

ATCA-based – LLRF Controls Engineering Test Stand User Interface via PyDM

SLAC TID Advanced Control System

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July 16, 2020

BOLD PEOPLE. VISIONARY SCIENCE. REAL IMPACT.



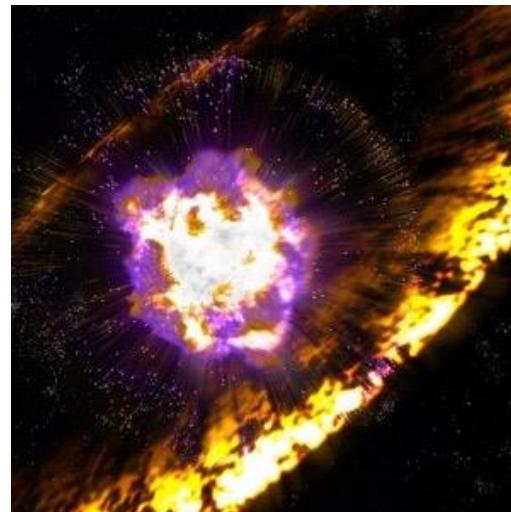
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Agenda

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- Background
 - Problem statement
 - Proposed solution
- Implementation Details
- Demo / ATCA_PyDM_Screens
- What is Next
- Q&A



Background

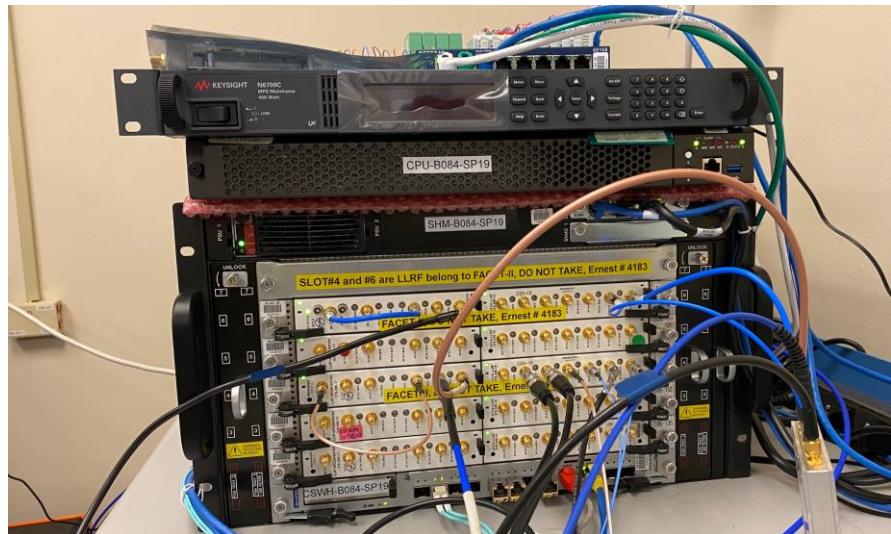
Problem Statement

- The engineers and technicians need a user Interface to help them testing of control's hardware. In this case the LLRF controls hardware

Proposed Solution

- Using the great, next generation PyDM. PyDM is a PyQt-based framework for building user interfaces for control systems.

ATCA-Based LLRF Engineering and Controls Hardware Test Stand

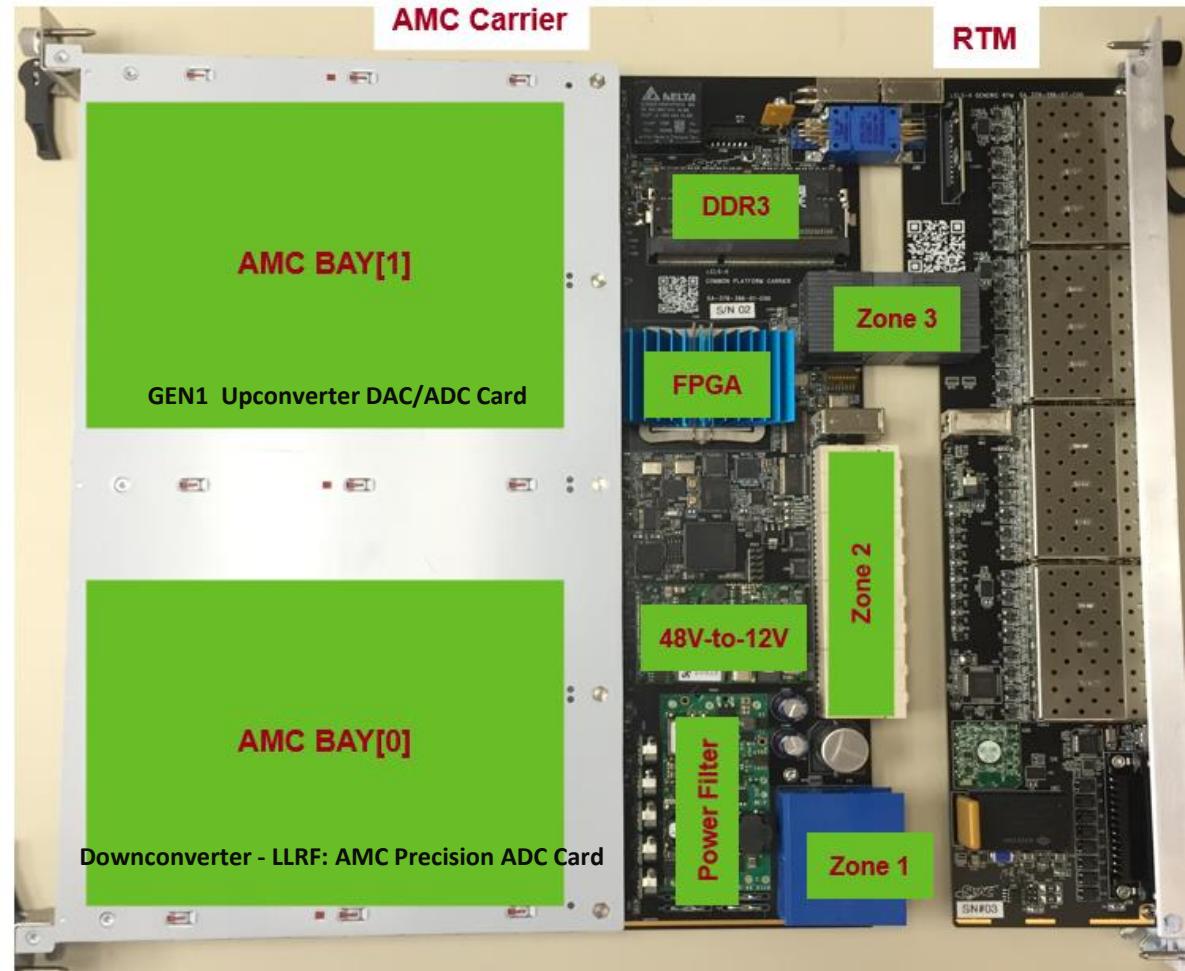


LLRF ATCA Platform

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In order to do the LLRF project, we need the:

- FPGA with LLRF firmware in it
- daughters cards plugged in
- RTM plugged in – and that makes up the LLRF controller.



Front Panel View of LLRF Hardware

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PC_379_396_17_C03_A01: GEN1 Upconverter DAC/ADC Card



PC_379_156_06_C00_A01: GEN2 Upconverter DAC/ADC Card



Used by
FACET

PC_379_396_16_C03_A01: Downconverter - LLRF: AMC Precision ADC Card

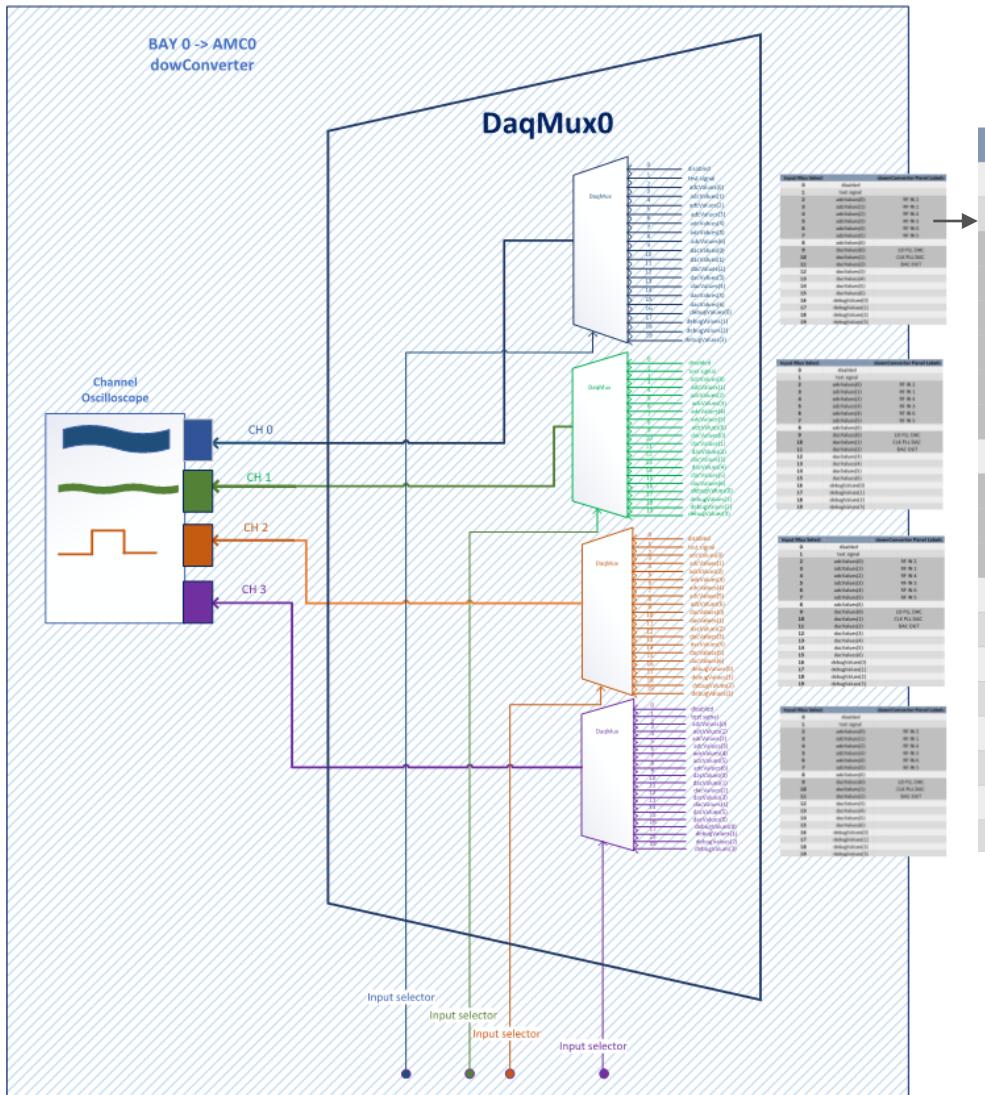


PC_379_396_19_C02:
RF Interlock RTM



DaqMuxV2 – Bay0 (Down Converter)

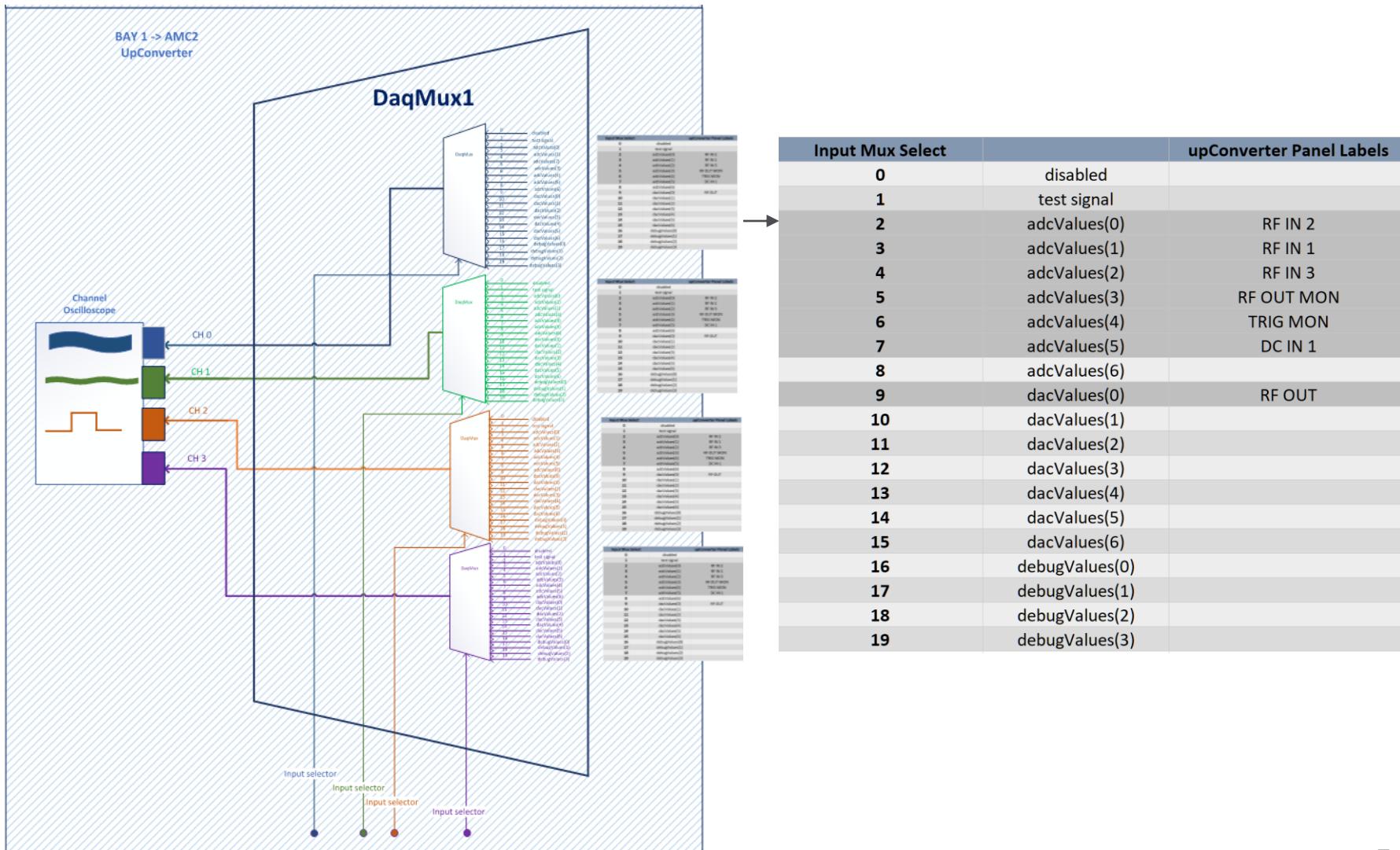
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Input Mux Select		downConverter Panel Labels
0	disabled	
1	test signal	
2	adcValues(0)	RF IN 2
3	adcValues(1)	RF IN 1
4	adcValues(2)	RF IN 4
5	adcValues(3)	RF IN 3
6	adcValues(4)	RF IN 6
7	adcValues(5)	RF IN 5
8	adcValues(6)	
9	dacValues(0)	LO PLL DAC
10	dacValues(1)	CLK PLL DAC
11	dacValues(2)	DAC OUT
12	dacValues(3)	
13	dacValues(4)	
14	dacValues(5)	
15	dacValues(6)	
16	debugValues(0)	
17	debugValues(1)	
18	debugValues(2)	
19	debugValues(3)	

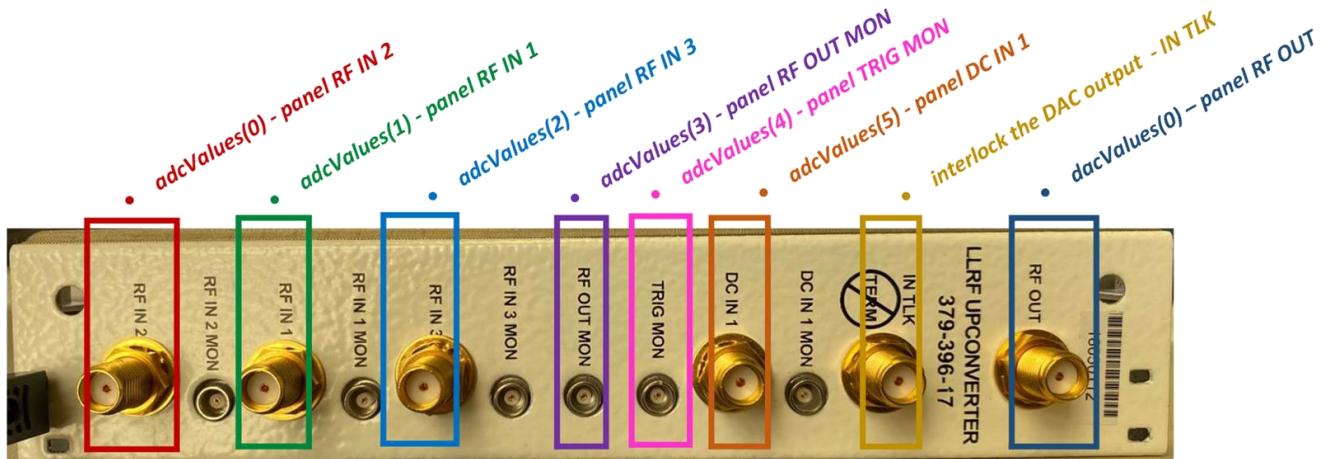
DaqMuxV2 – Bay1 (Up Converter)

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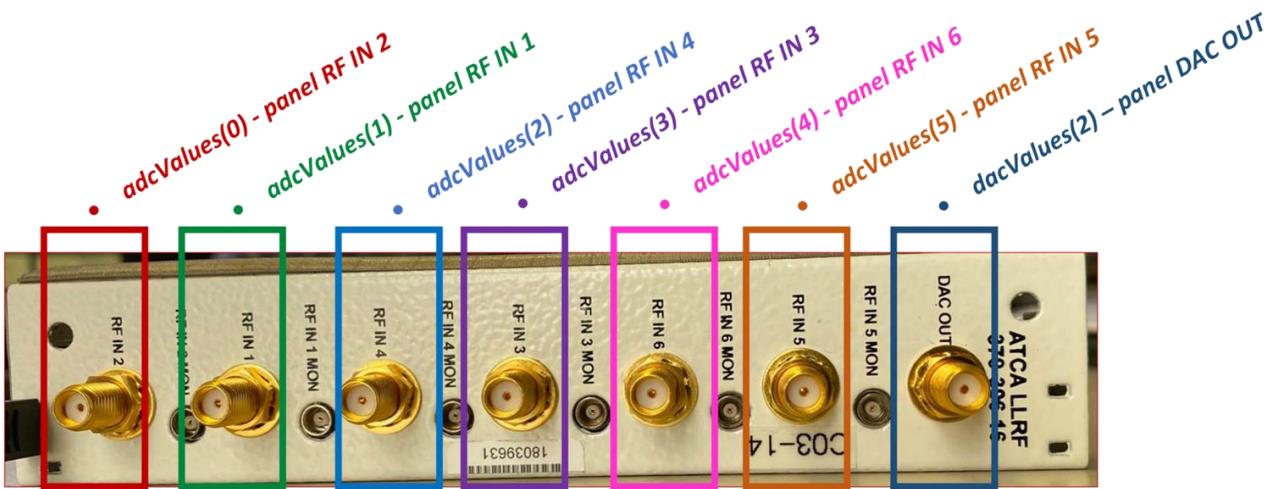


Front Panel Inputs Mapping

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PC_379_396_17_C03_A01: GEN1 Upconverter DAC/ADC Card



PC_379_396_16_C03_A01: Downconverter - LLRF: AMC Precision ADC Card

PV Mapping Research for DaqMuxV2



Work that has to be done before putting the screens together.

PVs	Description	Remarks	Conversion	CPSV Name (YAML, Register Name)	EDM Labels
\$DEVICE:DAQMUX\$(MUX)_TRGDAQ	Soft Trigger	\$MUX = [0..1]	0: Normal; 1: Trigger	TriggerSw	Trigger Daq
\$DEVICE:DAQMUX\$(MUX)_ARMMHWTRG	Arm Hardware Trigger	\$MUX = [0..1]	0: Normal; 1: Arm	TriggerHwArmed	Arm Hardware Trig
\$DEVICE:DAQMUX\$(MUX)_FRZBUF	Freeze Buffer	\$MUX = [0..1]	0: Normal; 1: Freeze	FreezeSw	Freeze Buffer
\$DEVICE:DAQMUX\$(MUX)_CLTRGST	Clear Trigger Status	\$MUX = [0..1]	0: Normal; 1: Clear	TriggerClearStatus	Clear Trg Status
\$DEVICE:DAQMUX\$(MUX)_CSCDTRG	Cascaded Trigger	\$MUX = [0..1]	0: Disable; 1: Enable	TriggerCscMask	Cascaded Trigger
\$DEVICE:DAQMUX\$(MUX)_AUTOREARM	Auto re-arm	\$MUX = [0..1]	0: Disable; 1: Enable	TriggerHwAutoRearm	Auto Re-arm
\$DEVICE:DAQMUX\$(MUX)_DAQMODE	Trigger Mode	\$MUX = [0..1]	0: Trigger Mode; 1: Continue Mode	DaqMode	Daq Mode
\$DEVICE:DAQMUX\$(MUX)_PACKETHEADER	Packet Header	\$MUX = [0..1]	0: Disable; 1: Enable	PacketHeaderEn	Packet Header
\$DEVICE:DAQMUX\$(MUX)_HWFRZ	Hardware Freeze	\$MUX = [0..1]	0: Disable; 1: Enable	FreezeHwMask	Hardware Freeze???
\$DEVICE:DAQMUX\$(MUX)_DEC RATE DIV	Decimate Rate Divisor	\$MUX = [0..1]	Divisor Number	DecimationRateDiv	Decimate Rate Divisor
\$DEVICE:DAQMUX\$(MUX)_BUFSIZE	Buffer Size	\$MUX = [0..1]		DataBufferSize	Buffe Size
\$DEVICE:DAQMUX\$(MUX)_TRGCNT	Trigger Count	\$MUX = [0..1]		TrigCount	Trigger Count
\$DEVICE:DAQMUX\$(MUX)_DBGINPVALID	DEBUG Input Valid	\$MUX = [0..1]		DbgInpValid	Debug Input Valid
\$DEVICE:DAQMUX\$(MUX)_DBGLINKRDY	DEBUG Link Ready	\$MUX = [0..1]		DbgLinkReady	Debug Link Ready
\$DEVICE:DAQMUX\$(MUX)_TS_SEC	DaqMux Timestamp, Second	\$MUX = [0..1]		TimeStamp ??	Daq Timestamp (sec)
\$DEVICE:DAQMUX\$(MUX)_TS_NSEC	DaqMux Timestamp, Nano-Second	\$MUX = [0..1]		TimeStamp ??	Daq Timestamp (nsec)
\$DEVICE:DAQMUX\$(MUX)_INPMUXSEL\$(CH)	Input MUX Selector	\$MUX = [0..1]; \$CH = [0..19]			
\$DEVICE:DAQMUX\$(MUX)_INPMUXSELSTR\$(CH)	Input Mux Selector/String output	\$MUX = [0..1]; \$CH = [0..3]			
\$DEVICE:DAQMUX\$(MUX)_STRMPAUSE\$(CH)	Stream Pause	\$MUX = [0..1]; \$CH = [0..3]	0: Stream; 1: Pause	StreamPause	Stream Pause
\$DEVICE:DAQMUX\$(MUX)_STRMRDY\$(CH)	Stream Ready	\$MUX = [0..1]; \$CH = [0..3]	0: Not Ready; 1: Ready	StreamReady	Stream Ready
\$DEVICE:DAQMUX\$(MUX)_STRMOVF\$(CH)	Stream Overflow	\$MUX = [0..1]; \$CH = [0..3]	0: Normal; 1: Overflow	StreamOverflow	Stream Overflow
\$DEVICE:DAQMUX\$(MUX)_STRMERR\$(CH)	Stream Error	\$MUX = [0..1]; \$CH = [0..3]	0: No Error; 1: Error	StreamError	Stream Error
\$DEVICE:DAQMUX\$(MUX)_INPDATAVALID\$(CH)	Input Data Valid	\$MUX = [0..1]; \$CH = [0..3]	0: Invalid; 1: Valid	InputDataValid	Input Data Valid
\$DEVICE:DAQMUX\$(MUX)_STRMENABLED\$(CH)	Stream Enabled	\$MUX = [0..1]; \$CH = [0..3]	0: Disabled; 1: Enabled	StreamEnabled	Stream Enabled
\$DEVICE:DAQMUX\$(MUX)_FRAMECNT\$(CH)	Frame Counter	\$MUX = [0..1]; \$CH = [0..3]		FrameCnt	Frame Count
\$DEVICE:DAQMUX\$(MUX)_FORMATSIGWIDTH\$(CH)	Format Sign Width	\$MUX = [0..1]; \$CH = [0..3]			Format Sign Width
\$DEVICE:DAQMUX\$(MUX)_FORMATDATAWIDTH\$(CH)	Format Data Width	\$MUX = [0..1]; \$CH = [0..3]		FormatDataWidth	Format Data Width
\$DEVICE:DAQMUX\$(MUX)_FORMATSIGN\$(CH)	Format Sign	\$MUX = [0..1]; \$CH = [0..3]	0: Disable; 1: Enable	FormatSign	Format Sign
\$DEVICE:DAQMUX\$(MUX)_DECIMATION\$(CH)	Decimation	\$MUX = [0..1]; \$CH = [0..3]	0: Disable; 1: Enable	DecimalAveraging	Decimation

PV Mapping Research Continued for AMC Cards



DownConverter		EDM Attenuator Attenuator PVs	Temperature Labels	Temperature PVs
\$(DEVICE) - Llrf Down Converter"	ch0	"\$(DEVICE):DNC_ATTEN0"	Temp 0	"\$(DEVICE):DNC_TEMP0"
DEVICE = SIOC:B084:RF53:0	ch1	"\$(DEVICE):DNC_ATTEN1"	Temp 1	"\$(DEVICE):DNC_TEMP1"
	ch2	"\$(DEVICE):DNC_ATTEN2"	Temp 2	"\$(DEVICE):DNC_TEMP2"
	ch3	"\$(DEVICE):DNC_ATTEN3"	Temp 3	"\$(DEVICE):DNC_TEMP3"
	ch4	"\$(DEVICE):DNC_ATTEN4"		
	ch5	"\$(DEVICE):DNC_ATTEN5"		
<hr/>				
UpConverter		Attenuator Label Attenuator PVs	Temperature Labels	Temperature PVs
\$(DEVICE) - Llrf Up Converter"	ch0	"\$(DEVICE):UPC_ATTEN0"	Temp 0	"\$(DEVICE):UPC_TEMP0"
DEVICE = SIOC:B084:RF53:0	ch1	"\$(DEVICE):UPC_ATTEN1"	Temp 1	"\$(DEVICE):UPC_TEMP1"
	ch2	"\$(DEVICE):UPC_ATTEN2"	Temp 2	"\$(DEVICE):UPC_TEMP2"
	ch3	"\$(DEVICE):UPC_ATTEN3"	Temp 3	"\$(DEVICE):UPC_TEMP3"

RF_Waveform	X-Y Graph	WFs
<PREFIX>=DEVICE	yPv {0 "\$(WF)"} WF=<PREFIX>:STR0:STREAM_SLOWSHORT0	
DEVICE = SIOC:B084:RF53:0	value { "\$(CH)"}	WF=<PREFIX>:STR0:STREAM_SLOWSHORT1
		WF=<PREFIX>:STR0:STREAM_SLOWSHORT2
		WF=<PREFIX>:STR0:STREAM_SLOWSHORT3
		WF=<PREFIX>:STR1:STREAM_SLOWSHORT0
		WF=<PREFIX>:STR1:STREAM_SLOWSHORT1
		WF=<PREFIX>:STR1:STREAM_SLOWSHORT2
		WF=<PREFIX>:STR1:STREAM_SLOWSHORT3

DEMO Time



Launching the screens:

Log into **lcls-dev3**

```
ssh username@lcls-dev3
source /afs/slac/g/lcls/epics/setup/epicsenv-7.0.3.1-1.0.bash
source /afs/slac/g/lcls/package/pydm/use_pydm.bash
cd /afs/slac/g/controls/development/users/csewell/ATCA_PyDM_Screens
```

For Bld 84

```
pydm -m 'DEVICE=SIOC:B084:RF52:0' scope.py
```

or for Bld 34:

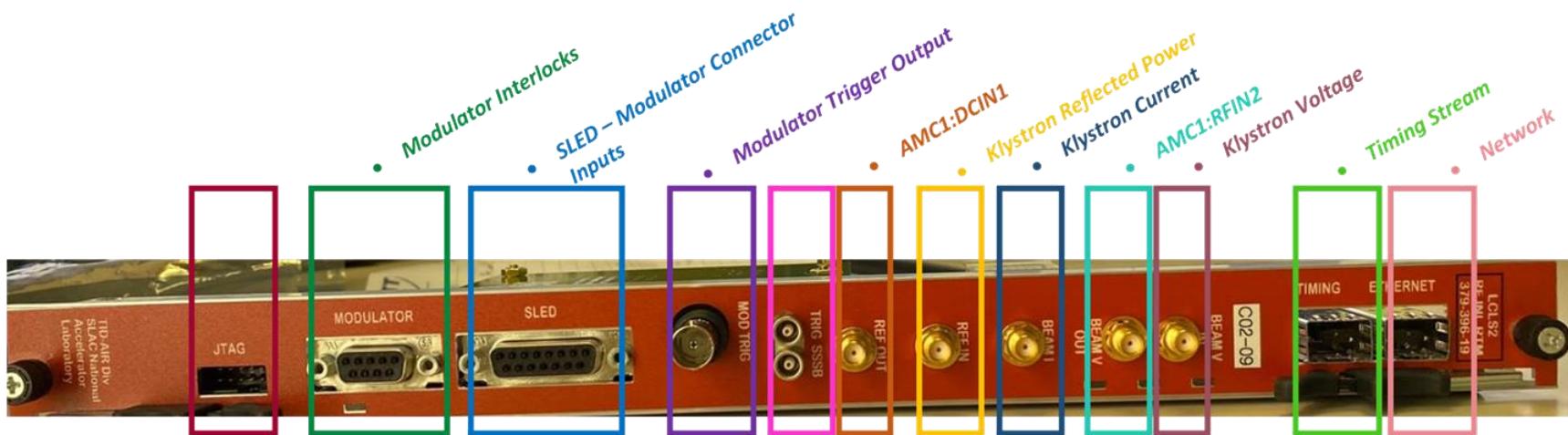
```
pydm -m 'DEVICE=SIOC:B34:RF13:0' scope.py
```

You can also find the ATCA_PyDM_Screens repository at:

https://github.com/cristinasewell/ATCA_PyDM_Screens

What is next

- Finish Integrating the RTM in the UI
- Integrate Gen2 Up Converter in the UI
- Improve UI based on user feedback
- Keep Learning
-



RTM – Progress



waveforms:

SIOC:B084:RF52:0:RTM_BCURR_WF- rtm fast adc
SIOC:B084:RF52:0:RTM_BCURR_PK - peak value
fault history [0..3]
SIOC:B084:RF52:0:FAULTHIST0 RTM_BCURR_WF
SIOC:B084:RF52:0:FAULTHIST1 RTM_BCURR_WF
SIOC:B084:RF52:0:FAULTHIST2 RTM_BCURR_WF
SIOC:B084:RF52:0:FAULTHIST3 RTM_BCURR_WF

SIOC:B084:RF52:0:RTM_BVOLT_WF - rtm fast adc
SIOC:B084:RF52:0:RTM_BVOLT_PK- peak value
fault history [0..3]
SIOC:B084:RF52:0:FAULTHIST0 RTM_BVOLT_WF
SIOC:B084:RF52:0:FAULTHIST1 RTM_BVOLT_WF
SIOC:B084:RF52:0:FAULTHIST2 RTM_BVOLT_WF
SIOC:B084:RF52:0:FAULTHIST3 RTM_BVOLT_WF

SIOC:B084:RF52:0:RTM_RE_WF - rtm ffast adc
SIOC:B084:RF52:0:RTM_RE_PK
fault history [0..3]
SIOC:B084:RF52:0:FAULTHIST0 RTM_RE_WF
SIOC:B084:RF52:0:FAULTHIST1 RTM_RE_WF
SIOC:B084:RF52:0:FAULTHIST2 RTM_RE_WF
SIOC:B084:RF52:0:FAULTHIST3 RTM_RE_WF

RTM:

SIOC:B084:RF52:0:RTM_CLEARFAULT - Clear fault command
SIOC:B084:RF52:0:RTM_STATUS_HEX - rtm status (hex)
SIOC:B084:RF52:0:RTM_FAULTOUT - fault out
SIOC:B084:RF52:0:RTM_FAULTSUMY - rtm summary
SIOC:B084:RF52:0:RTM_ADCLOCK - ADC lock status
SIOC:B084:RF52:0:RTM_MOTR_ON - motor running

SLED bits:

RF ON - SIOC:B084:RF52:0:RTM_RF_ON
Motor Timeout - SIOC:B084:RF52:0:RTM_MOTR_TIMEOUT
Motor deturning (running) - SIOC:B084:RF52:0:RTM_MOTR_DETUNING
Motor Tunning (running) - SIOC:B084:RF52:0:RTM_MOTR_TUNING
Lower Tuned - SIOC:B084:RF52:0:RTM_LOWER_TUNED
Upper Tuned - SIOC:B084:RF52:0:RTM_UPPER_TUNED
Motor Nnnnot Tuned - SIOC:B084:RF52:0:RTM_MOTR_NOT_TUNED
Lower Detuned - SIOC:B084:RF52:0:RTM_LOWER_DETUNED
Upper Detuned - SIOC:B084:RF52:0:RTM_UPPER_DETUNED
Motor Not Detuned - SIOC:B084:RF52:0:RTM_MOTR_NOT_DETUNED
Modulator Fault - SIOC:B084:RF52:0:RTM_MOD_FAULT
Beam Current Under Threshold - SIOC:B084:RF52:0:RTM_CURR_UNDER
Beam Current Over Threshold - SIOC:B084:RF52:0:RTM_CURR_OVER
Beam Voltage Over Threshold - SIOC:B084:RF52:0:RTM_VOLT_OVER
Forward Power Over Threshold - SIOC:B084:RF52:0:RTM_FP_OVER
Reflected Power Over Threshold - SIOC:B084:RF52:0:RTM_RP_OVER

threshold:

SIOC:B084:RF52:0:BC_ILK_RAW- beam current
SIOC:B084:RF52:0:SET_BC_ILK_RAW

SIOC:B084:RF52:0:BV_ILK_RAW- beam voltage
SIOC:B084:RF52:0:SET_BV_ILK_RAW

SIOC:B084:RF52:0:RE_ILK_RAW- reflected power
SIOC:B084:RF52:0:SET_RE_ILK_RAW

SLED:

SIOC:B084:RF52:0:RTM_SLED_TUNED
SIOC:B084:RF52:0:RTM_SLED_DETUNED
SIOC:B084:RF52:0:RTM_SLED_SUMY
SIOC:B084:RF52:0:RTM_SLED_SML

EDM Screens

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./Klystron_RTM_debugging.edl (on lcls-dev3)

Clear Fault Command	Clear Fault
RTM Status (Hex)	00000000
Fault Out	OK
RTM Summary	OK
ADC Lock Status	Locked
Motor Running	OFF

RF ON (1:on, 0:off)

Motor Timeout

Motor Detuning (running)

Motor Tuning (running)

Lower Tuned

Upper Tuned

Motor Not Tuned

Lower Detuned

Upper Detuned

Motor Not Detuned

Modulator Fault

Beam Current Under Threshold

Beam Current Over Threshold

Beam Voltage Over Threshold

Forward Power Over Threshold

Reflected Power Over Threshold

Threshold: Beam Current **20.61**

Beam Voltage **24.40**

Reflected Power **9.53**

RTM Settings

Clear Fault	RTM Staus Hex 35904
Threshold	
Set Threshold	
Beam Current:	20.610046
Beam Voltage:	24.490356
Reflected Power:	9.533691
SLED Tuned	1
SLED Detuned	0
SLED Summary	0
SLED SML	0
Fault Out	
RTM Summary	0
ADC Lock Status	1
Motor running	0

SLED - Modulator Connector Inputs

- █ RF ON
- Motor Timeout
- Motor Detuning
- Motor Tuning
- █ Lower Tuned
- █ Upper Tuned
- Motor Not Tuned
- Lower Detuned
- Upper Detuned
- █ Motor Not Detuned
- Modulator Fault
- Beam Current Under Threshold
- Beam Current Over Threshold
- Beam Voltage Over Threshold
- Forward Power Over Threshold
- Reflected Power Over Threshold

Form - PyDM

File View History Tools

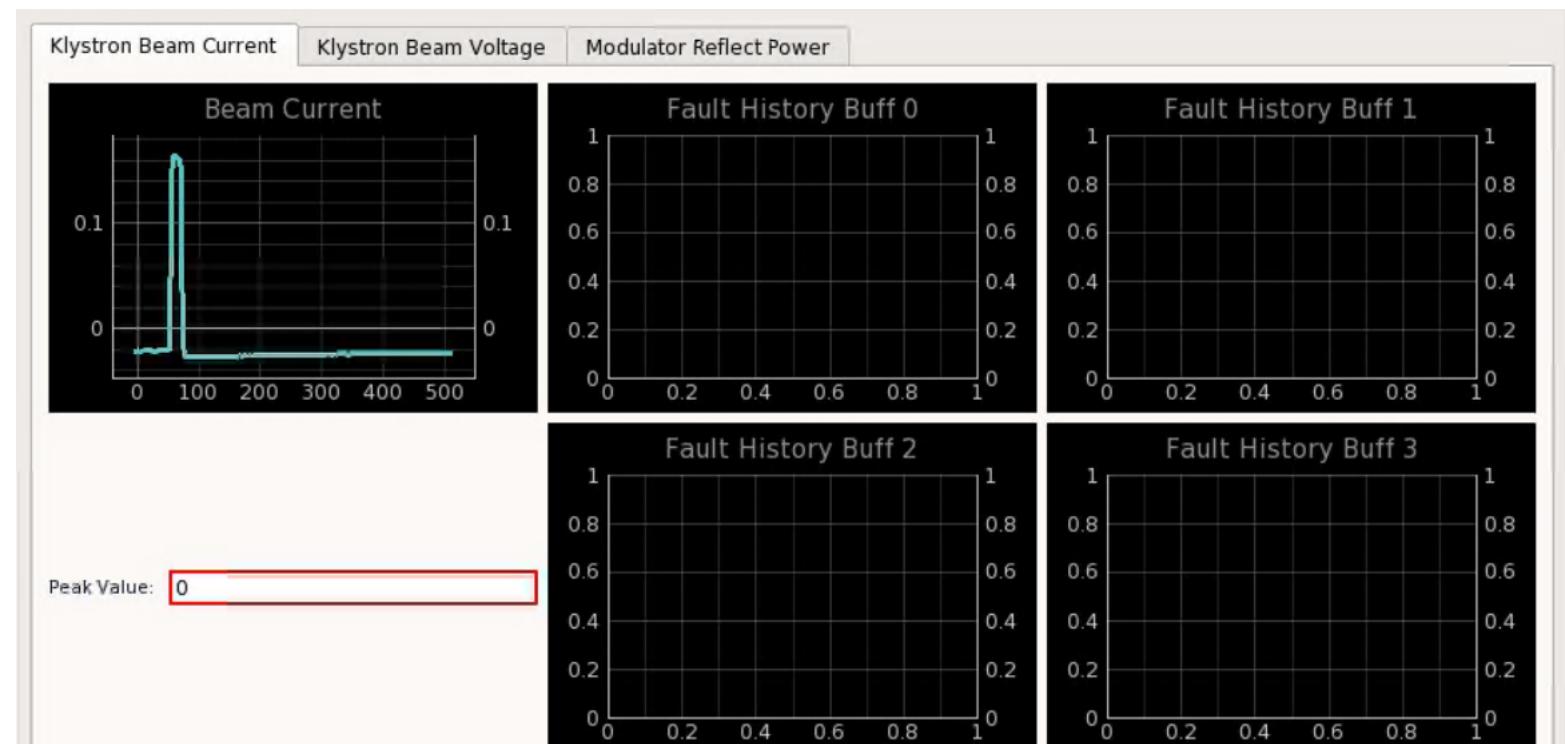
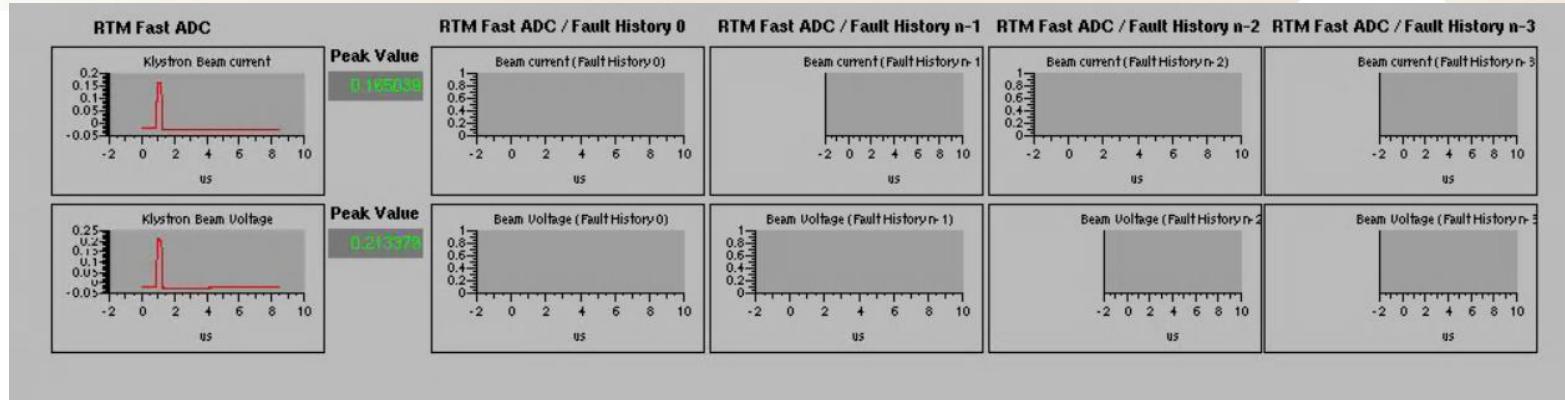
Back Forward Home

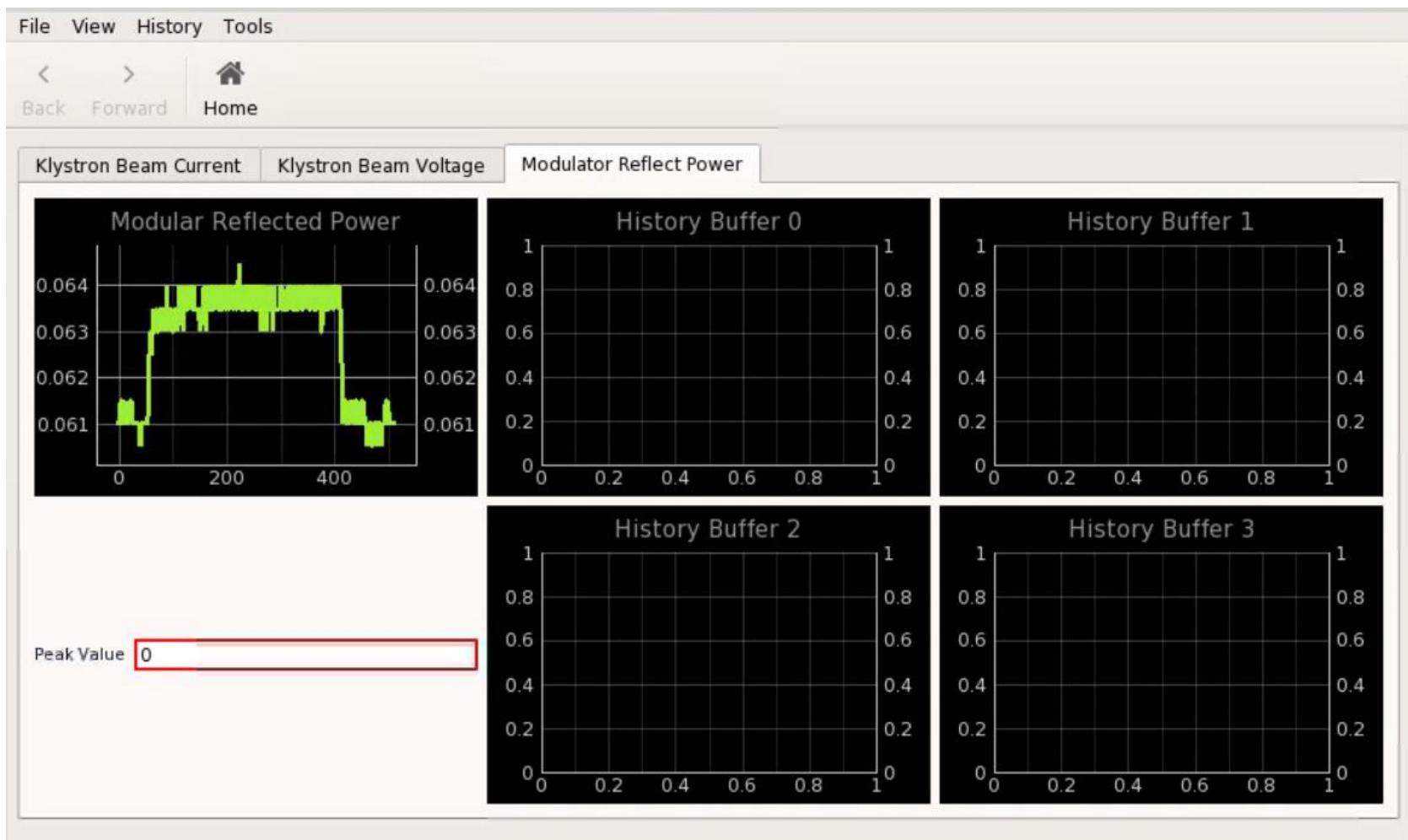
Set Pulse Width and Delay

	Width	
	ACCEL	STDBY
LLRF TRIG		
MOD TRIG	TRG02	TRG03
SSSB TRIG	TRG03	TRG04
RTM TRIG		
	Delay	
LLRF TRIG		
MOD TRIG		
SSSB TRIG		
RTM TRIG		

EDM Screens - PyDM

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Acknowledgment



Special Thanks to:

- Mitch
- Jesus
- Kukhee
- Ernest
- Hugo
- others...

References

Hugo Slepicka

<https://slaclab.github.io/pydm/>
<https://github.com/slaclab/pydm>

Jesus Stanescu

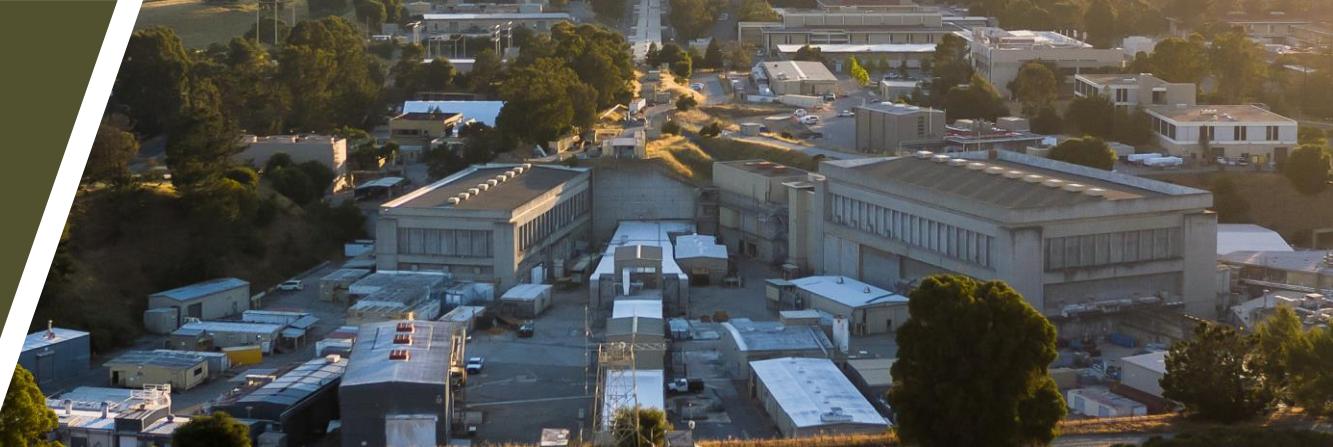
<https://confluence.slac.stanford.edu/display/ppareg/Common+Platform+Training>
<https://slaclab.github.io/cpsw/README.yamlDefinition.html>

John Sikora

https://www.slac.stanford.edu/~jsikora/facet-ii/llrf/RTM_Tests_2020July.shtml
https://www.slac.stanford.edu/~jsikora/facet-ii/llrf/files/RTM_Test01.txt
https://www.slac.stanford.edu/~jsikora/facet-ii/llrf/files/Get-MR-LLRF_data01.py

Kukhee

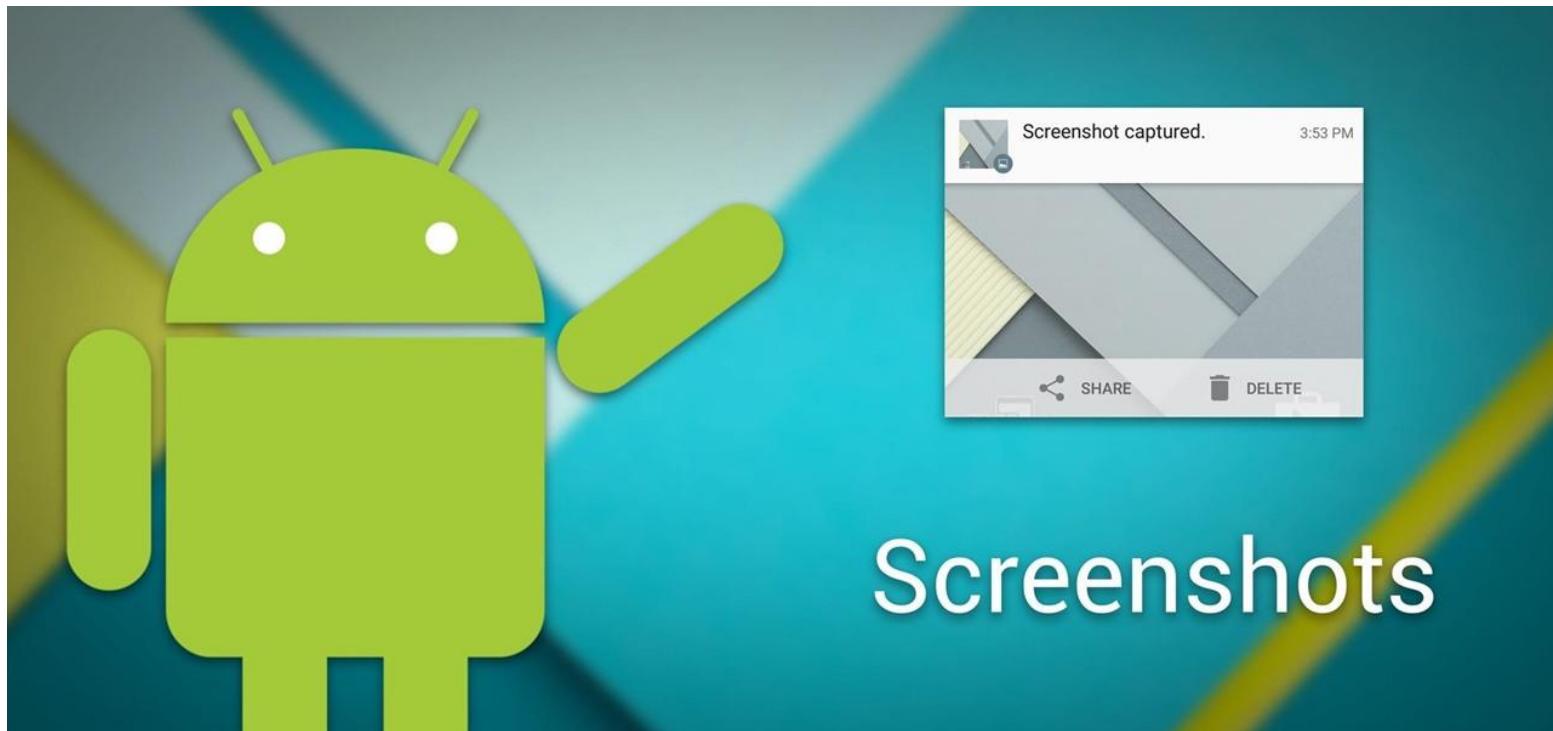
https://confluence.slac.stanford.edu/display/~khkim/LLRF_HLS+IOC+application
<https://confluence.slac.stanford.edu/display/~khkim/RFCommon>
<https://confluence.slac.stanford.edu/display/~khkim/ATCA+Common>
<https://confluence.slac.stanford.edu/display/~khkim/RTM+Interlock+Driver>
<https://confluence.slac.stanford.edu/display/~khkim/interlockRtmAsyn>



Q & A

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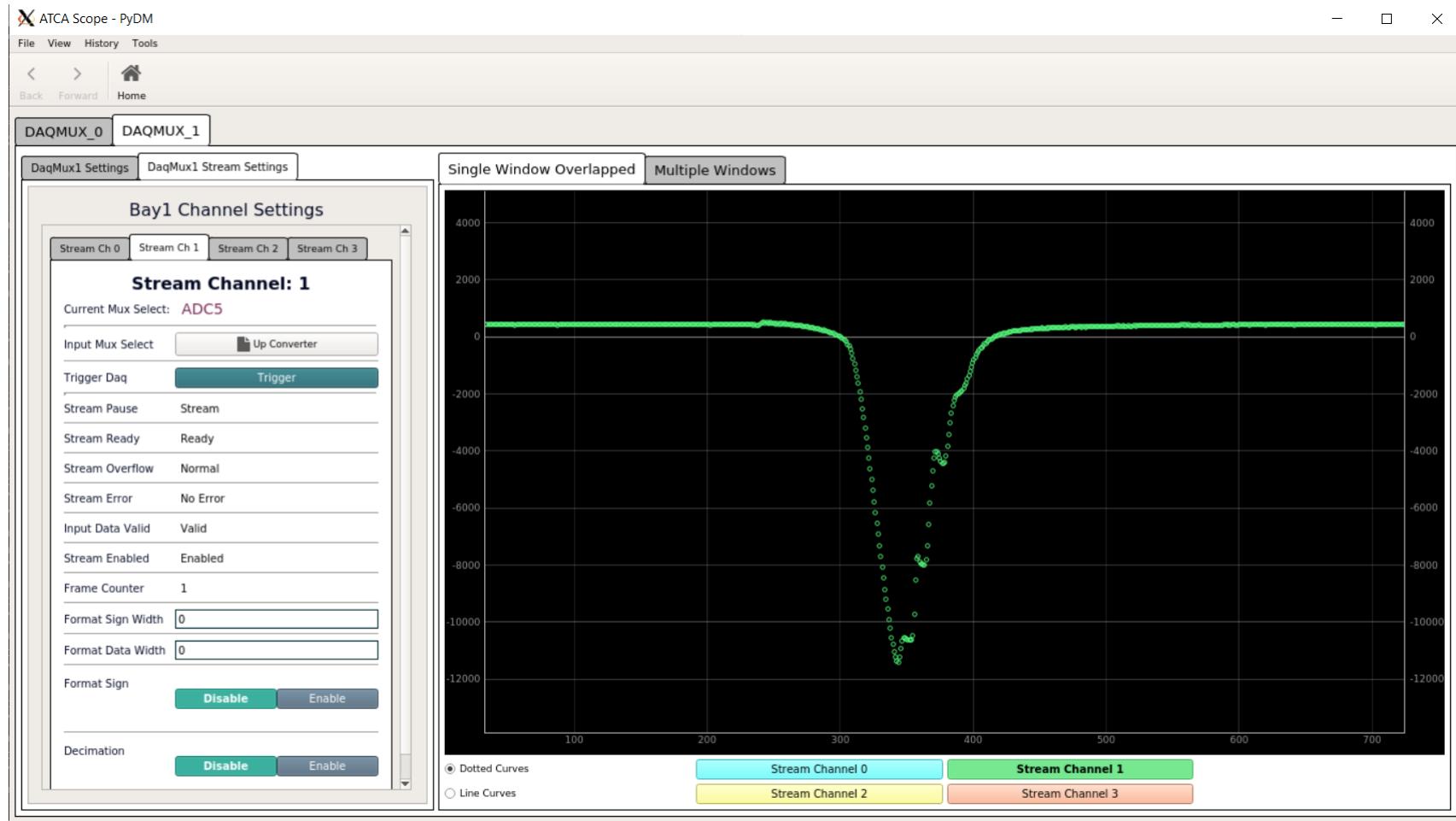
Screenshots



Screenshots

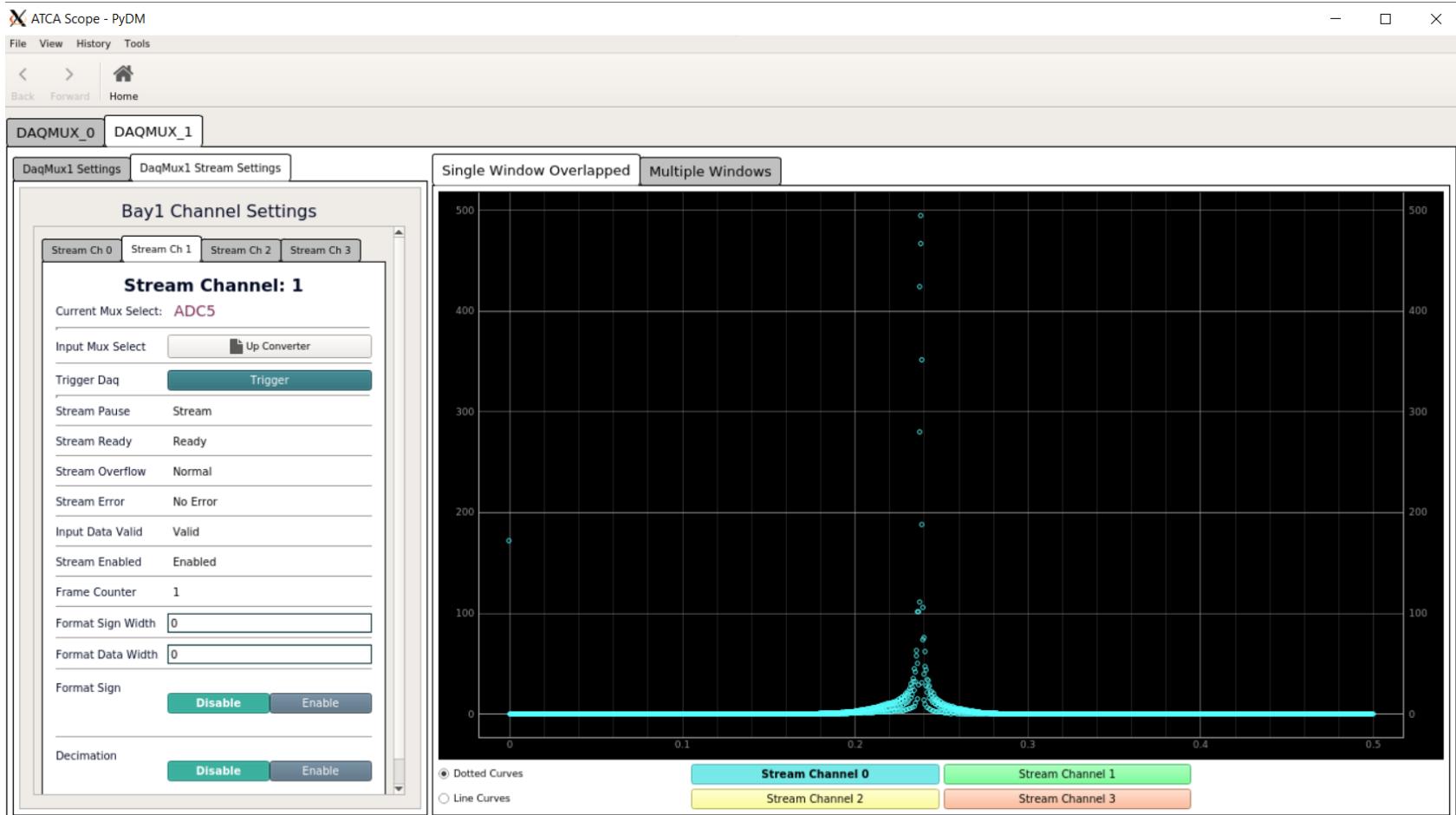
LLRF DaqMux Screenshots

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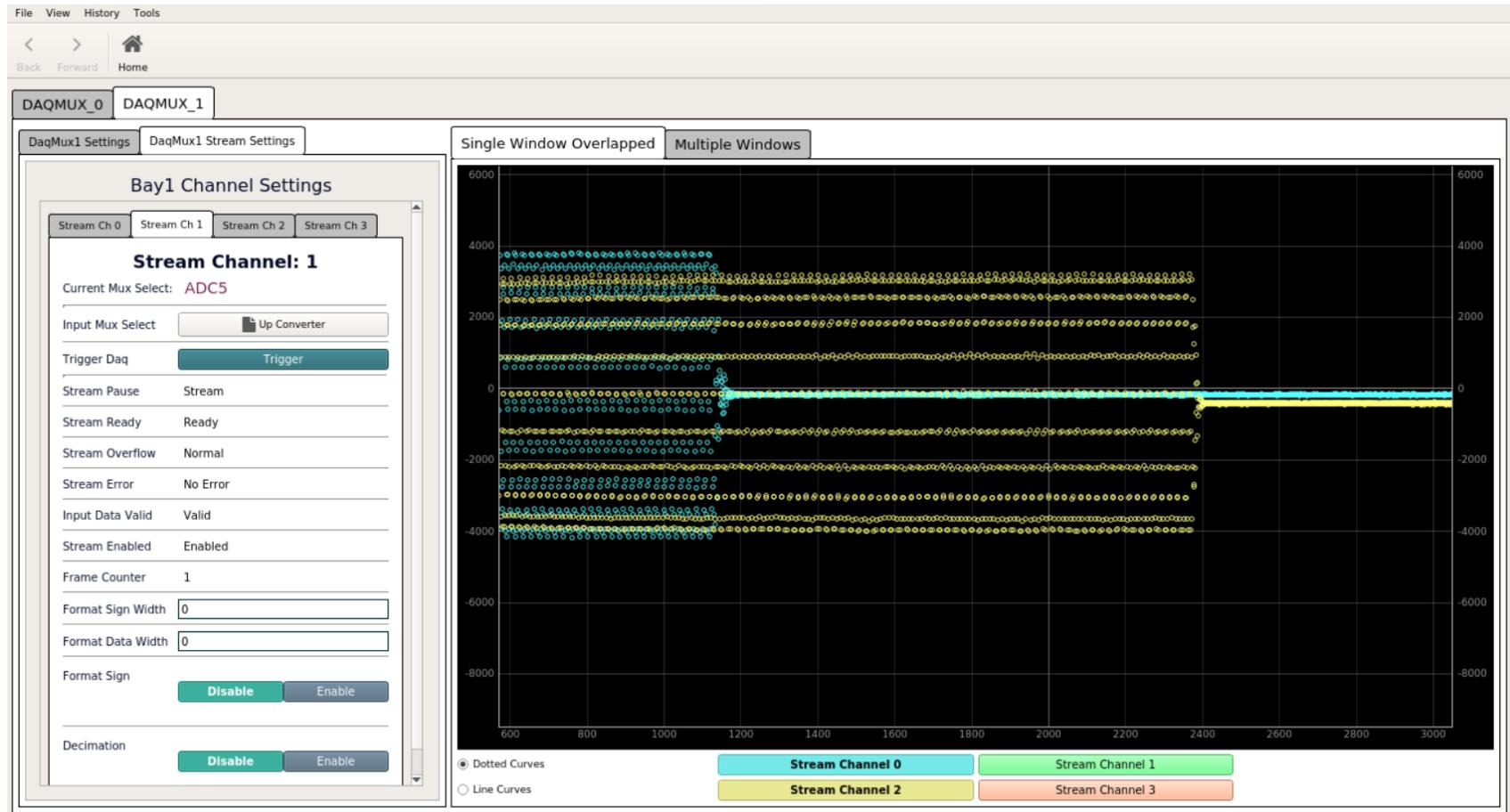
DaqMux1 – Stream Channel 0 Waveform

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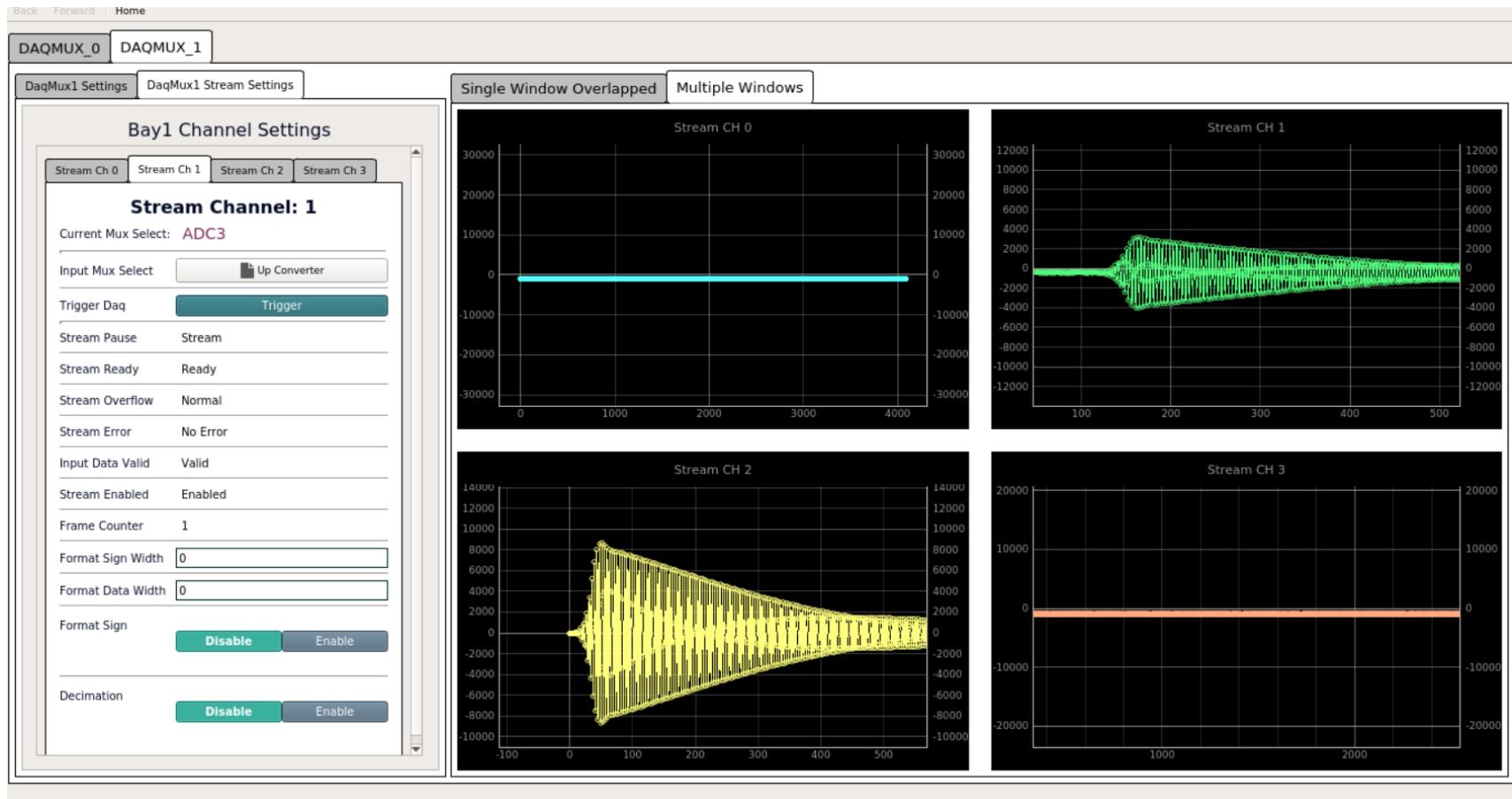


DaqMux1 – Stream Ch 0 & 2 Waveforms

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Multiple Views



Front Panels

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Down Converter - PyDM

File View History Tools

Back Forward Home

PC_379_396_16_C03_A01: Downconverter - LLRF: AMC Precision ADC Card

AMC Down Converter Settings

	Down Converter	Attenuators	Input Mux Select	Temperatures
0:	Disabled			
1:	Test			
RF IN 2	ATTENO: 62	2: adcValues(0)	44.2812	
RF IN 1	ATTEN1: 53	3: adcValues(1)	45.4609	
RF IN 4	ATTEN2: 43	4: adcValues(2)	45.7734	
RF IN 3	ATTEN3: 53	5: adcValues(3)	42.3984	
RF IN 6	ATTEN4: 53	6: adcValues(4)		
RF IN 5	ATTEN5: 53	7: adcValues(5)		
LO PLL DAC		8: adcValues(6)		
CLK PLL DAC		9: dacValues(0)		
DAC OUT		10: dacValues(1)		
		11: dacValues(2)		

Up Converter - PyDM

File View History Tools

Back Forward Home

PC_379_396_17_C03_A01: GEN1 Upconverter DAC/ADC Card

AMC Up Converter Settings

	Up Converter	Attenuators	Input Mux Select	Temperatures
0:	Disabled			
1:	Test			
RF IN 2	ATTENO : 63	2: adcValues(0)	50.9609	
RF IN 1	ATTEN1: 63	3: adcValues(1)	50.1797	
RF IN 3	ATTEN2: 63	4: adcValues(2)	51.2109	
RF OUT MON	ATTEN3: 63	5: adcValues(3)	51.2109	
TRIG MON		6: adcValues(4)		
DC IN		7: adcValues(5)		

Mux Settings

File View History Tools

< > Home

DAQMUX_0 DAQMUX_1

DaqMux1 Settings DaqMux1 Stream Settings

DaqMux1

Freeze Buffer	Freeze
Clear Trigger Status	Clear
Trigger Count	56552526
Hardware Trigger Armed	Normal Arm
Cascaded Trigger	Disable Enable
Auto Re-arm	Disable Auto Rerarm
Daq Mode	Trigger Continue
Packet Header	Disable Enable
Hardware Freeze	Disable Enable
Decimation Rate Divisor	0
Buffer Size	4096
Debug Input Valid	0x3fbf
Debug Link Ready	0x3ffbf
Timestamp (s:ns)	963688637 225468309