**ATF bunch phase measurement Box**

**Function:** The bunch phase measurement box is designed to measure the phases of the two bunches in the ATF ring relative to the 714MHz RF and relative to each other.

**Performance:** The box phase noise is <.03° 714MHz RMS. The phase drift and offset could not be measured with the existing test equipment. Measurements indicate a channel difference stability of 0.4° 714MHz. This was probably limited by the test system.

**Operating Principal:** The BPM signal is narrow band filtered at 714MHz. This signal is mixed against a 714MHz reference signal. The mixer output is low pass filtered (at 100Mhz), and then amplified. The amplified signal is switched into a pair of integrators (0.1 second time constant). The integrator outputs are proportional to the phase (with the phase near zero).
**Signal Connections and controls:**

**BPM input:** This is connected to the output of the BPM. Fast cables with good transmission at 714MHz must be used. An input attenuator to provide a DC path should be used. Required signal level is based on the 714MHz content of the signal. (See later instructions). *Avoid the use of any active buffers in this signal path.*

**Local Osc 714MHz 10dBm:** This is connected to a phase stable 714 reference signal of 10 +/- 1 dBm. The input needs a phase adjust that does not produce significant amplitude variations. A 714PLL can be set up using a synthesizer if necessary.

**Push to set offset (switch):** Pressing this button (momentary contact, non latching) removes the BPM input signal. It is used when setting the integrator zeros. Note: Fine offset adjustment should be done when the BPM signal phase is near null due to the finite isolation of the switch. Do not leave switch on for long to avoid thermal changes.

**Ch 1 Offset, Ch2 Offset (Knobs):** These set the zeros for the integrators. They should be used when the “push to set offset” button is depressed, and when all other signals are present. Adjust offsets to <50 microvolts. Offsets have noticeable temperature drift.

**Ch1 out, Ch2 out:** These are the voltmeter outputs. *DO NOT TERMINATE.* The maximum output is a few hundred millivolts. They must be read with a resolution of <50 microvolts. The output scaling varies with signal level, but is approximately 3mv/degree (714MHz).

**Ch1 TTL in, CH2 TTL in:** These are the gate inputs. *Terminate these inputs with feed through terminators.* TTL gate timing is set relative to the observed pulses on the monitor outputs. Gate width is approximately 50nsec.

**Ch1 mon out, Ch2 mon out:** These monitor the alternate RF switch outputs. *THESE OUTPUT MUST BE TERMINATED.* With no TTL input signal (with terminators on the TTL inputs), the IF signal will be directed to the monitor outputs. When the TTL inputs are high no signal should be seen (there is some slight feed through). The gate signals can be seen on these outputs by increasing the scope gain. Note that noise will be seen when the gates are active, even with no BPM input signal.
Box Operation:

1. Plug in box. If behavior is strange, check power supplies to be sure they operate correctly with Japanese AC. If not, use external +/-24 V to replace the two big supplies.

2. Apply 714MHz RF, 10dBm.

3. Be sure the TTL inputs have 50Ohm terminators installed.

4. Attach the monitor outputs to a fast (>300MHz BW, >1GS/S) scope. Terminate in 50 Ohms. If the scope is remove, put terminators on the connectors.

4. Attach the BPM signal. USE A FAST CABLE. It is the 714 component which matters. Start with a strongly attenuated signal and increase. Look at the Ch1 and Ch2 monitor outputs.

5. When signal is seen on the monitor outputs (should be ugly pulses about 50ns long, similar on both channels), Adjust the 714 MHz input phase to maximize the signals. Adjust the BPM signal level (with attenuators) to get ~200mV maximum output.

6. Attach the TTL gates. Start with 50ns gates, starting about 5ns before the pulses. Look at the monitor output with the input disabled (push button). The gates should be visible (at high gain) on the outputs. Remember that you are looking at the signal which is NOT sent to the integrators.

7. Adjust the gate stop timings to match the first zero crossing of the output signal. We have played a lot with gate timings, and are not sure what the optimal approach is. This seems to work OK.

8. Attach the monitor outputs to a voltmeter. You should see signals of around 100mv.

9. Adjust the phase to zero the voltmeter outputs. Note that the two channels have different zeros (by up to several millivolts). This is not well understood, but is believed to be due to different gate timings and / or charge injection in the switches.
10. Press the button, and zero the voltmeters using the offset adjust knobs. These drift a lot - do this often (every data point?) when taking data.

11. Adjust the 714 phase to maximize the voltmeter outputs. Should be 100mv to a few x100mv. Check the monitor voltage on the scope. Should be around 200mv. Record readings.

12. Adjust the 714 phase to zero the voltmeter outputs. Check the integrator zero with the button (fix if needed).

13. Measure the mv/Deg714 sensitivity at this input level. Should be a few mv/Degree.

14. Proceed to measure.

Notes:

The Op amps in the system are OP177, very high precision amps (much better than we need). If they are trashed, a standard precision op amp (op07, op27) should be OK, but a non-precision amp like a LF355 has too much offset.

We do not know what part of the box goes non-linear first. The output gain can be changed by changing the attenuator between the two amplifiers (in the center of the box).

The biggest error source in the box is the charge injection of the RF switches. These can probably be substantially improved in a future revision.

The amplifiers are not DC coupled. If the RF switches are left on, there will be not (meaningful) output from the voltmeter. Even if only one bunch is used, you must use the switches to gate the pulses from the amplifiers.

The signal path in the box has various filters and attenuators. Of these, only the 714 bandpass is really necessary. The rest are there because they seemed like a generally good idea.

The pots can be replaced with a DAC, and the button with an IDOM for fully remote operation.