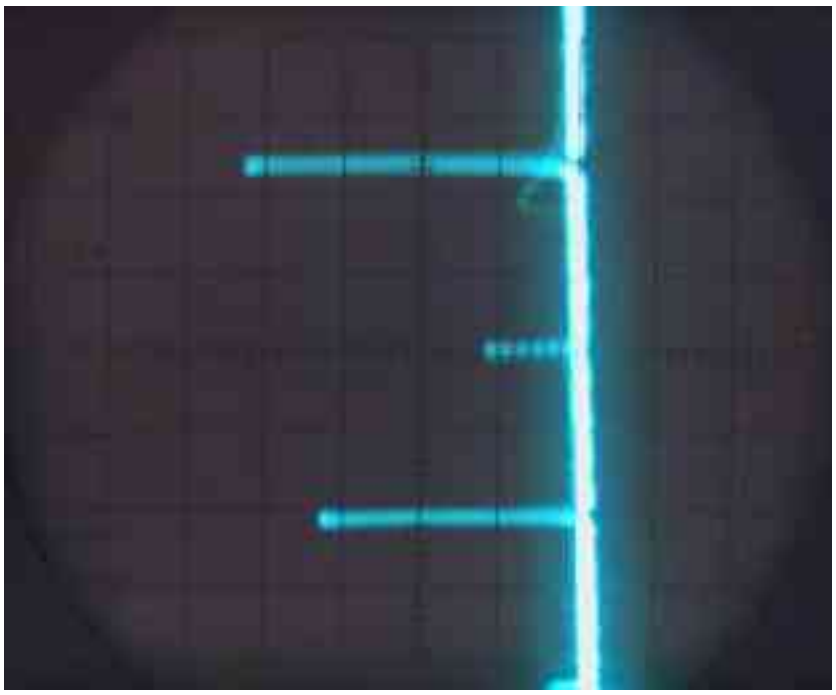
{gallery}sasweepgen/3{/gallery}

The analyser is set to cover 0-120MHz with the input connected to a signal generator tuned to 30MHz and the input attenuator at 22dB. Harmonics at 60, 90 and 120MHz are visible. The left

image shows a quite low sweep rate: the frequency peaks are clear and sharp.

Note the the faint ghost image between 30MHz and 60Mhz is due to the retrace caused by the vertical part of the sawtooth waveform being not precisely vertical. The diode in the integrator takes a small but noticeable time to charge the capacitor. At this low sweep rate the ghost image is unobtrusive. It would be worthwhile to redesign the sawtooth generator to produce a more perfect output waveform. An easy modification which would reduce but not eliminate the problem might be to use a smaller value capacitor and larger sweep rate potentiometer.

At higher sweep rates (medium image) the height of the frequency peaks begins to be reduced and they are wider. The ghost image also becomes more visible, as the finite charge time of the capacitor becomes more significant in relation to the total sweep time. At still higher sweep rates the frequency peaks become short and take on a loop-type appearance. In practice the optimum compromise appears to be a sweep rate as low as possible but not so low as to cause unacceptable display flicker. Of course, with a higher bandwidth oscilloscope the problem wouldn't be troublesome (though the ghost image would still need to be reduced).



Another reason why I included a front panel sweep rate control was that my oscilloscope appears to suffer from a small horizontal wobble at 50Hz mains frequency. It helps to have the ability to eliminate the wobble by selecting a sweep rate which zero-beats with the mains frequency.

For pure entertainment, but then somewhat scientifically justified by the need to find out if the horizontal wobble really is the fault of a cheap oscilloscope or the fault of my bad design in the spectrum analyser, here's what happens when you swap the X and Y outputs to the oscilloscope. Sure enough, horizontal wobble remains, but now manifesting itself on the size of the peaks rather than their position on the now vertical frequency axis. To perform the test required readjustment of the oscilloscope settings, notably drastic reduction of vertical gain and selection of maximum possible horizontal gain.

Interestingly the test also showed improved linearity of the frequency axis when in the swapped X-Y mode. Linearity of a simple varicap swept VCO such as this will never be perfect due to the non-linear relationship between reverse voltage, capacitance and frequency. Despite this the linearity appears very impressive in this simple spectrum analyser. The slight non-linearity is visible in the proper traces above as greater distance between 90 and 120MHz peaks at the right of the screen, compared to the distance between 60 and 90Mhz peaks. The X-Y swap is much better - excellent, that's one more thing I can blame on the cheap oscilloscope!

Alternative Sweep Generator

Richard VA3NDO has built an alternative sweep generator using a 555 IC and an op-amp inverter suitable for 'scopes with inverted X drive. **Read more...**