# A Very Wideband Analog Autocorrelation Spectrometer

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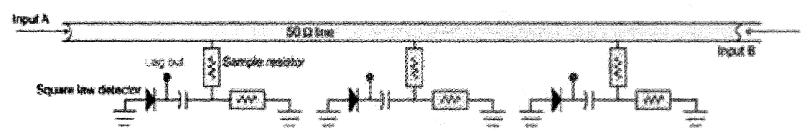
Astronomical receivers for the THz range require very wideband spectrometers, several GHz or more for extragalactic spectroscopy, but the required frequency resolution is relatively low. The usual choice is a digital autocorrelator, but these spectrometers have bandwidths limited to ~1GHz for a single unit, and few bit samplers have a limited dynamic range without adding sampling noise. An alternative is to use analog techniques to autocorrelate the signals. While it may seem to be working against the trend of improved performance of digital circuits, in fact this technique is making equally rapid progress because of the ever increasing availability of low-cost high-performance microwave components.

Our technique of analog autocorrelation is to split a signal two ways and send it in opposite directions down a single transmission line. The line is tapped periodically, and the tap signals go to detector diodes as shown in Fig 1. A square law detector produces an output proportional to the sum of the power in each signal plus the product of the two voltages. Rapid phase switching of one signal produces an AC output for the product term while the other component remains constant. The outputs of all of the detectors form the autocorrelation function of the signal. In this work we have constructed an analog correlator with up to 8 GHz bandwidth having 256 lag measurements. Four delay lines with 64 taps each fit on a single circuit board along with the detectors, AC preamplifiers, A/D converters, and all of the digital logic needed to read out the A/D's and average the data. A second microwave circuit board produces the 10 mW signals needed to drive the lines as well as the phase switching. Components used in the driver are limited to 1.5-8.0 GHz, as increased bandwidth is possible but not cost effective. The full circuit is shown in Fig. 2.

The spectrometer is working with the expected 31 MHz resolution, and shows radiometric noise in 1 hr integrations on a wideband signal with a fast beam switch. Switching speed must be faster than 10 seconds on and off time in a completely unstabilized environment, but should be much better with temperature control. The cost is $2500 for the complete correlator board, and $1000 for the driver board making this a very inexpensive way to cover wide bandwidths. This spectrometer will be used as the backend for a 74-110 GHz receiver used to search for highly redshifted galactic lines.

Wider bandwidth is possible with this technique but the limit is set by the parts density on a PC board, and at present ~10 GHz is a practical limit. In the future, smaller parts will increase this limit. Higher resolution comes by simply adding delay lines.

Figure 1. Basic autocorrelator circuit. Signals A and B are the same input with a time delay.



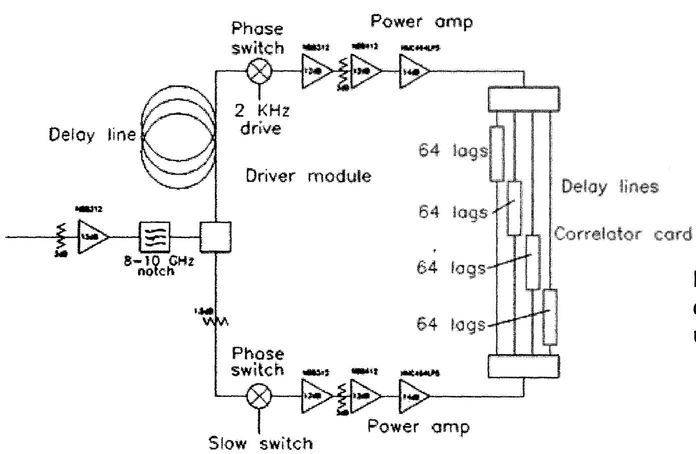




Figure 2. Complete autocorrelator with driver circuit. The delay lines are made using coaxial cable.