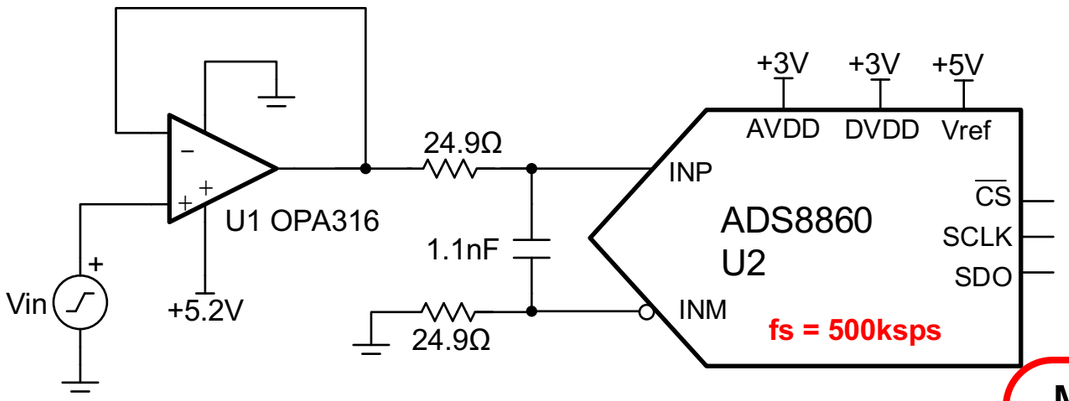
Crossover Distortion
Hands-on Experiment
TIPL 4101-L
TI Precision Labs – ADCs

by Art Kay and Dale Li

Required/Recommended Equipment

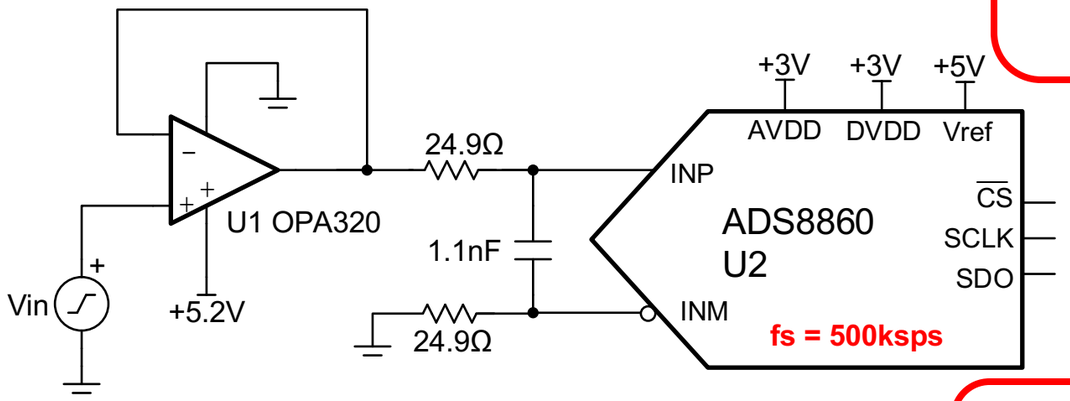
- Calculation
  - Simple calculation using OPA320 and OPA316 Data Sheet
- Simulation
  - No simulation in this experiment.
- Measurement
  - PLABS-SAR-EVM-PDK
  - http://www.ti.com/tool/plabs-sar-evm-pdk
  - Download EVM software and purchase EVM

Op Amp with and without input Crossover distortion



PARAMETER: OPA316 – Has Crossover		MIN	TYP	MAX	UNIT
V_{CM}	Common Mode Voltage	(V-)-0.2		(V+)+0.2	V
CMRR	(V-)-0.2 < Vcm < (V+)-1.4V	76	90		dB
	(V-)-0.2 < Vcm < (V+)+0.2V	65	80		

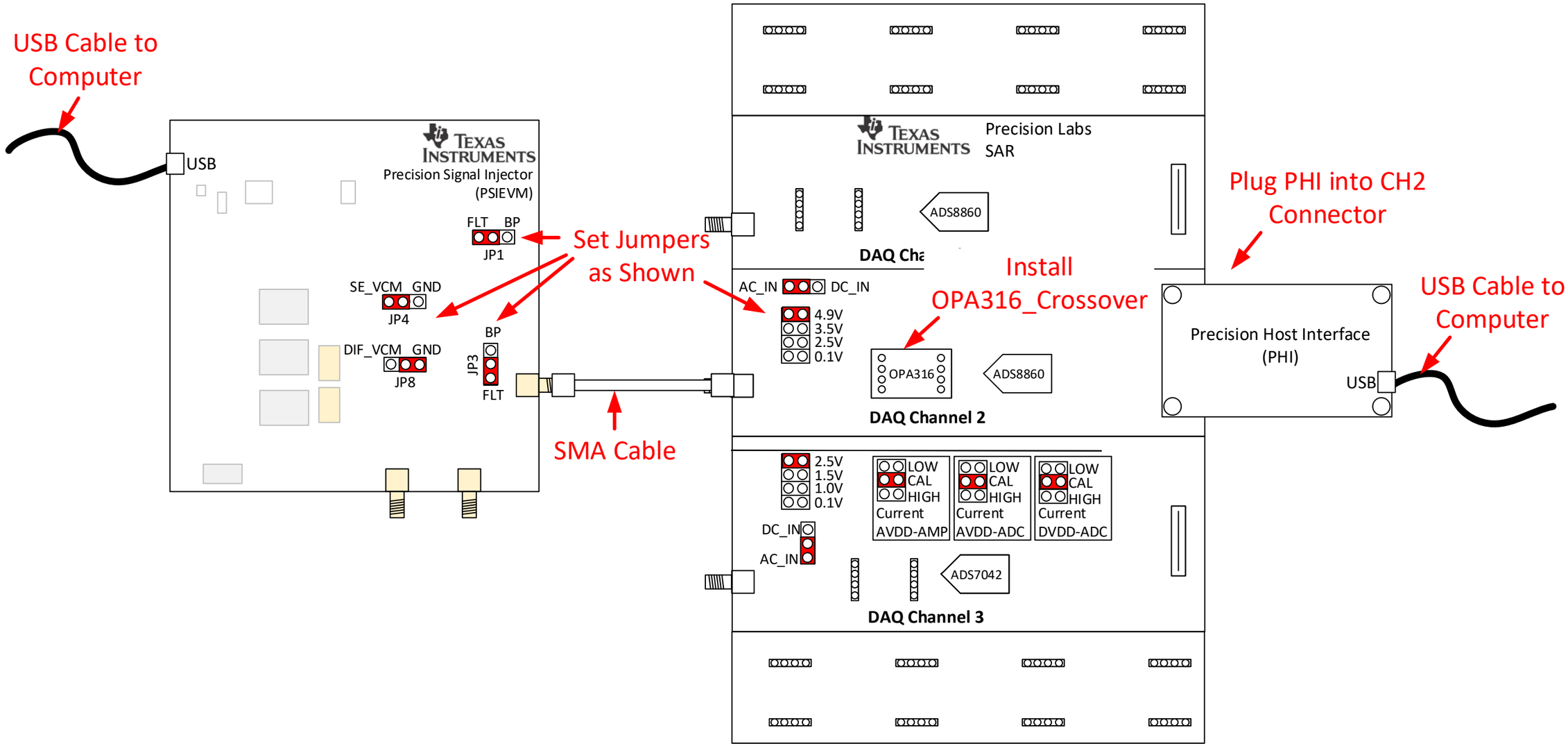
Much better CMRR 1.4V below positive rail. For 5.2V supply, crossover happens at 3.8V (5.2V – 1.4V = 3.8V)



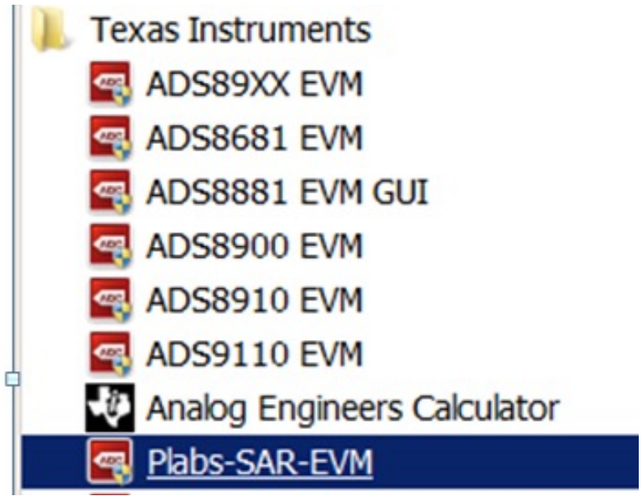
PARAMETER: OPA320 – No Crossover		MIN	TYP	MAX	UNIT
V_{CM}	Common Mode Voltage	(V-)-0.1		(V+)+0.1	V
CMRR	(V-)-0.1 < Vcm < (V+)+0.1V	100	114		dB

Much better CMRR across entire common mode range.

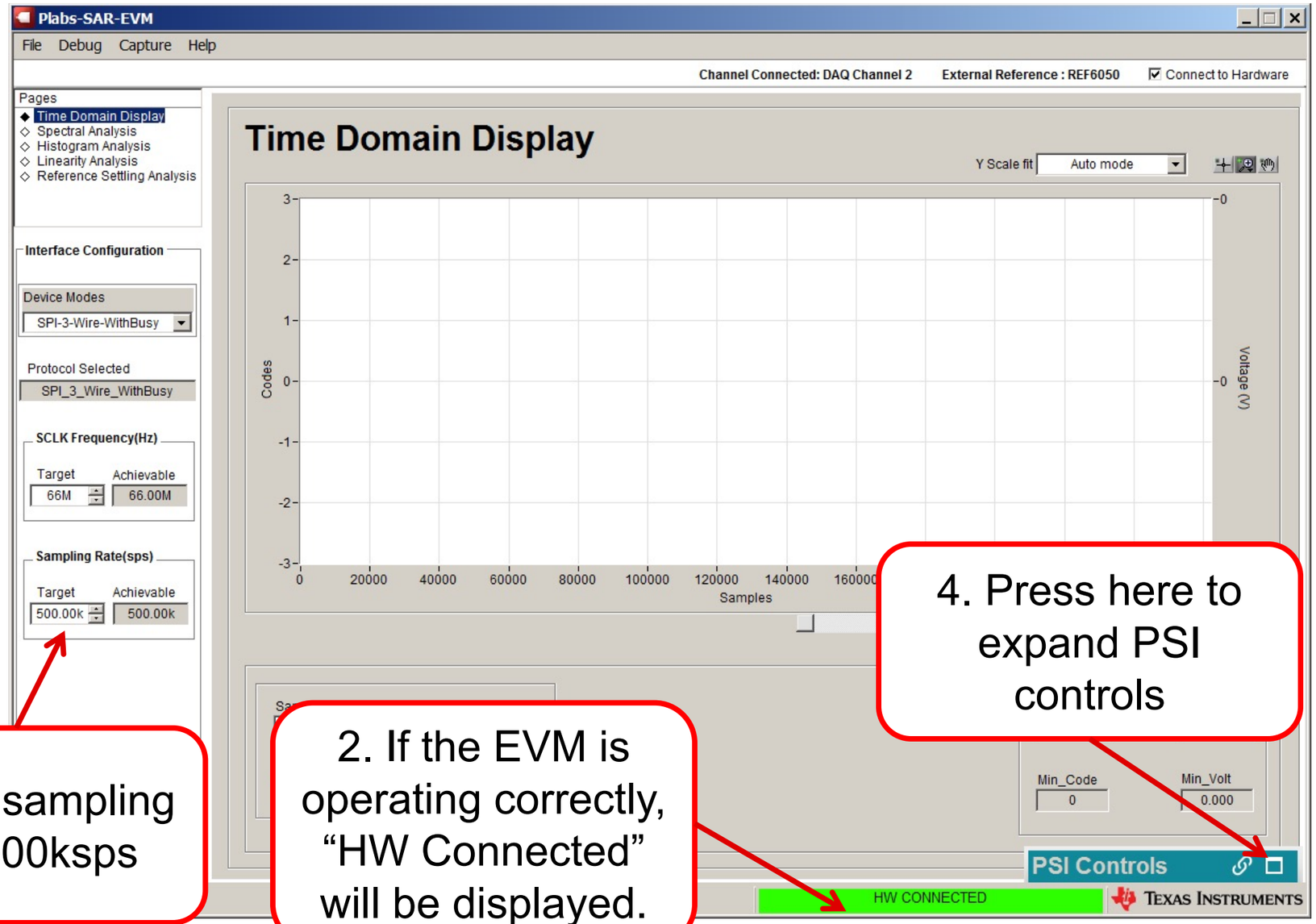
Connect the hardware



Start & Setup the PLABS-SAR EVM Software



1. Select “Plabs-SAR-EVM” from “start>All Programs”

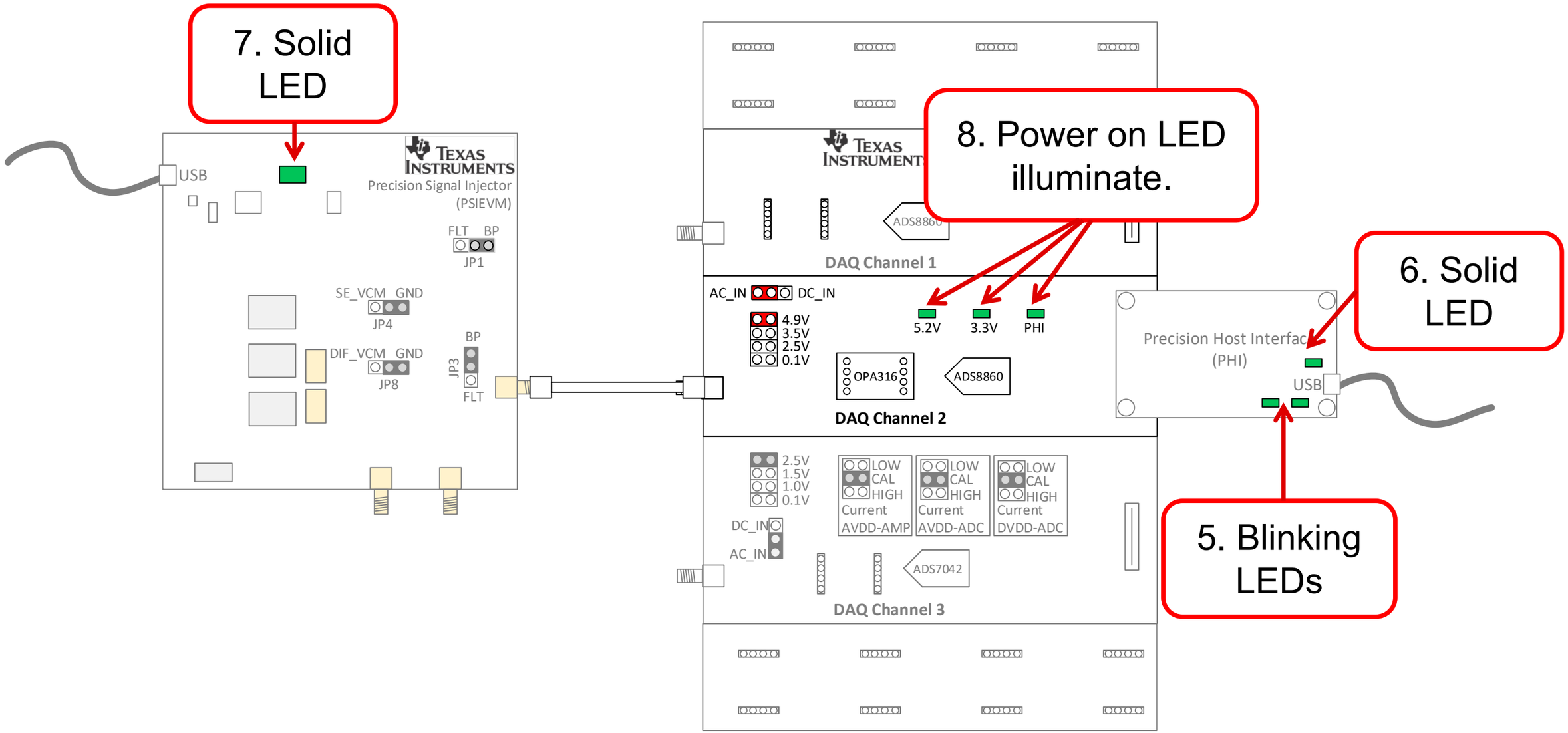


3. Set the sampling rate to 500ksps

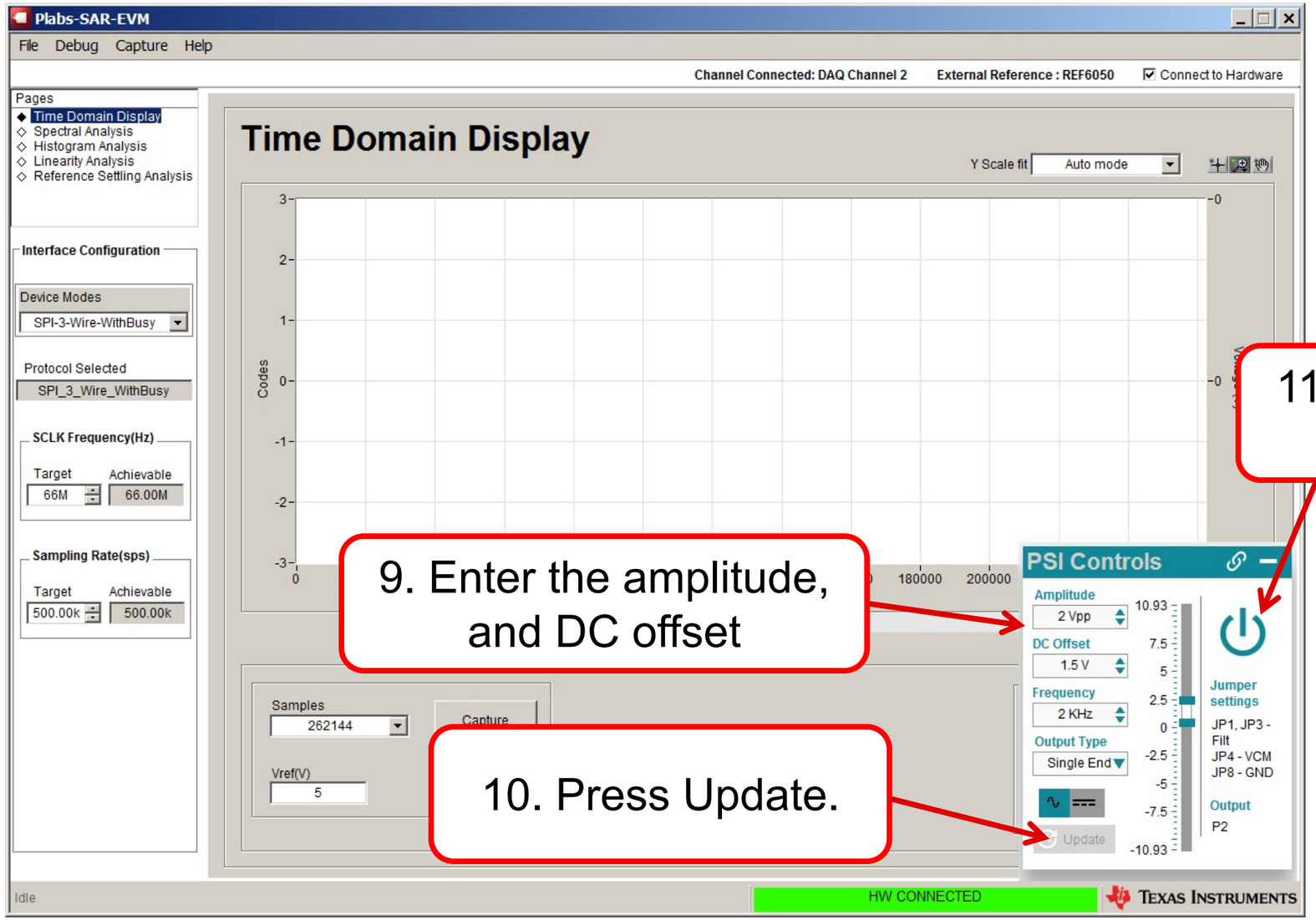
2. If the EVM is operating correctly, “HW Connected” will be displayed.

4. Press here to expand PSI controls

Power-on LEDs illuminate



Setup the PSI

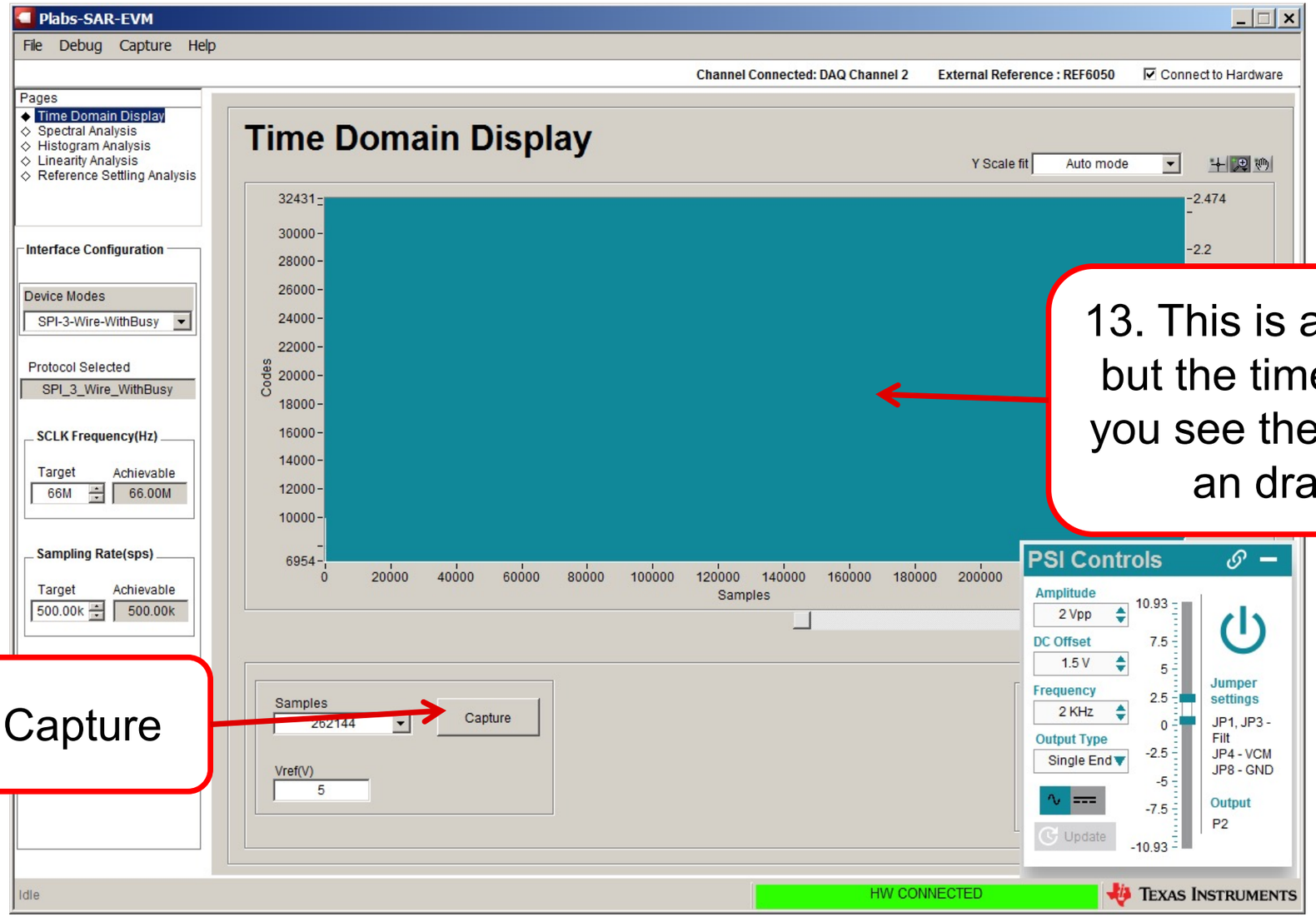


9. Enter the amplitude, and DC offset

10. Press Update.

11. Click to Turn on output.

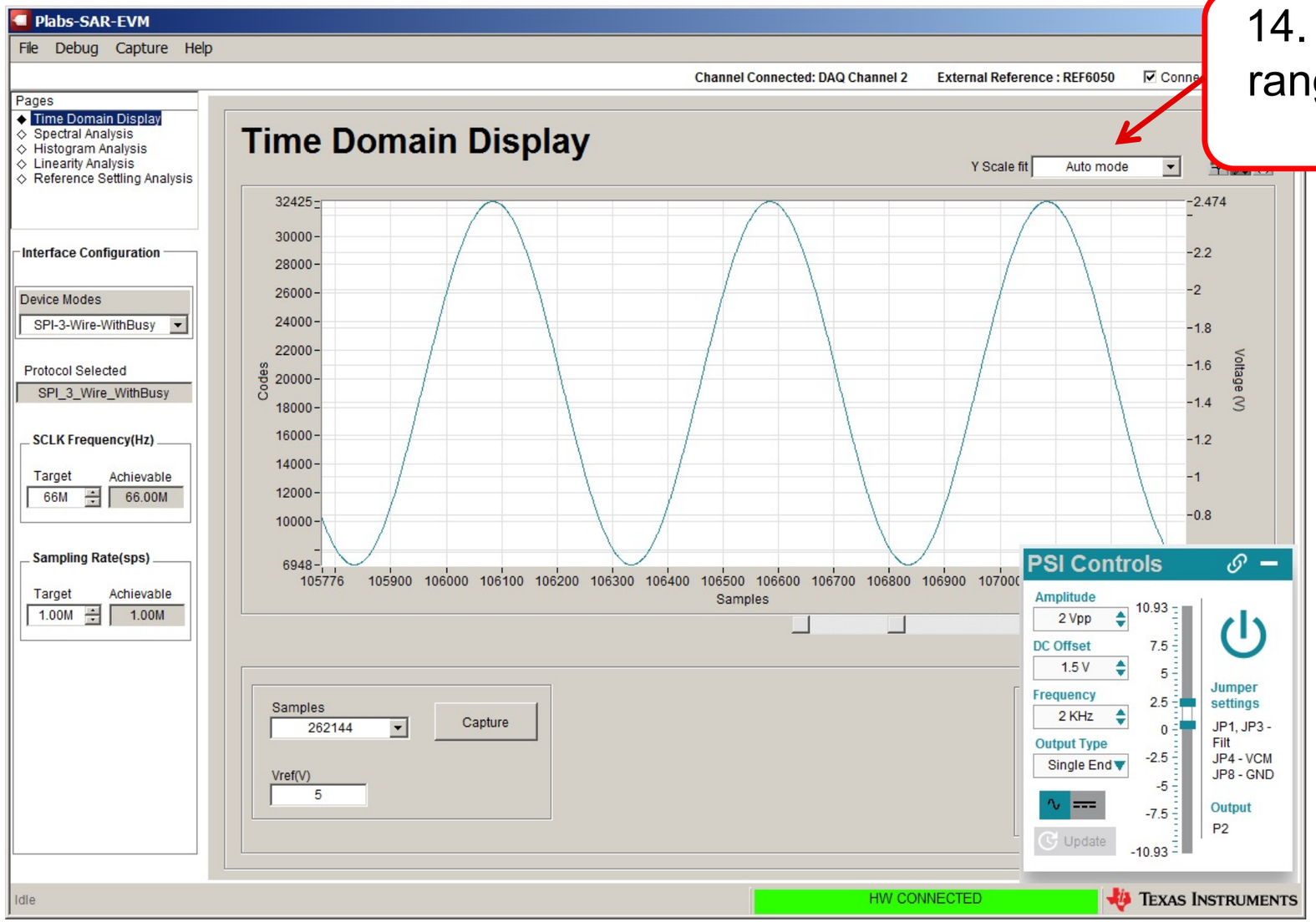
Capture the waveform and zoom in.



13. This is a sine wave output, but the time scale doesn't let you see the wave. Right click an drag to zoom in.

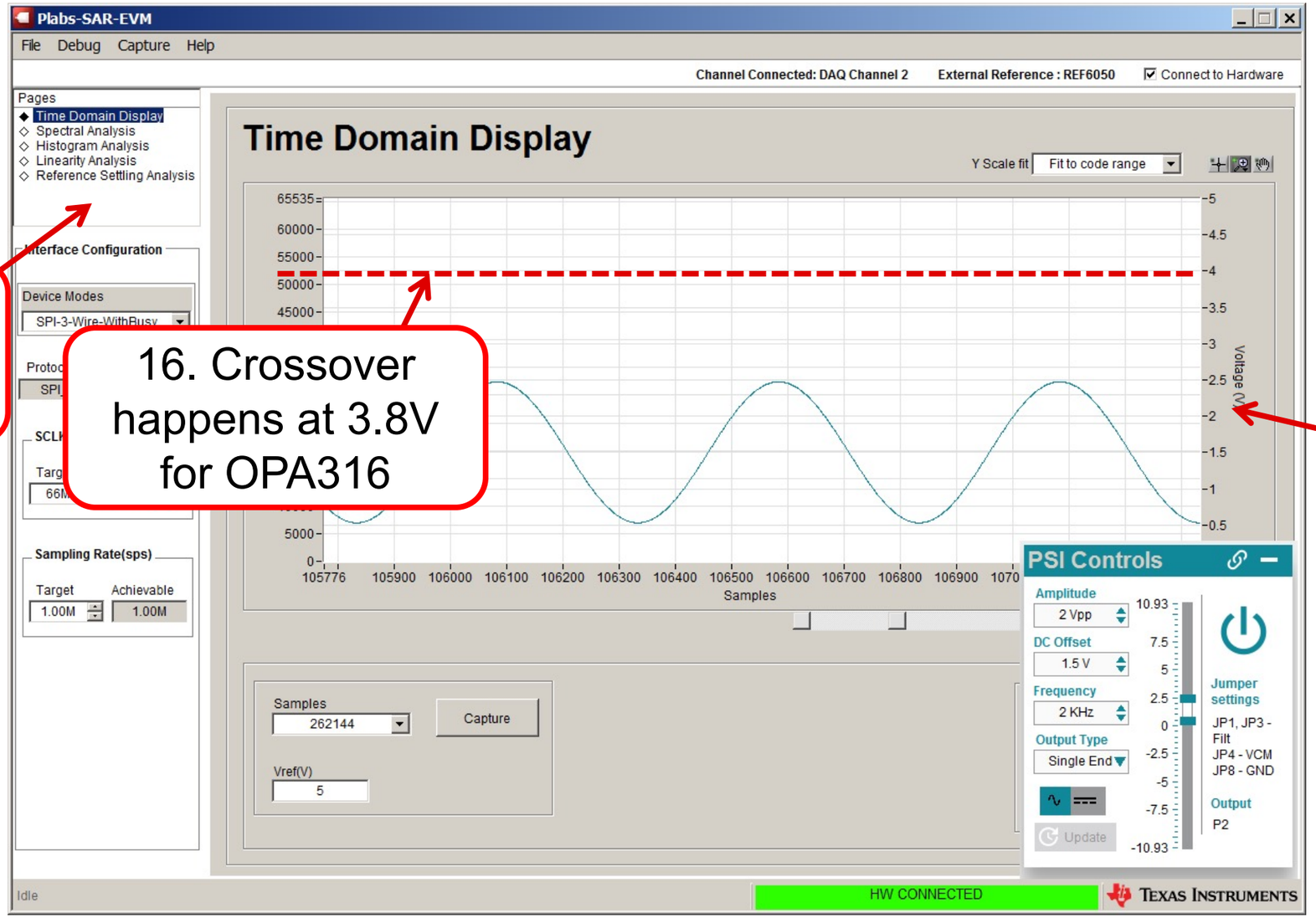
12. Press Capture

Capture the waveform and zoom in.



14. Select “Fit Code to range” to show the full scale range.

Capture the waveform and zoom in.

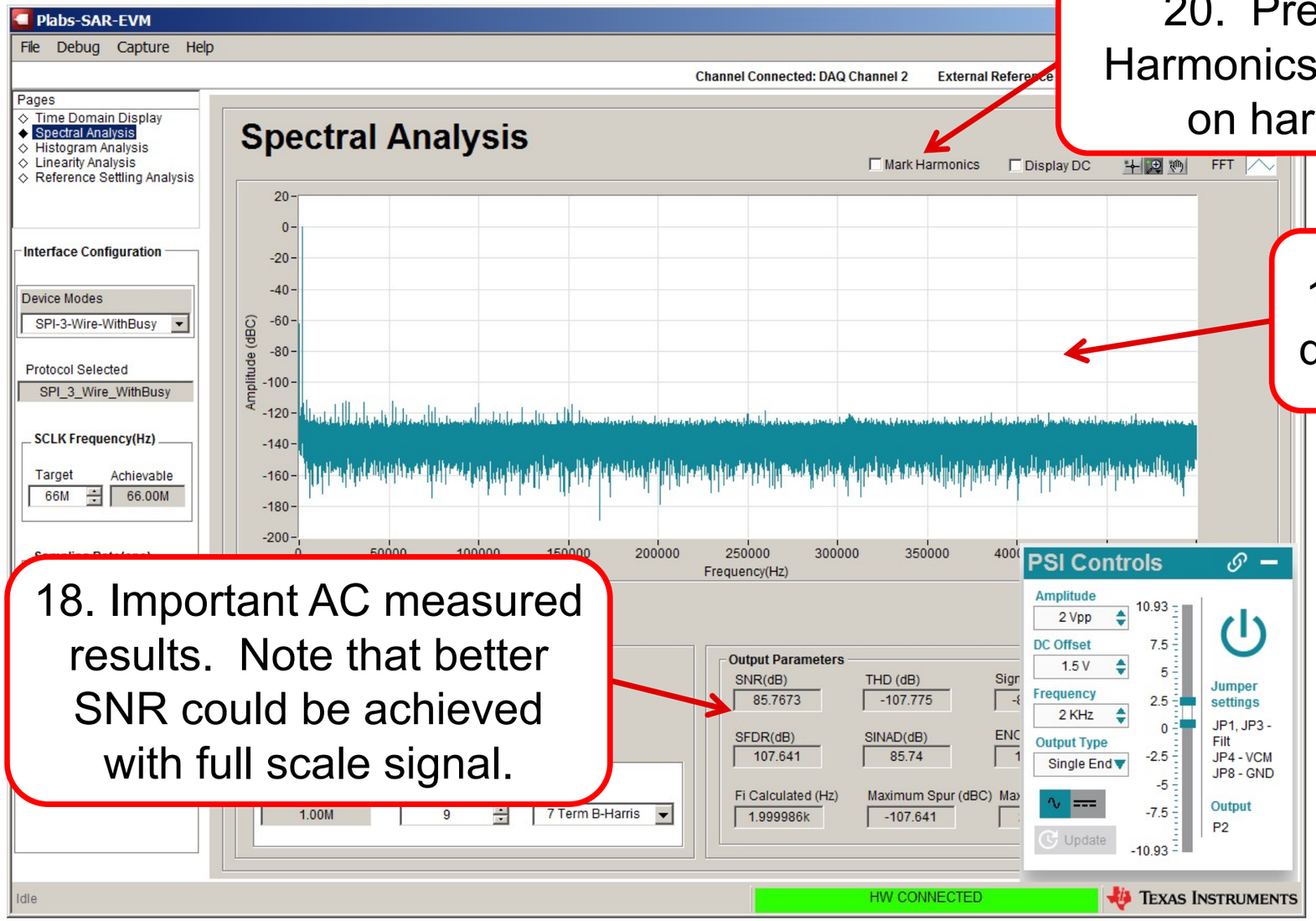


17. Change to "Spectral Analysis"

16. Crossover happens at 3.8V for OPA316

15. Now you can see that the full scale range is displayed (5V) in this example.

Frequency Domain Results

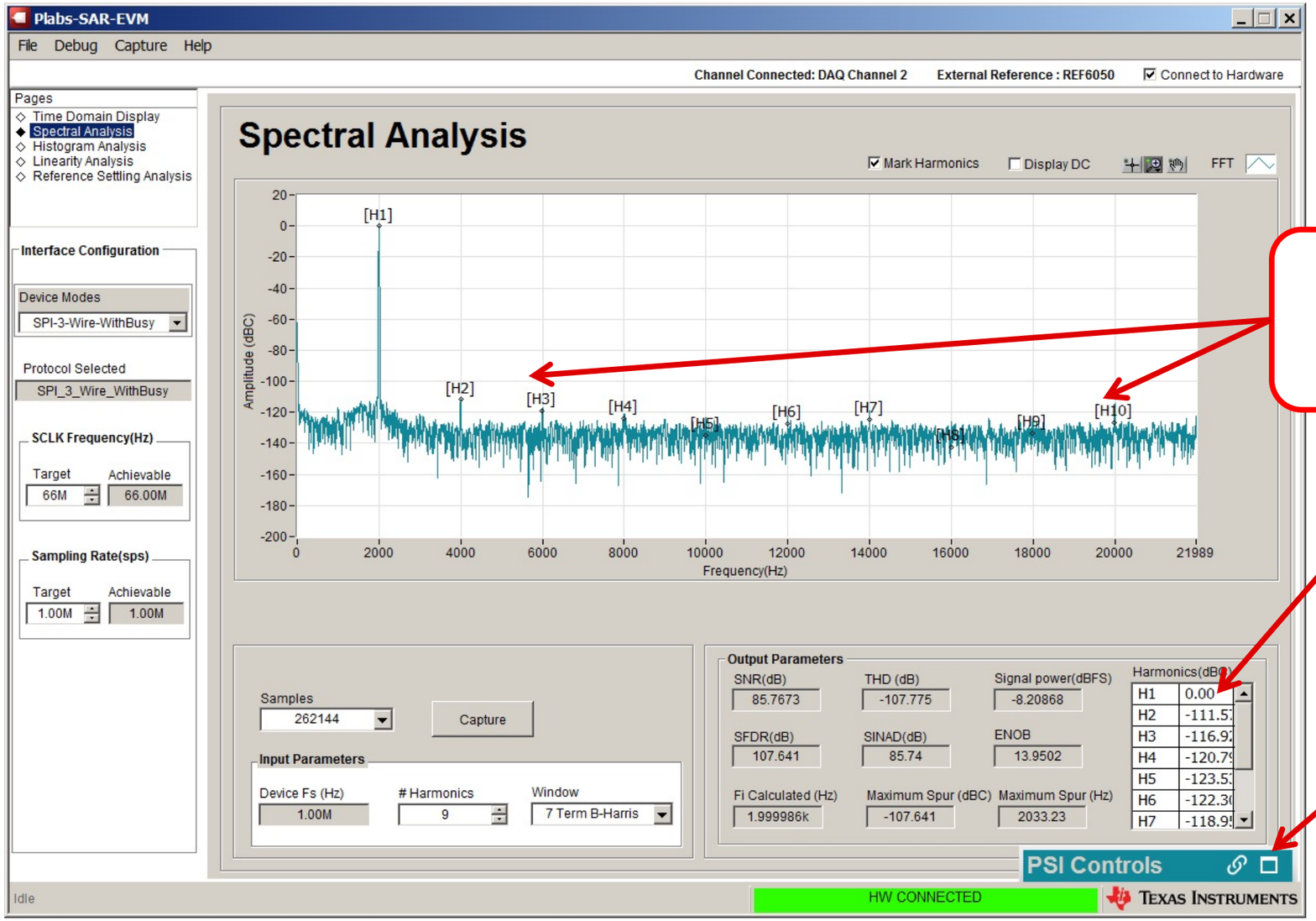


20. Press “Mark Harmonics” to zoom in on harmonics.

19. Frequency domain display

18. Important AC measured results. Note that better SNR could be achieved with full scale signal.

Mark Harmonics



21. Zoom in on harmonics marked H2 …H10

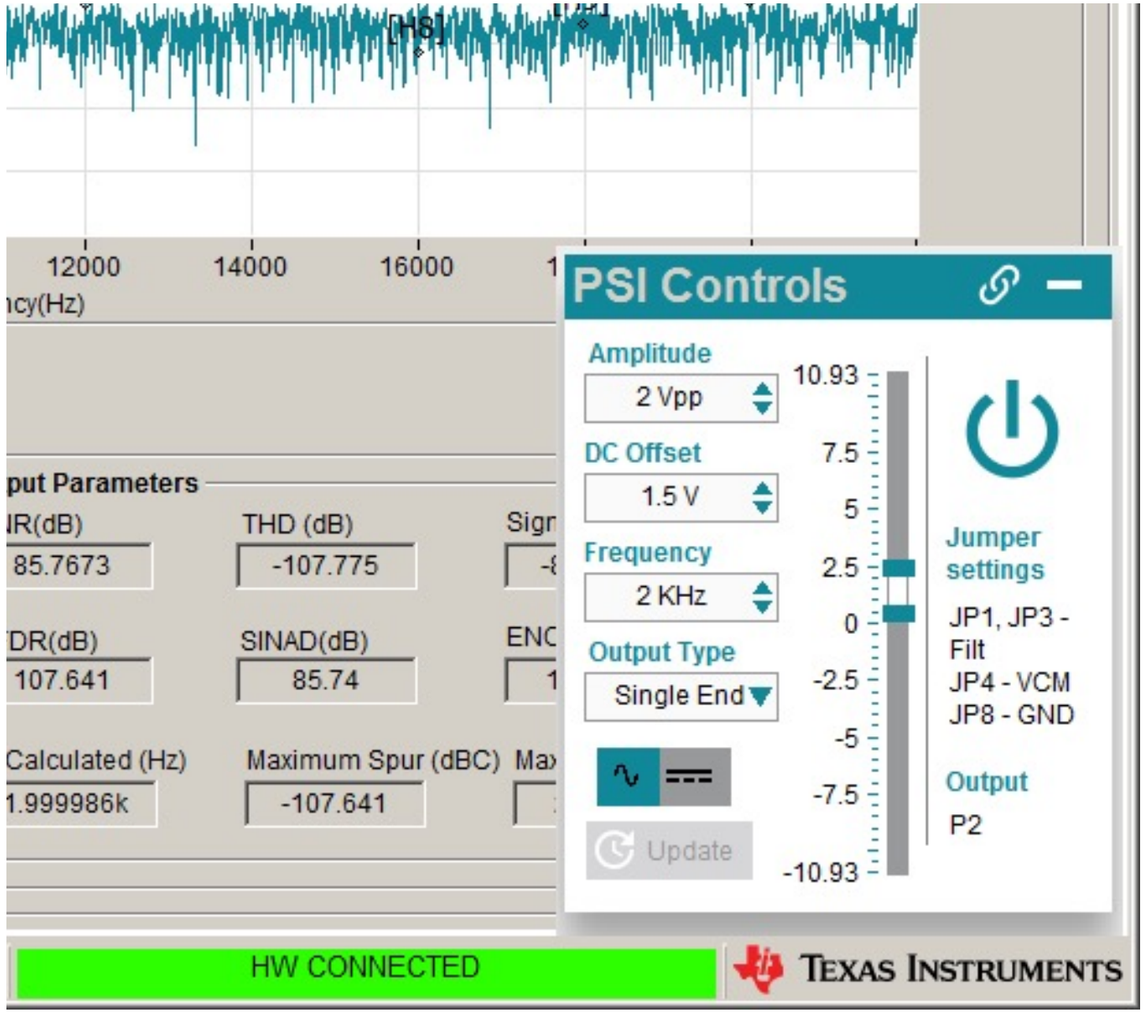
22. Amplitude of harmonics in table form.

23. Minimize or maximize PSI controls as needed.

Enter Vin, Vcm to compare OPA316 and OPA320

fin = 2kHz, fsamp = 500kHz
Crossover region at 3.8V on OPA316

PSI Signal Settings		Calculated PSI Min and Max Output		OPA316 Expected	
Vin (Vpp)	Vcm (V)	Vmin (V)	Vmax (V)	SNR (dB)	THD (dB)
2	1.5	0.5	2.5	85.3	-104.4
2	2	1	3	85.3	-102.9
2	3	2	4	85.2	-98.8
2	3.2	2.2	4.2	85.2	-83.8
2	3.5	2.5	4.5	85.1	-76.1
2	3.8	2.8	4.8	85.0	-77.2



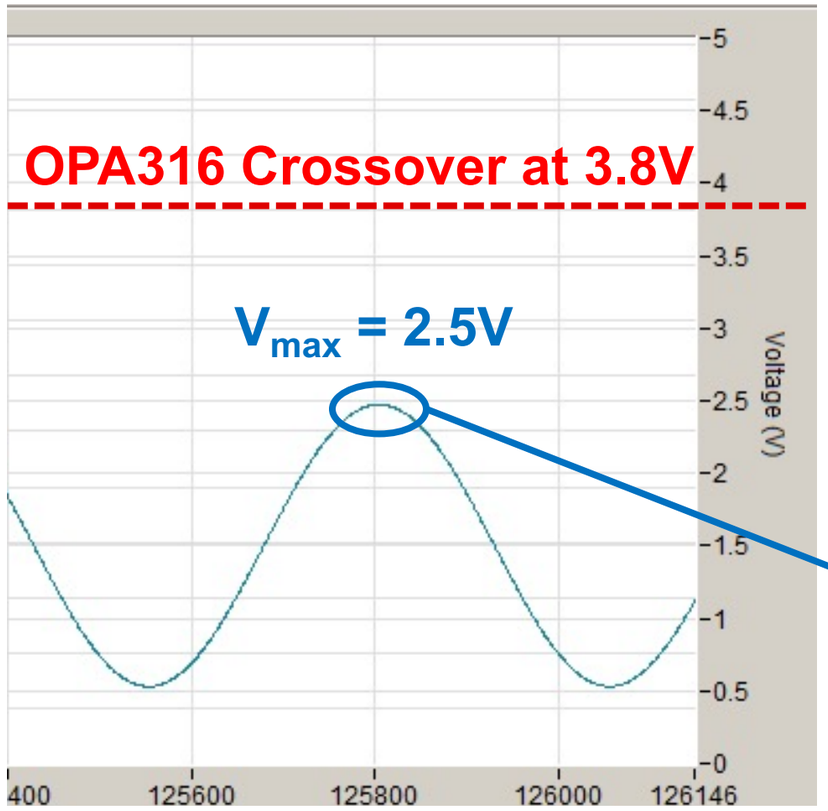
Measured vs Expected Results

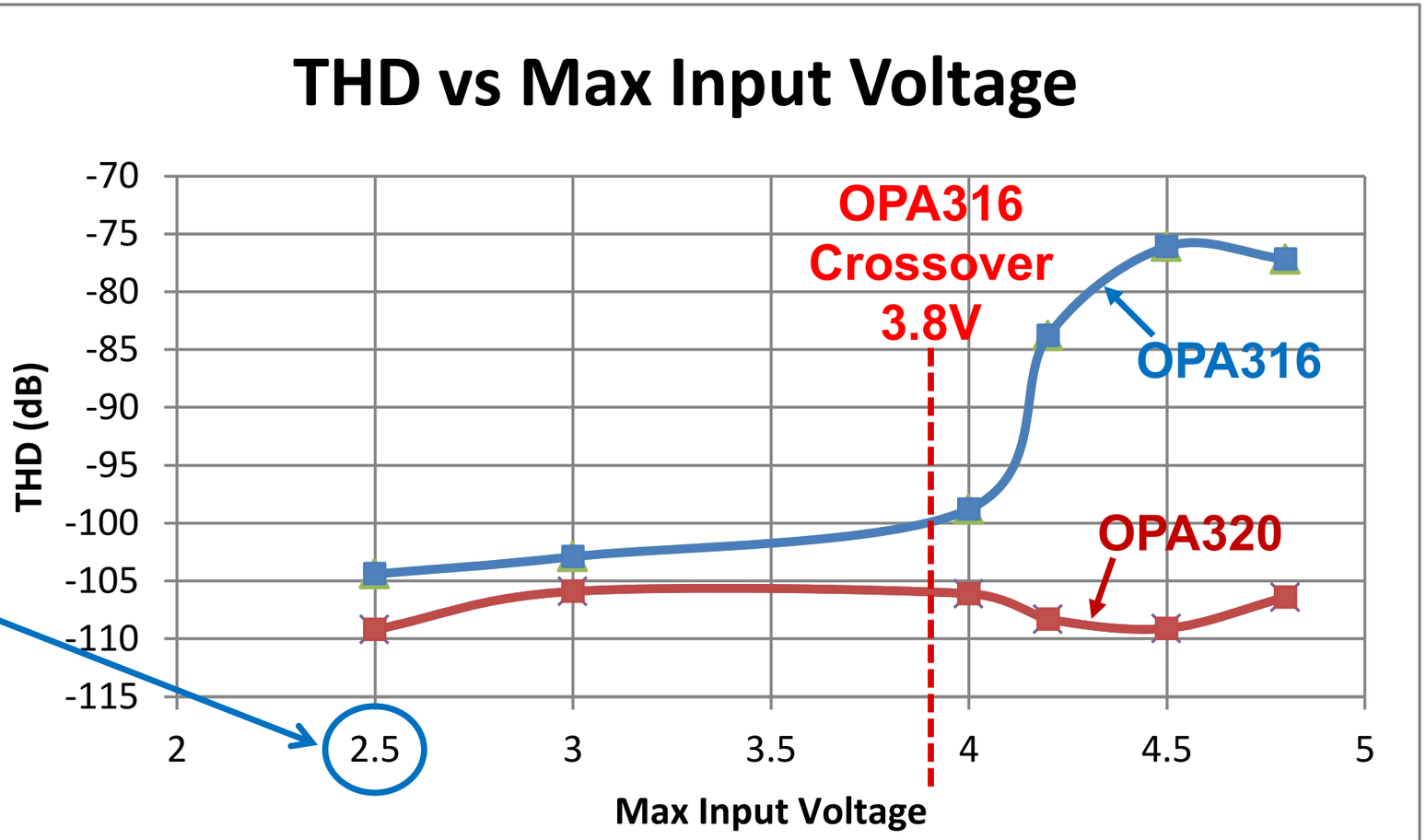
Your results should show the same trend as the expected result but the specific values will differ.

fin = 2kHz, fsamp = 500kHz
Crossover region at 3.8V on OPA316

PSI Signal Settings		Calculated PSI Min and Max Output		OPA316 Expected		OPA316 Measured		OPA320 Expected		OPA320 Measured	
Vin (Vpp)	Vcm (V)	Vmin (V)	Vmax (V)	SNR (dB)	THD (dB)	SNR (dB)	THD (dB)	SNR (dB)	THD (dB)	SNR (dB)	THD (dB)
2	1.5	0.5	2.5	85.3	-104.4			85.7	-109.2		
2	2	1	3	85.3	-102.9			85.6	-105.9		
2	3	2	4	85.2	-98.8			85.7	-106.1		
2	3.2	2.2	4.2	85.2	-83.8			85.6	-108.3		
2	3.5	2.5	4.5	85.1	-76.1			85.6	-109.1		
2	3.8	2.8	4.8	85.0	-77.2			85.7	-106.4		

Graph of results





Microsoft Excel Worksheet

Click here to access Excel Spreadsheet for data collection.

Your results should show the same trend as the expected result but the specific values will differ.

Thanks for your time!