HTRP
MEMO NO. 105

To: Jack Campbell, Larry Beno, Bob Hjellming, Rick Perley, Jim Cordes, Mark McKinnon

From: Tim Hankins

Subj: Detector for the Analog Sum

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For pulsar observing we have, for the last 5 years, been using the "grey box" built by Chuck Broadwell, for square-law detection of two Analog Sum signals. This box accepts two analog sum inputs, it detects and amplifies the signals, then passes them through a track-and-hold circuit to eliminate the signal "drop-out" during the waveguide switch cycle.It contains an adjustable *RC* integration time constant, and was modified about two years ago to permit adding a DC offset to "buckout" the detected contribution from the system temperature. It contains circuitry to stretch the "DATA_VALID" logic signal slightly to avoid a switching transient at the end of each waveguide switch cycle, and it contains a logic inverter to output a stretched "DATA_INVALID" logic signal, which is used by my data acquisition system to detect the waveguide switch cycle.

The "grey box" has been essential for the work we have done, so far, but it was originally built as a temporary measure for some other application. It has several problems. One of its channels has an unacceptable amount of 60 Hz related hum. It is not gain stable, and it is microphonic; mechanical motion sometimes results in large output voltage excursions.

There are a number of pulsar experiments and others which will require detected analog sum signals. To optimize the use of array time, I propose that the "grey box" be rebuilt as a permanent VLA instrument. It will be a useful adjunct to the new MK III VLBI filter bank detectors currently being designed for the HTRP (High Time Resolution Processor), and will be used for some experiments in preference to the filter bank detectors.

It is clear that the HTRP interface is a relatively long time off. I would like to have the new "grey box" for the late November, early December set of pulsar observations (pulsar HI absorption, time-resolved pulsar polarimetry). I offer the following to support its development.

1. I submitted a list of specifications for the "new grey box" in May 1986. I enclose a copy of this document with a revised set of specifications (very few changes).

2. I have a program for printed circuit board layout that I have used very successfully. This program permits plated-through holes, automatic ground-plane layout, multiple layers, cost estimates before design submission, two-week fabrication turn around, and a very simple user interface. If the revised design requires a printed circuit, I will be happy to make the program available and advise in its use.

3. The current "grey-box" uses LH0033 buffers for its output. I have a supply of these somewhat expensive circuits, and I would be happy to donate them to this cause.

4.I will be willing to assist in the design, layout, and construction of the "new grey box" (we really must have a better name for it!).

Specifications for a new Analog Sum Detector

1. **Number of channels**. Although we can now sensibly use only 2 i.f.'s. in phased-array mode, we now need only two Analog Sum detectors. In the future we may want to detect all four i. f.'s, so provision for two additional channels should be considered.

2. **Input**: The Analog Sums. It would be very convenient to include a 1 db-per-step attenuator at the input to the detectors. This will permit convenient adjustment for level, depending upon the pulsar strength, the system temperature, the number of antennas contributing to the Analog Sum. A monitor of the input level similar to the level monitors on the Analog Sum Switch panel built for the Voyager program would be useful, but not necessary.

3. **Output:** ±5 volts or ± 10 volts.range. The Intel data acquisition system that I currently use for pulsar signal averaging has an A/D input range of ±5 v. The HTRP (High Time Resolution Processor) is currently configured for ±10 volts. The current "grey box" output buffers are capable of driving 50 ohm loads. Although the input impedances to the data acquisition and monitoring devices are much larger, we have taken advantage of the low output impedance to minimize hum and noise pickup by loading the output with 50 ohms.

There must be sufficient gain in the system to give at least 1.0 vrms output with a time constant of 1.0 ms. with the input bandwidth of 50 MHz.

A calibrated bias adjustment of the output should be included. A 10-turn potentiometer calibrated in volts would be adequate. This DC "buckout" is essential for compensating for the constant output due to the detected system temperature.

A simple output voltage monitor such as an edge reading panel meter would be desirable and convenient, but not necessary. A peak-reading pulse-stretched LED indicating saturation (>10v ?) would be convenient, as well.

Provision for adding the two detected output voltages should be made. One possibility would be an output selector switch with four positions *A*, *B*, and *A* + *B*, and *ground*.

4. **Integration time constant**: The existing "grey box" has a range of *RC*-time constants from 1 μs to 1 sec in three two-decade ranges. This is an adequate range; I do not anticipate that the short end of this range will be useful, so a minimum time constant of 10 μs should be adequate. The existing arrangement for time constants has proven satisfactory.

5. **Post-detection gain**: For the experiments conducted thus far, the single value of post-detection gain has been adequate. Consideration of additional gain settings of 0.1, 0.2, 0.5, 1.0, 2, 5, and 10 should be made.

6. **Form factor**: Until the HTRP and the INTEL system are permanently incorporated into the VLA system, I anticipate that the development of these systems will require access to both the front and back of their chassis. One possibility for a convenient form factor would be for these detectors to be mounted in a 19" rack chassis which could be used either in a rack (in the future) or on a table (during development) on or under the computer in use.

7. **Additional considerations**: In late November we will be receiving three IBM-PC/AT compatible boards which are part of the Princeton pulsar timing system that I designed and Dan Stinebring has cloned over the last several years. There are a number of external signals that this system will require, including:

1-second tick from the station standard clock.(TTL)
10-second tick from the station standard clock (TTL).
20 MHz from the station standard. (+13 dbm)
Detected Analog Sum outputs
Detected outputs from the Mark III VLBI filter bank.
Correlator gate
DATA_VALID

The timing system will have a number of output signals for monitoring, as well. Perhaps all of these should be routed to a separate panel with BNC connectors for patching to the appropriate destinations.

Tim Hankins, 13 October 1988