SPS High Bandwidth Transverse Feedback System MD

Dynamic Range Measurements of ADC

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1. The goal of the MD is to identify and quantify the dynamic range of the ADC and the Tek scope. the method used for these measurements are as follows.
 - a) Use a signal generator at 100/200/400 MHz to generate an independent signal, apply it to the input of the feedback system and Tek scope through some adjustable attenuation chain (60 dB or more necessary).
 - b) Initial, adjust the signal level with minimum attenuation so that the level is very close to full scale on the recording device. For the snap shot, the level should be about -128/127. Take several snap shots.
 - c) Attenuate the signal, (in most cases 5 dB steps) down to -60 dB or lower acquiring several data records for each attenuation step
 - d) Process the spectrograms, which will reveal the full scale and noise floor.
 - e) Tests on the scope follow the ADC tests. Set the gain so that the largest signal is nearly saturating the screen. Attenuate the signal as above, but do not change the scope gain! The scale should remain constant for the entire measurement.
 - f) Next, go back to the ADC but inject the signal into the receiver chain to quantify the noise floor from the gain stages and equalizer.
 - g) Terminate with 50Ω the input of the receiver chain and acquire data.
2. Setup feedback system
 - a) All signal cables were reconnected as they were before yesterday's aliased line troubleshooting measurements.
 - b) Set trigger thresholds
 - i. Injection: 0.5 V
 - ii. Fiducial: 0.35 V
 - c) Check fiducial signal via Strobe 4
 - d) Load pass through FIR filter from yesterday, MAR-22-2013-1230
 - e) Under MMCM control set phases
 - i. ADC sys clock phase: 15
 - ii. ADC reset clock phase: 10
 - iii. DAC sys clock phase: 16
 - f) Under DSP/FIR control hit ADC Reset

3. With the ADC input terminated at $50\ \Omega$ at the front panel, repeat acquisition from yesterday to see that the system is in the same condition. Perform a couple of acquisitions with the snap shot memory. Number of turns before record: 1, number of turns to read: 20k. File are listed below
 - a) 1047, process, see line at 0.196
 - b) 1052
 - c) 1053
 - d) 1054
 - e) 1055
4. Measurement of the ADC without the receiver chain.
 - a) At 100 MHz
 - i. Find appropriate signal level to inject into the ADC.
 - A. Measure 500 mV_p signal on scope with range 100 mV/div , synthesizer 400 mV . 1059, ADC saturated.
 - B. Remove signal, measure with open input. 1101, ± 1 count
 - C. Reduce signal level to 497 mV_{pp} on scope, $\rightarrow 200\text{ mV}$ on synthesizer. 1105, -81/82 counts.
 - D. Increase signal level to 590 mV_{pp} on scope $\rightarrow 225\text{ mV}$ on synthesizer. 1108, -1/1 counts. I forgot to connect signal to ADC. Connect to ADC, 1110, -95/94 counts.
 - E. Increase signal level to 794 mV_{pp} on scope $\rightarrow 300\text{ mV}$ on synth. 1113, -127/126 counts, saturated.
 - F. Reduce signal level to 754 mV_{pp} on scope $\rightarrow 285\text{ mV}$ on synth. 1116, -122/121, just under saturation.
 - G. Increase signal level to 770 mV_{pp} on scope $\rightarrow 292\text{ mV}$ on synth. 1120, -121/121. Strange, input signal not stable?
 - H. Increase signal level to 790 mV_{pp} on scope $\rightarrow 300\text{ mV}$ on synth. 1124, forgot to connect signal to ADC. Connect to ADC, 1126, -127/126. This seems to be the saturations limit. However, this tells me that the ADC can really only accept a 400 mV_p signal, not the advertised 500 mV_p .
 - ii. Start measurement, adding attenuation. See Table 1.

Table 1: Data files acquired during feedback tests on Mar. 23, 2013 to quantify the dynamic range of the ADC using a 100 MHz synthesized signal.

Snapshot File	Attenuation (dB)	ADC Counts	
		Lower	Upper
1131	20	-12	12
1133	30	-4	5
1135	40	-2	3
1138	50	-1	2
1141	3	-88	88
1143	6	-63	64
1146	9	-45	46
1148	12	-32	33
1151	15	-23	24
1339	60		
1344	70		
1348	65		

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Table 1 – continued from previous page

Snapshot File	Attenuation (dB)	ADC Counts	
		Lower	Upper
1351	68		
1356	60		
1357	65		
1358	70		
1359	50		
1400	55		
1402	45		
1403	40		

b) At 200 MHz

i. Find appropriate signal level to inject into the ADC.

- A. Signal level 785 mV_{pp} on scope, $\rightarrow 300 \text{ mV}$ on synthesizer. 1155, -123/123 counts.
- B. Note that when 100 MHz signal was measured after the dynamic range test, the level was 808 mV_{pp} measured on the scope. Synthesizer must not be very well regulated.

ii. Measurement, add attenuation. See Table 2.

Table 2: Data files acquired during feedback tests on Mar. 23, 2013 to quantify the dynamic range of the ADC using a 200 MHz synthesized signal.

Snapshot File	Attenuation (dB)	ADC Counts	
		Lower	Upper
1158	3	-86	87
1200	6	-61	62
1202	9	-43	44
1204	12	-31	32
1206	15	-22	23
1208	20	-12	13
1210	30	-4	5
1212	40	-2	1
1412	70		
1413	65		
1414	60		
1415	55		
1416	50		
1417	45		
1418	40		

c) At 400 MHz

i. Find appropriate signal level to inject into the ADC.

- A. Signal level 750 mV_{pp} on scope, $\rightarrow 300 \text{ mV}$ on synthesizer. 1215, -111/110 counts.
- B. Increase signal level to 802 mV_{pp} on scope, $\rightarrow 320 \text{ mV}$ on synthesizer. 1218, -118/117 counts.
- C. Increase signal level to 827 mV_{pp} on scope, $\rightarrow 330 \text{ mV}$ on synthesizer. 1220, -122/121 counts.
- D. Increase signal level to 851 mV_{pp} on scope, $\rightarrow 340 \text{ mV}$ on synthesizer. 1223, -126/125 counts.

ii. Measurement, add attenuation. See Table 3.

Table 3: Data files acquired during feedback tests on Mar. 23, 2013 to quantify the dynamic range of the ADC using a 400 MHz synthesized signal.

Snapshot File	Attenuation (dB)	ADC Counts	
		Lower	Upper
1225	3	-87	88
1227	6	-61	62
1228	9	-43	44
1230	12	-31	32
1231	15	-22	23
1233	20	-13	14
1235	30	-4	5
1237	40	-2	3
1405	40		
1406	45		
1407	50		
1408	55		
1409	60		
1410	65		
1411	70		

5. Measurement with the Tek scope.

- a) The scope was set up in the way typical to our pickup measurements. The scope was triggered using the scope trigger signal generated in the Faraday cage, and the synthesized signal was measured on Ch2 (the *delta* channel). The gain for Ch2 was held constant at 80 mV/div for the entire measurement (full scale here correlated to just saturating the ADC). The data was acquired in 'sample' mode at a rate of 20 GS/s (similar to our operating rate). The synthesized signal amplitude was varied with attenuation steps of 5 dB up to 70 dB for both system measurements at frequencies 100, 200, 400 MHz. See Table 4.
- b) The signal levels were similar for the Tek scope as they were for the ADC.

Table 4: Data files acquired on Mar. 23, 2013 to quantify the dynamic range of the Tek scope

Tek File	Attenuation (dB)	Frequency (MHz)
143427	0	100
143501		200
143600		400
143658	5	400
143745		200
143821		100
143923	10	100
143959		200
144047		400
144209	15	400
144246		200
144322		100
144433	20	100
144510		200
144545		400

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Table 4 – continued from previous page

Tek File	Attenuation (dB)	Frequency (MHz)
144646	25	400
144722		200
144757		100
144909	30	100
144946		200
145022		400
145121	35	400
145157		200
1452		100
145346	40	100
145433		200
145708		400
145830	45	400
150002		200
150146		100
153522	45	100
153559		200
153650		400
153822	50	400
153857		200
153933		100

6. Measurement of the ADC with the receiver chain. As schematic of the receiver chain with associated gains and attenuation is shown in Fig. ??.

a) Find appropriate receiver attenuation and signal levels for various frequencies. Checked to make sure I was not saturating Miteq amplifiers

i. 100 MHz

A. Signal level 810 mV_{pp} on scope, → 100 mV on synthesizer. 1615, -127/126 counts, saturated.

B. With 3 dB added, 1618, -101/94

ii. 200 MHz

A. Signal level 800 mV_{pp} on scope, → 170 mV on synthesizer. 1652, -127/126 counts, saturated.

B. Signal level ? mV_{pp} on scope, → 100 mV on synthesizer. 1654, -86/83 counts.

C. Signal level 760 mV_{pp} on scope, → 150 mV on synthesizer. 1656, -127/123 counts, saturated.

iii. 400 MHz (notice some DC offset, from the equalizer?)

A. 150 mV on synthesizer. 1659, -92/85 counts.

B. 190 mV on synthesizer. 1700, -116/106 counts.

C. 200 mV on synthesizer. 1702, -123/111 counts.

D. 210 mV on synthesizer. 1703, -127/116 counts, saturated.

b) Measurement, add attenuation. See Table 5.

Table 5: Data files acquired during feedback tests on Mar. 23, 2013 to quantify the dynamic range of the ADC with the receiver.

Tek File	Attenuation (dB)	Frequency (MHz)
1705	0	400
1706		200
1707		100
1708	5	100
1709		200
1710		400
1711	10	400
1712		200
1713		100
1714	15	100
1715		200
1716		400
1717	20	400
1718		200
1719		100
1720	25	100
1721		200
1722		400
1723	30	400
1724		200
1725		100
1726	35	100
1727		200
1728		400
1729	40	400
1730		200
1731		100
1732	45	100
1733		200
1734		400
1735	50	400
1736		200
1737		100
1738	55	100
1739		200
1740		400
1741	60	400
1742		200
1743		100
1744	65	100
1745		200
1746		400
1747	70	400
1748		200
1749		100

7. Terminate with $50\ \Omega$ at the input of the receiver chain.

a) 1753

- b) 1754
- c) 1755
- d) 1756
- e) 1757