

## Correcting the Accumulator Extraction Energy and Phase

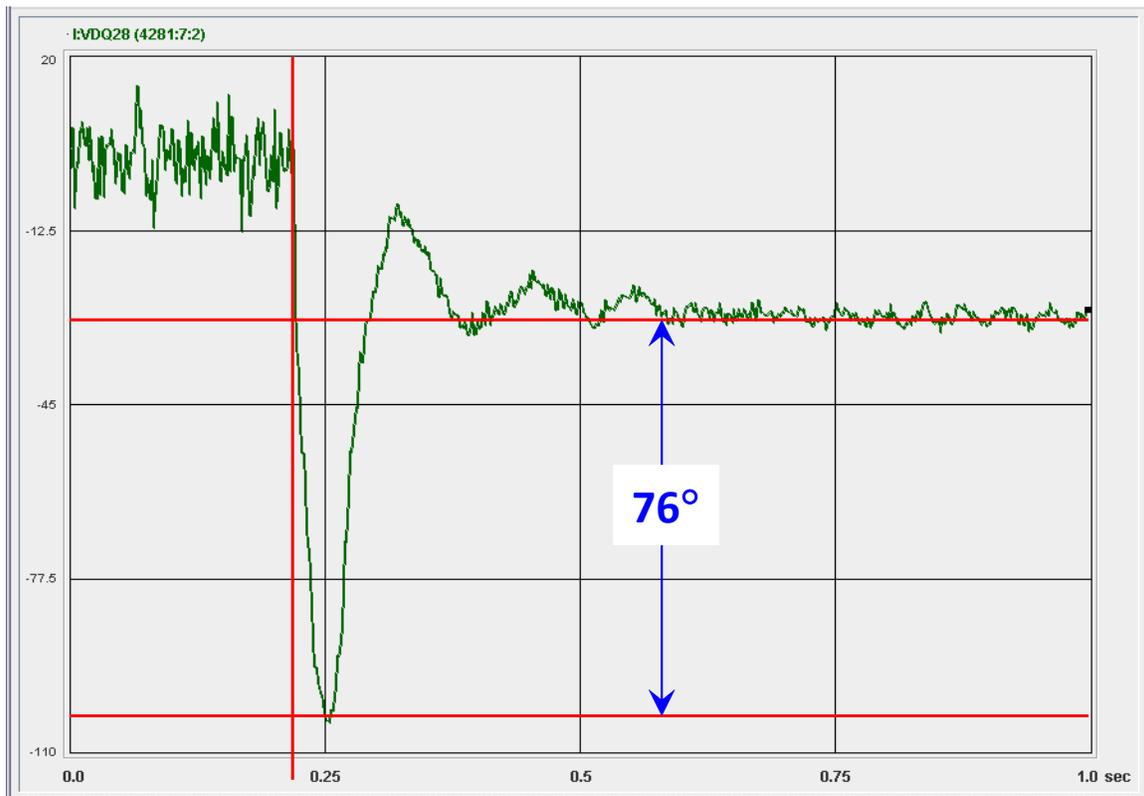
Updated: July 28, 2008

This note is a collection of procedures that facilitate the measurement and correction of Accumulator-Main Injector energy and phase mismatches.

**IMPORTANT:** Prior to correcting an energy mismatch, it is important to verify that the Accumulator energy has been properly set. This is accomplished by performing the Accumulator energy alignment procedure, which can be found in the Pbar Tuning Guide (<http://www-pbar-tuning.fnal.gov/>).

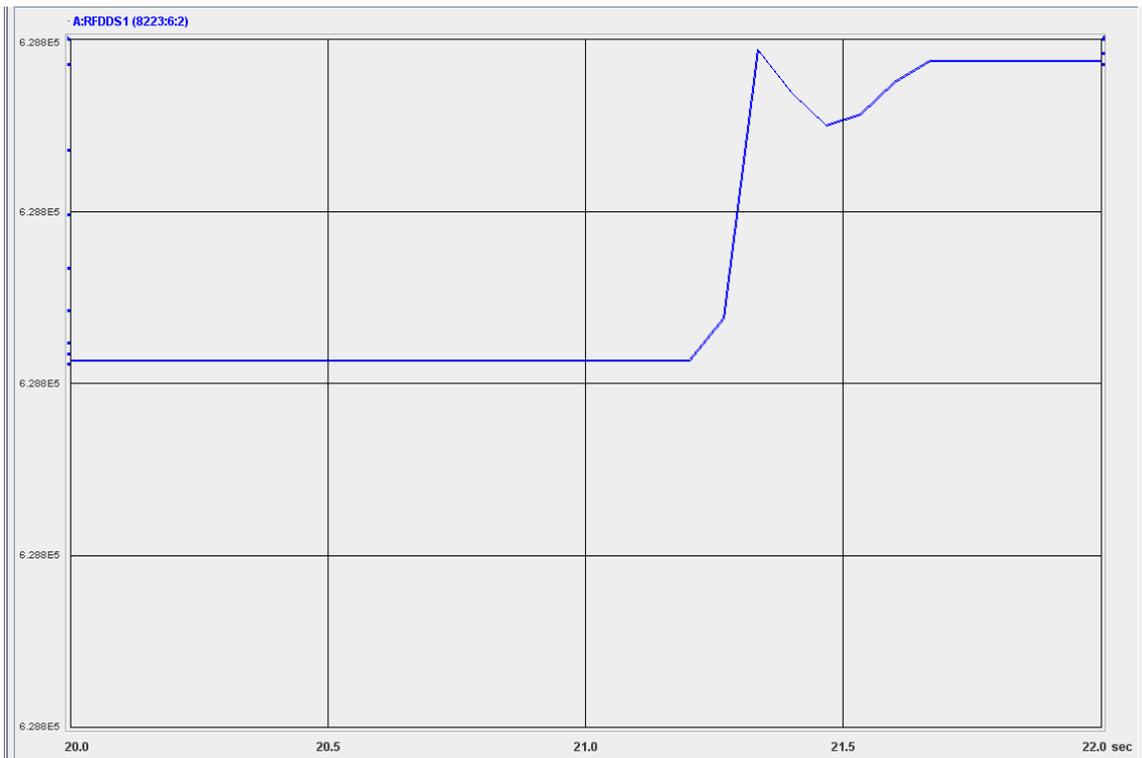
### Setup Plots

1. Make a plot of I:VDQ28 (MIRF 2.5 MHz phase detector) vs. time. This can be done from a FTP or SDA's plot viewer.
  - To get an FTP triggered at the right time, restore FTP file Pbar 9. Trigger the plot on a \$9A + 1.5 sec. Plot I:VDQ28 and set the vertical scale from  $-45^\circ$  to  $15^\circ$ . Set the time base from 1.5 to 1.9 sec.
  - To view the SDA plot: open the view called MIRF\_Phase\_RR\_SW.xml, select a transfer (or transfers) from case 7 (Transfer Pbars from Accum to MI for RR). The resulting plot looks like the figure below:



**Figure 1.** This is a plot of MIRF phase versus time (0 = \$9A + 1.5 sec). The above plot shows a pure energy error. In general, there may be a phase error as well. The phase error is the value of I:VDQ28 – baseline when beam arrives. The phase baseline and the beam arrival time are indicated by the red lines.

2. Make a plot of A:RFDDS1 (ARF4 frequency  $\div$  4) vs. time. This can also be done from a FTP or SDA's plot viewer.
  - To get an FTP triggered at the right time, restore FTP file Pbar 3. Trigger the plot on a \$91 + 20 sec. Plot A:RFDDS1 and set the vertical scale from 628760 to 628768. Set the time base from 20 to 22 sec.
  - To view the SDA plot: open the view called ARF4\_Frequency\_RR.xml, select a transfer (or transfers) from case 6 (Unstack Pbars for RR). Since SDA's plot viewer views don't save the axis scaling, you will have to setup the axes yourself. Set xmin = 20 sec, xmax = 22 sec; ymin = 628761 Hz, ymax = 628765 Hz. The resulting plot looks like the figure below:



**Figure 2.** The above figure is a plot of A:RFDDS1 versus time relative to a \$91. Phase lock with MIRF happens at approximately 21.2 sec. At this time the ARF4 frequency is changed until it's phase matches that of MIRF. Ideally, there should be no frequency excursion during phase lock. This plot shows a 1.7 Hz error in A:RLLEXF.

## Energy Error

The Accumulator – MI energy match is adjusted by changing A:RLLEXF and the MIRF frequency by the same amount at  $h = 1$ . If either frequency is changed without a corresponding change in the other, the energy will not change. Changing these two frequencies by different amounts will change the amount by which the RF frequency of beam on the Accumulator extraction orbit is changed during phase lock with MIRF. The procedure below will correct an energy mismatch and zero the frequency excursion during phase lock.

1. Estimate the MIRF phase excursion.

The phase excursion is how far the phase detector swings from the baseline on the first oscillation. In Figure 1 above, the phase swing is about  $-76^\circ$ .

2. Estimate the change to A:RLLEXF required to correct the error.

The change required is approximately  $-1$  Hz per  $+15^\circ$  of phase swing. Therefore, the correction required above is:

$$\Delta(\text{A:RLLEXF}) = \frac{-1 \text{ Hz}}{15^\circ} \cdot (-76^\circ) = 5 \text{ Hz}$$

3. Estimate the change in A:RLLEXF and/or MIRF frequency required to zero the ARF4 frequency excursion during phase lock.

The frequency excursion shown in Figure 2 is  $+1.7$  Hz suggesting that the value of A:RLLEXF be raised by  $1.7$  Hz or the MIRF frequency be lowered by  $1.7$  Hz (at  $h = 1$ ) to zero the frequency excursion.

4. Calculate the changes to A:RLLEXF and MIRF frequency to simultaneously zero the energy error and zero the phase lock frequency excursion.

The changes that accomplish this in the above example are:

$$\Delta(\text{A:RLLEXF}) = 5 \text{ Hz}$$

$$\Delta(\text{MIRF freq}) = 5 \text{ Hz} - 1.7 \text{ Hz} = 3.3 \text{ Hz}$$

5. Before the markers on the VSA longitudinal display have been frozen, change A:RLLEXF by the amount calculated in step 4.

6. Change the MIRF capture frequency:

- Open I6
- Load state 20 (interrupt to the right of **MI State:** [ ] – 4<sup>th</sup> row from the top – for a directory of available states)  
**Important:** Select the ACTIVE file (not the OPERATIONAL or STUDIES files).
- Change the DATUM1 number in row 0 by  $84 \times$  the number calculated in step 4. In this case the net change is  $277$  Hz. The number to change is circled in the figure below. After the change has been made, interrupt on **\*Send to Hardware**.

7. When transfers are complete, update the value for A:RLLEXF in the “Fast Rec Shots & Tuneup” aggregate of the Pbar Ops Sequencer (Mode 19).

VMS PC:16 LLRF VXI CONTROL<NoSets>

I6 VXI LLRF Novice Mode (most restrictive) 28-JUL-06 15:32:38 Pgm\_Tools

SEQUENCE TABLE VIEWER CURVES ARRAYS required data

Sequence Table View

HrdwrID: [MILLRF] \*Send To Hardware \*Refresh \*Save To Database

MI State: [20 Accumulator pbars to MI to RR using Pbar stacking lattice ] Current state: 28

ROW	TYPE	SIGNAL	MESSAGE	DATUM1	DATUM2	DATUM3	DATUM4
0	Event	AnyReset	EnergyStepToFset	52817084			
1	Continue		V588 Feedback	0n	10	10	
2	Delay	0.0299910009	AlignXFR28toMIaa	no check			
3	Continue		XfrSyncAccToMI	0	-170	use devices	0
4	Continue		SetRposGain	10 db			
5	Continue		QscpUpdate	1000			
6	Continue		QscpSet	5	.004		
7	Delay	0.2000000030	EnergyArmSnapToFset	52811400	211.149994		
8	Continue						
9	Delay	0.4000000060	AlignH28RF2	17.900011			
10	Continue		V28sbcSet	0	2.7	.1	
11	Continue		RfHSelect	h28 control			
12	Continue		V588Set	All Off	0	1	Enable
13	Delay	1.5599999428	QdotfbOn			0	150GeV LPF
14	Delay	1.7000000477	V28sbcPlay	0	20	.5	10
15	Delay	2.7000000477	EnergyRampToFset	1	.6		
16	Delay	3.2999999523	XfrCogToRecycler	.3	0	-90	
17	Delay	4.2500000000	V28sbcPlay	0	2.7	.3	10
18	Delay	4.6999502182	V588Apg(t)Curve	All On		1	Enable
19	Event	EndCycle					
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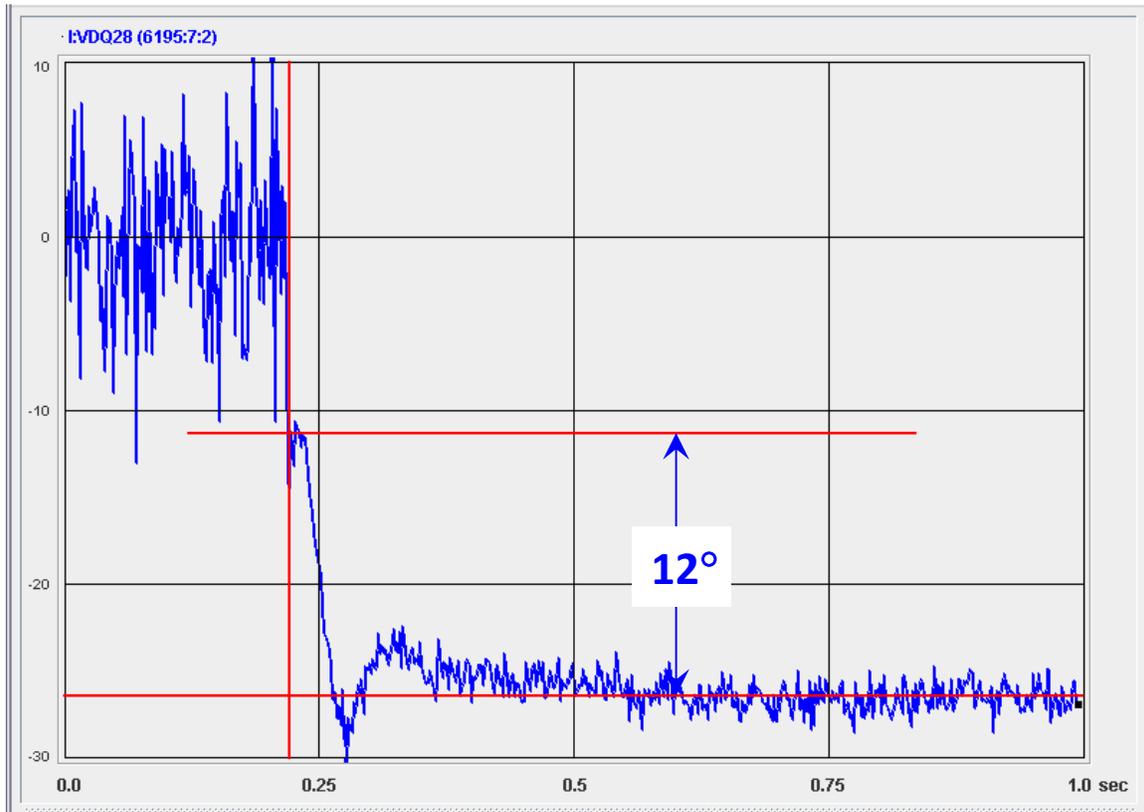
Messages

```

SEQUENCE : Receiving User Locks
SEQUENCE : Requesting User Locks
LLRF: initialized on CNS->231
PGM: Signal help disabled
PGM: Message help disabled
PGM: Bubble help enabled
    
```

## Phase Error

1. Estimate the value of I:VDQ28 at the moment beam arrives in the Main Injector.



**Figure 3.** This plot shows a nearly pure phase error of approximately 12° to 15°. The phase baseline and the beam arrival time are indicated by the red lines.

2. Subtract the phase error measured in step 1 from the present value of A:R4MIPS.  
Thus, to correct the phase error shown in Figure 3, the value of A:R4MIPS should be decreased by approximately 12°.
3. When transfers are complete, update the value for A:R4MIPS in the “Fast Rec Shots & Tuneup” aggregate of the Pbar Ops Sequencer (Mode 19).