NATIONAL RADIO ASTRONOMY OBSERVATORY
MEMORANDUM

DATE: October 26, 2001
FROM: Ron Maddalena
SUBJECT: Phase Tables and Switching Signals: Modes and Current Issues.

The GBT hardware devices use a phase or switching-signal table as a way to specify how switching signals and noise diode signals are set and to be used. This memo provides a description of the 'standard' phase tables that will be used for 'standard' observing. I also discuss the current restrictions of the existing phase table architecture.

1. Standard Phase Table Modes:

A properly-set phase table needs the following information:

- The switching master or device that is generating the switching signals. Current choices are: Spectrometer, Spectral Processor, and DCR. Other devices that use the phase table (LO1, a second backend, ...) are known as slave devices.
- Number of phases (number_phases), the number of phases in the table.
- A "phase start" array that contains number_phases values. Each element in the array is the fractional time within a full cycle of phases at which each phase is to start.
- A "cal_state" array. Each element is essentially a boolean stating whether the noise diode is to be on or off during a phase.
- A "sig_ref_state" array. Each element is a boolean stating whether devices are to consider data taken during a phase should be considered "signa" (on source, on frequency, ...), or "reference" (off source, frequency, ...).
- A blanking tiime array which provides the amount of blanking time in seconds that backends are to apply at the start of a phase.
- A switch period in seconds describing how long a cycle of the phase table will take.

Each device may also have ancillary parameters related to the phase table. For example, the Spectrometer and Spectral Processor allow one to set the number of seconds in an integration and the device calculates the number of phase cycles needed to achieve that integration time. On the other hand, the DCR allows one to set the number of phase cycles to be considered an integration and the device calculates the length of an integration from the number of cycles and switching period.. The DCR also has "Advanced Signal" fields for generating a switching signal ahead of a sig_ref_state change, a useful feature for high inertia switching devices like a tertiary. A full list of ancillary parameters is beyond the scope of this memo.

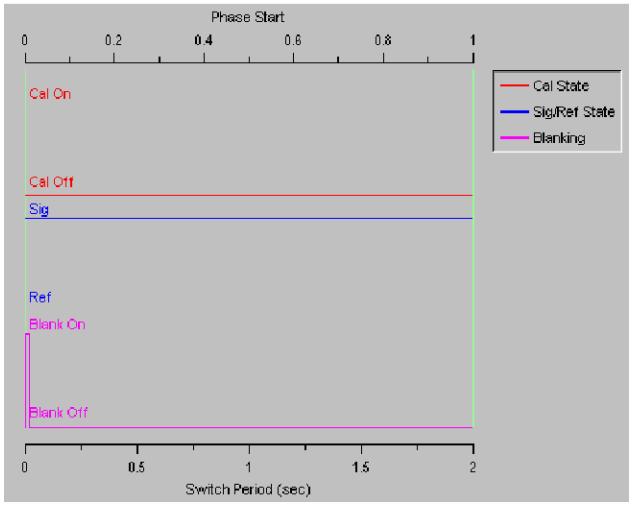
Additionally, each device has different criteria as to what is or isn't a legitimate phase table. After reviewing the legitimate phase tables allowed by every device, as well as what flavors of phase tables people will want to use, Toney Minter and I have concluded that four different "standard" phase tables will satisfy all devices and almost all experiments. GO

and CLEO use different but extremely similar formats for setting phase tables; both GO and CLEO now allow one to easily set up “standard” tables.

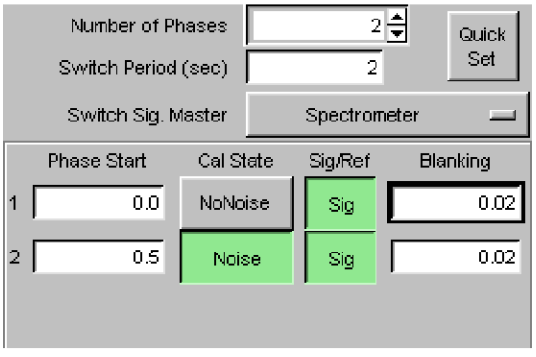
When a user wants a “standard” table, GO and CLEO assign values to the number of phases, phase start, cal state, and sig/ref state parameters. After these preliminaries are set, the user interfaces allows one to modify the switch period, blanking values, and switching master (respectively 2 seconds, 0.02 sec, and “Spectrometer” in the examples below). Blanking values for all phases should be the same for some devices but can be different for each phase for most devices (see §2). Modifying by hand any of the other entries in the phase table (number of phases, phase start, cal state, and sig/ref state) should be done with caution since changes will produce a non-standard phase table that some devices might consider illegal.

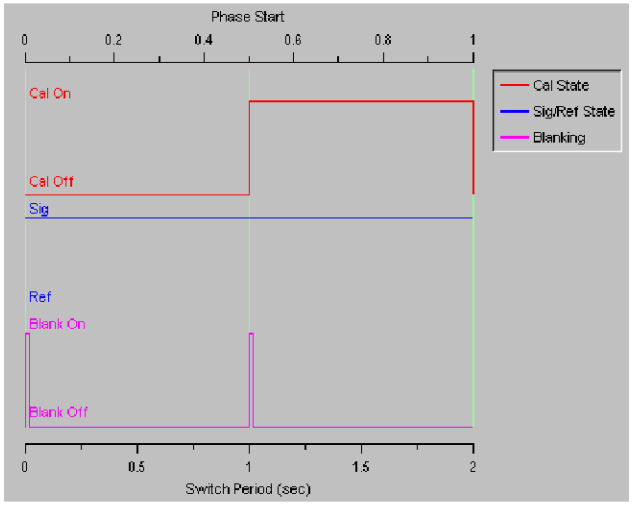
As a matter of convenience, I will use screen dumps of the CLEO displays to document the four types of phase tables. I also will provide screen dumps of the phase table graphs created by CLEO.

Total Power without Cal:

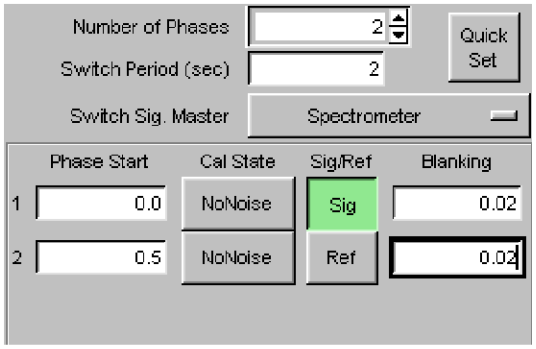


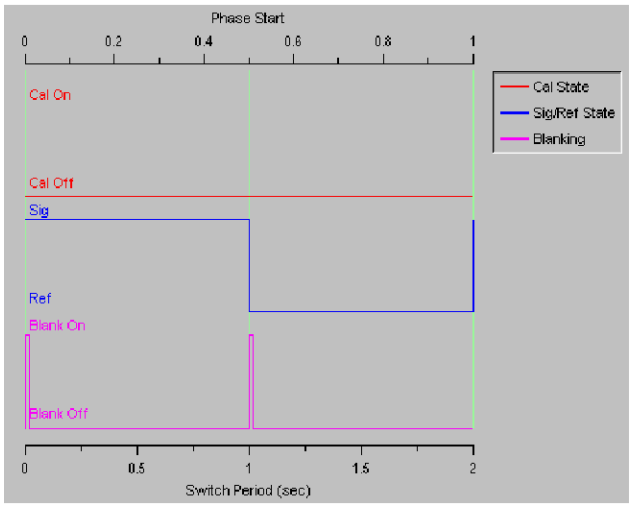
Total Power with Cal:



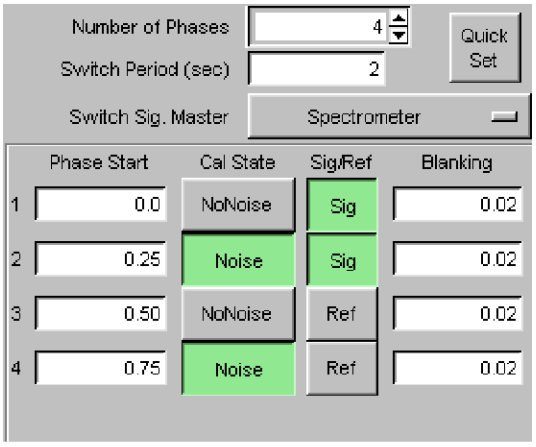


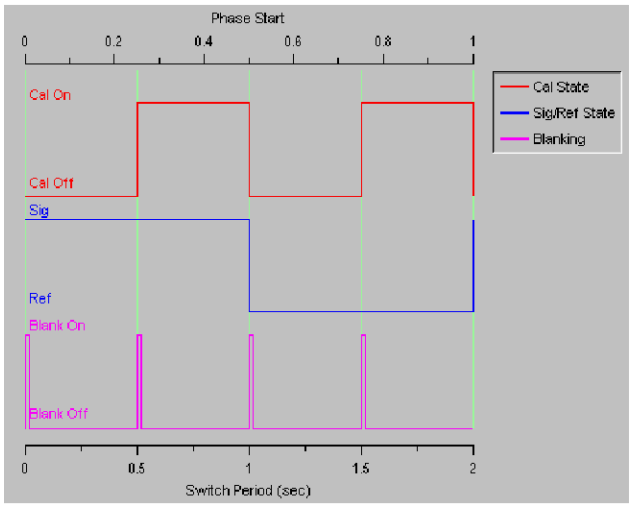
Switched Power without Cal:





Switched Power with Cal:





2. Phase Table Restrictions and Issues:

Although the current phase table implementation has been serving us well, there are a few restrictions that might soon need addressing. This will especially be true as users start stretching the system and new hardware like a tertiary are built. The issues I list are sometimes complicated and will require some discussion in order to prioritize. For example, the elimination of some restrictions requires coordinating the work between the engineering, M&C groups and GO and CLEO programmers. Also, there's a good chance this list is incomplete, though I hope it will spur others into adding the problems I overlooked. Also note that some items might have already been addressed

- The full potential of the current phase table scheme cannot be realized because of hardware limitations. And, sometimes the hardware is more versatile than can be accommodated by the phase table scheme. For example:
  - The Spectral Processor cannot be a slave device to switching signal masters of either the DCR or Spectrometer.

    - Only one master can be specified. Yet, the Spectrometer can be a both a master for a specified set of signals and slave for the rest.
    - For some types of observing, multiple devices may want to generate blanking signals. For example, LO1 may want to blank when the LO is out of lock. The antenna may want to blank if it is off position or moving from a signal to reference position for 'intra-scan' position switching. Neither of these devices can be specified as 'masters' and it is unclear whether the Spectral Processor, since it must be a master, would be able to repsond to an external blanking signal.
- For The Spectrometer, blanking must be the same for all phases. When we start to use frequency switching or a tertiary for beam switching, we can expect blanking will need to be substantial between Sig and Ref phases. However, blanking need not be substantial between cal on and off. The Spectrometer will have to use the same long blanking for cal on/off as it does for sig/ref, thereby increasing the inefficiency of frequency- and beam-switched observing. To make the observing more efficient, it is possible to specify a long switch period. However, beam switching will need to have a short switch period to be effective.
- The phase tables actually used by all the backends are slightly different than that requested because of the finite resolution of a backend's clocks. In the current architecture for Doppler tracking, LO1 will need to know the actual phase table. Unfortunately, LO1 knows only the commanded table and currently there isn't a mechanism for propagating actual phase tables from a backend to other. The problem may also affect "intra-scan" position-switched observing if the antenna needs to know the actual phase table.
- Doppler tracking in LO1 currently will update only when sig/ref changes states (and some frequency tolerance has been exceeded.) In total power observing, as defined above, there is no transitions from sig to ref and therefore there is no way to update Doppler tracking during total power observing.
- Cabling of the "Switching Signal Selector" currently is not tracked in the cabling file. Currently, any changes in the cabling will require changes in the M&C software, CLEO, and maybe GO as well. If the cabling to and from the "Switching Signal Selector" were in the cabling file, engineers and technicians could alter the cabling and file and no program changes would be needed.
- LO1, because of what looks like firmware problems, currently doesn't know how to work its way through a list of frequencies as specified by the Sig/Ref signals as needed for frequency switching.
- Altering phase tables values by hand to anything but those mentioned in §1 can produce illegal values. In some cases, it is very difficult to edit the phase table so as to clear the illegal values. This is frustrated by each backend having different rules as to what constitutes an illegal phase table. Thus, editing phase tables by hand requires a bit of experience and has to be done very carefully.
- Astronomical measurements in September showed a few problems with frequency switching. For example, the first phase table cycle seems to not correctly switch frequencies at the appropriate times. The Spectrometer Sig/Ref seems to be 90 degrees out of phase with the LO1 switching. A lot of work has gone on since these problems were discovered and need to be rechecked when M&C releases a version of LO1 that is capable of frequency switching.
- The sense of the TTL signal for cal on/off is opposite to that diagramed by CLEO (TTL high is cal off while the illustrations above show cal on as high). The CLEO displays can be easily changed if the engineers require it.