

ADC System Power Scaling

TIPL 4601-L

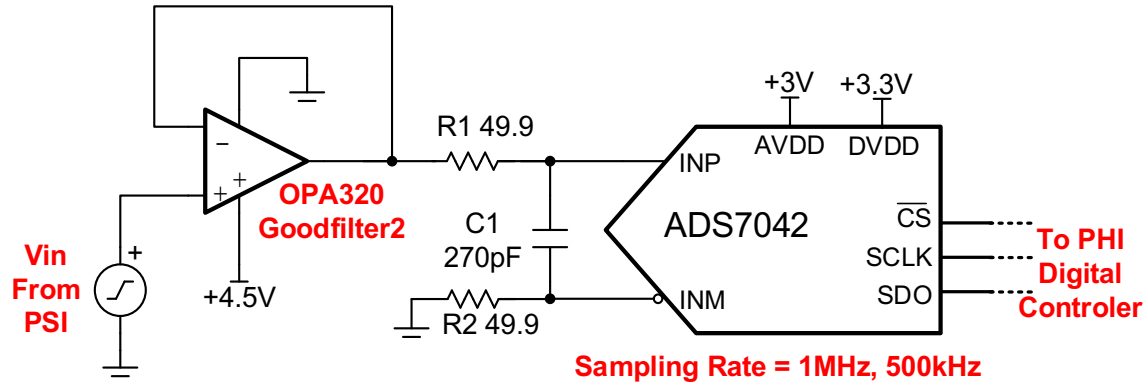
TI Precision Labs – ADCs

by Art Kay, Peggy Liska

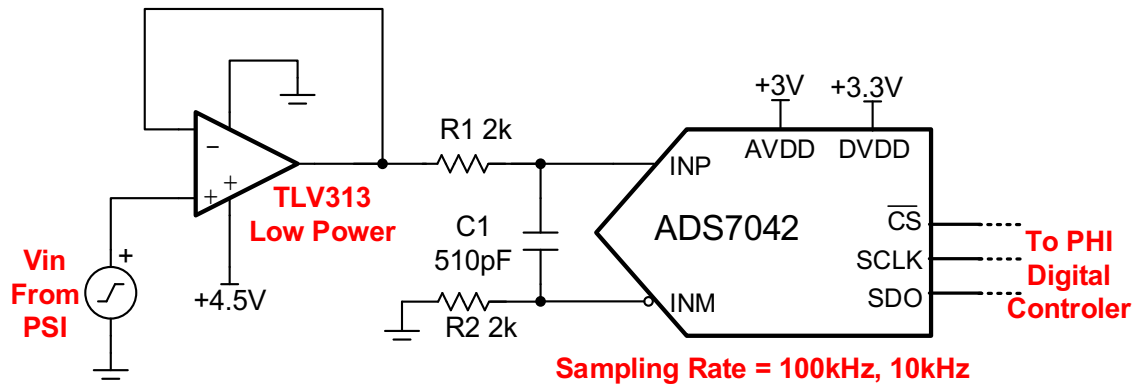
Required/Recommended Equipment

- Calculation
 - Calculate power for the amplifier, digital communications, and analog ADC supply
- Measurement
 - Short description of current shunt measurement
 - Measure power for different amplifiers and sampling rates
 - PLABS-SAR-EVM-PDK
 - <http://www.ti.com/tool/plabs-sar-evm-pdk>
 - Download EVM software and purchase EVM

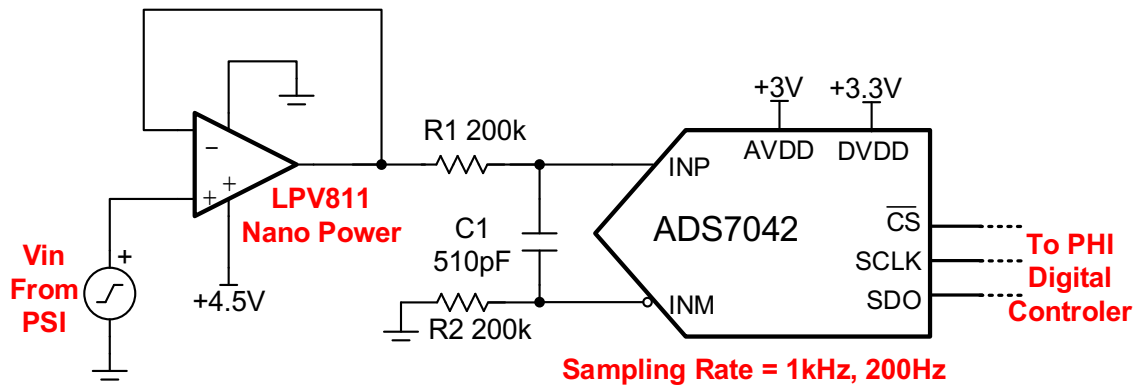
Circuits under test



OPA320 Parameter		Test Conditions	MIN	TYP	MAX	UNIT
GBP	Gain Bandwidth Product	Unity gain		20		MHz
I _Q	Quiescent current	V _s =5.5V, T _a =25°C		1.5	1.75	mA



TLV313 Parameter		Test Conditions	MIN	TYP	MAX	UNIT
GBP	Gain Bandwidth Product	Unity gain		1		MHz
I _Q	Quiescent current	V _s =5.0V, T _a =-40°C to 125°C		65	90	μA



LPV811 Parameter		Test Conditions	MIN	TYP	MAX	UNIT
GBP	Gain Bandwidth Product	Unity gain		8		kHz
I _Q	Quiescent current	V _s =3.3V, T _a =25°C		450	540	nA

Expected results

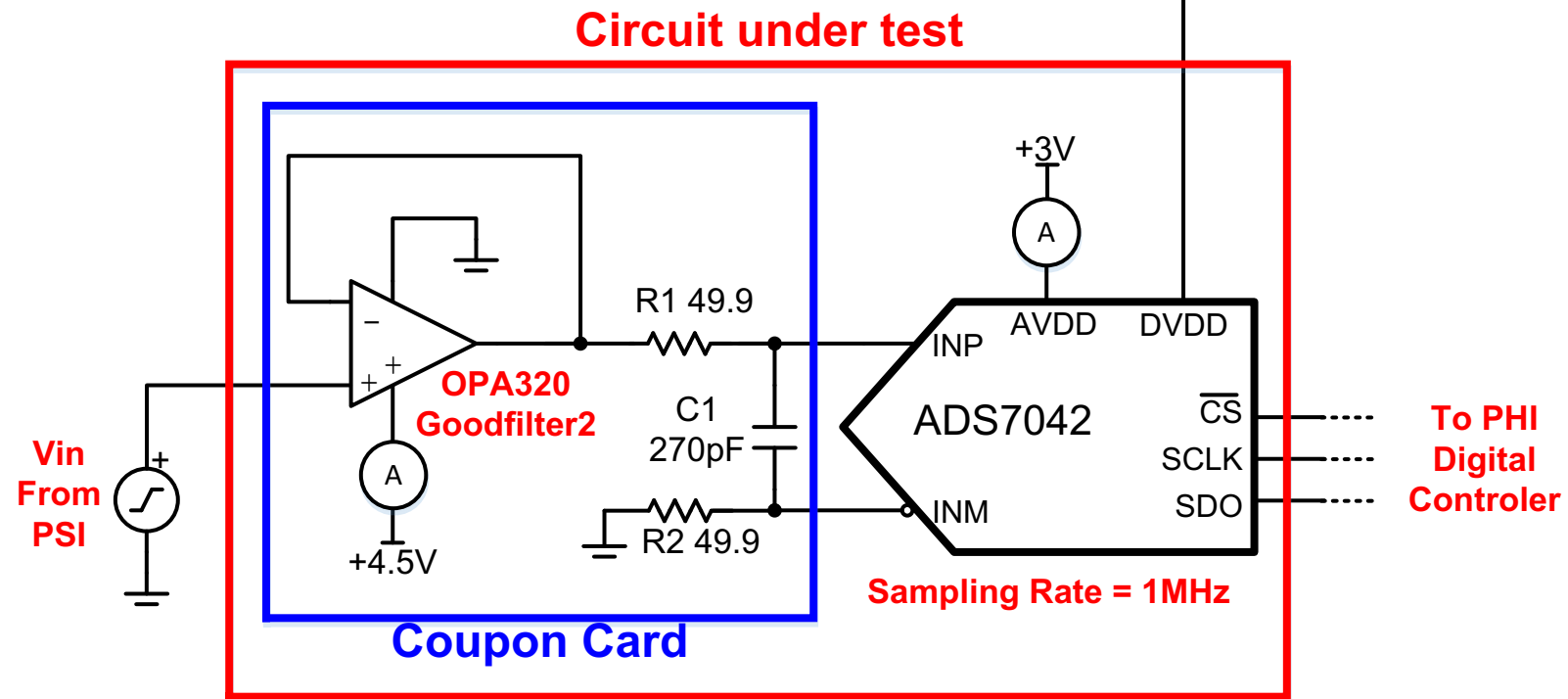
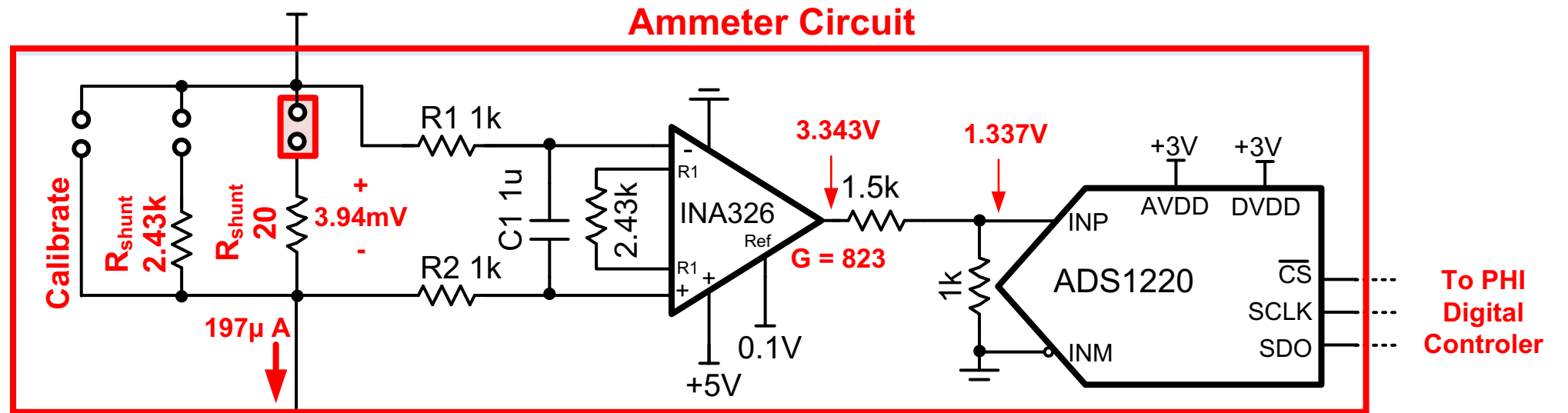
Amp	Sampling Rate	I _{Q_Amp} (μA) Max	P _{DVDD} (μW) Max	P _{AVDD} (μW) Max	P _{Q_Amp} (μW) Max	P _{TOTAL} (μW) Max
OPA320	1M	1,750	1306.80	690.00	7875.00	9871.80
OPA320	500k	1,750	653.40	345.00	7875.00	8873.40
TLV313	100k	90	130.68	69.00	405.00	604.68
TLV313	10k	90	13.07	6.90	405.00	424.97
LPV811	1k	0.54	1.31	0.69	2.43	4.43
LPV811	200	0.54	0.26	0.14	2.43	2.83

$$P_{DVDD} = V_{DVDD} \cdot (C \cdot V \cdot N_{bits} \cdot f_s) = 3.3V \cdot (10pF \cdot 3.3V \cdot 12 \cdot 500kHz) = 653.4\mu W$$

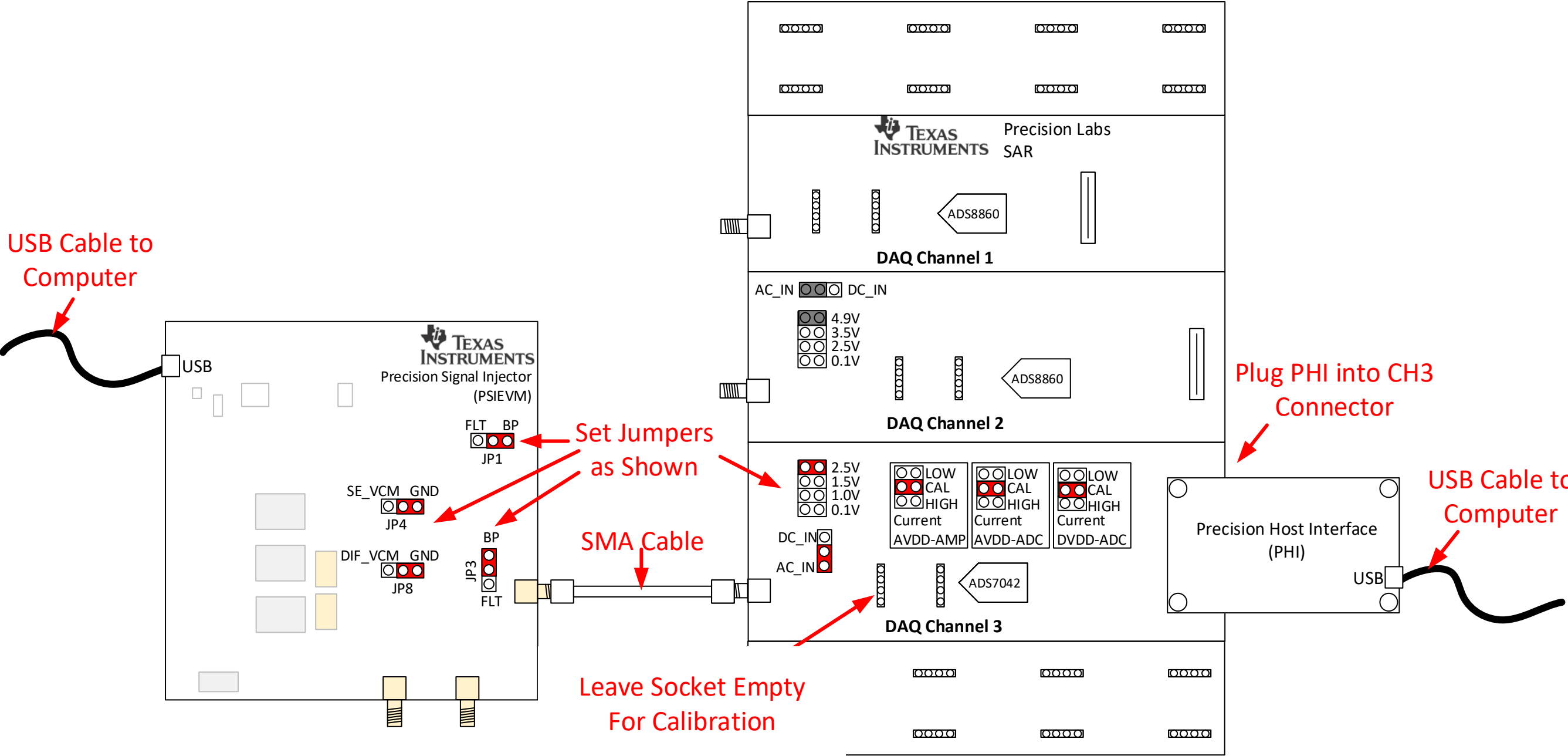
$$P_{AVDD} = V_{AVDD} \cdot \frac{I_{AVDD@1Msps} \cdot f_s}{1MHz} = 3.0V \cdot \frac{230\mu A \cdot 500kHz}{1MHz} = 345.0\mu W$$

$$P_{Q_Amp} = V_{AMP} \cdot I_{Q_Amp} = 4.5V \cdot 1.75mA = 7.875mW, I_{Q_AMP} \text{ from OPA320 data sheet.}$$

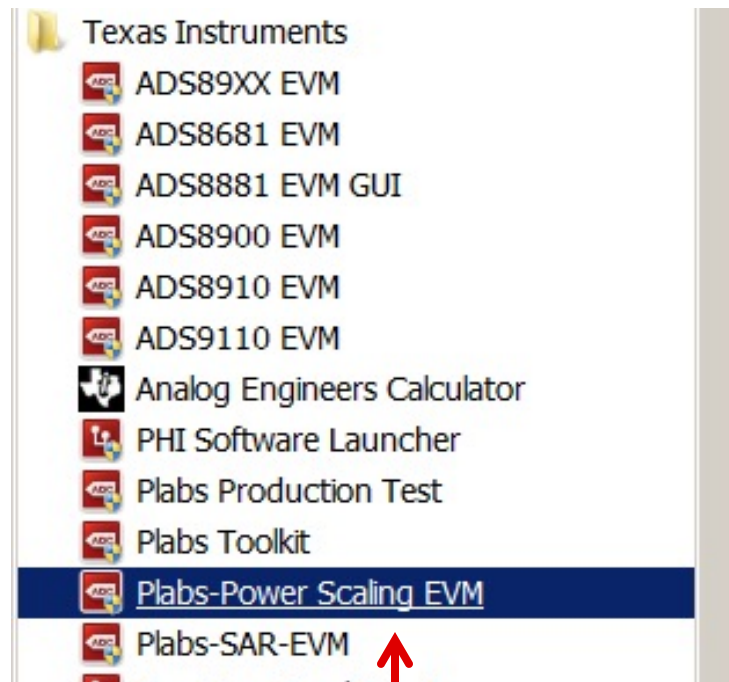
Supply Current Measurement Circuit



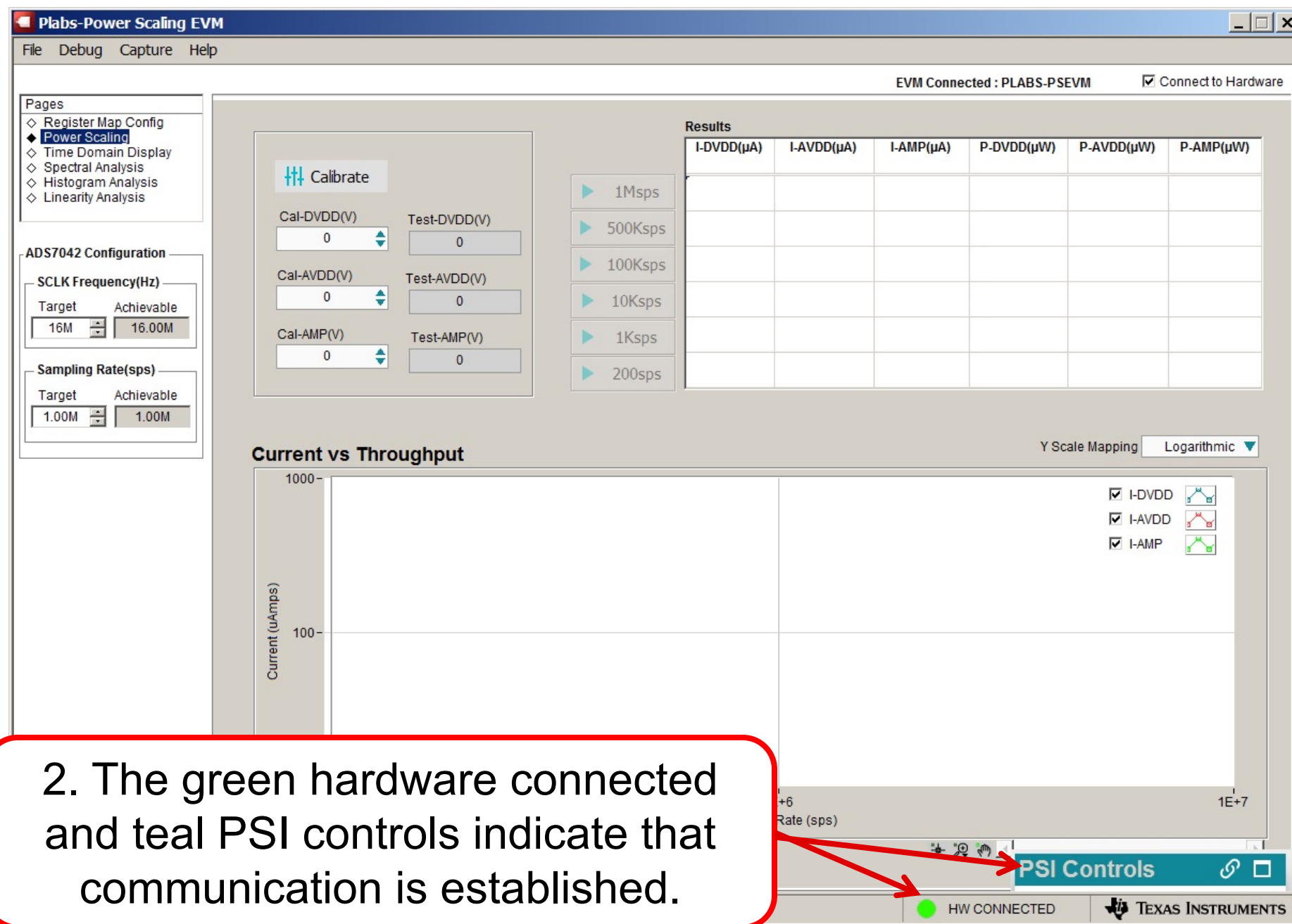
Connect the hardware



Start & Setup the Plabs-Power Scaling EVM Software



1. Select "Plabs-Power Scaling" from "start>All Programs"



2. The green hardware connected and teal PSI controls indicate that communication is established.

Calibrate system offsets

The screenshot shows the 'Plabs-Power Scaling EVM' software interface. The 'Calibrate' button is highlighted with a red box and an arrow pointing to it. The 'Jumper Settings' dialog is open, showing a schematic of the hardware with various jumpers and settings. The dialog includes a 'Continue' button at the bottom right. The background shows a 'Current vs Throughput' graph and a 'Results' table.

I-DVDD(μ A)	I-AVDD(μ A)	I-AMP(μ A)	P-DVDD(μ W)	P-AVDD(μ W)	P-AMP(μ W)

1. Set Jumpers as Shown. Remove coupon card from socket. Sampling rate will be adjusted automatically.

2. Press "continue" after the hardware is configured.

Measure OPA320 at different sampling rates

1. Start by measuring system power at 1Msps and 500ksps. At these sampling rates we will use the OPA320.

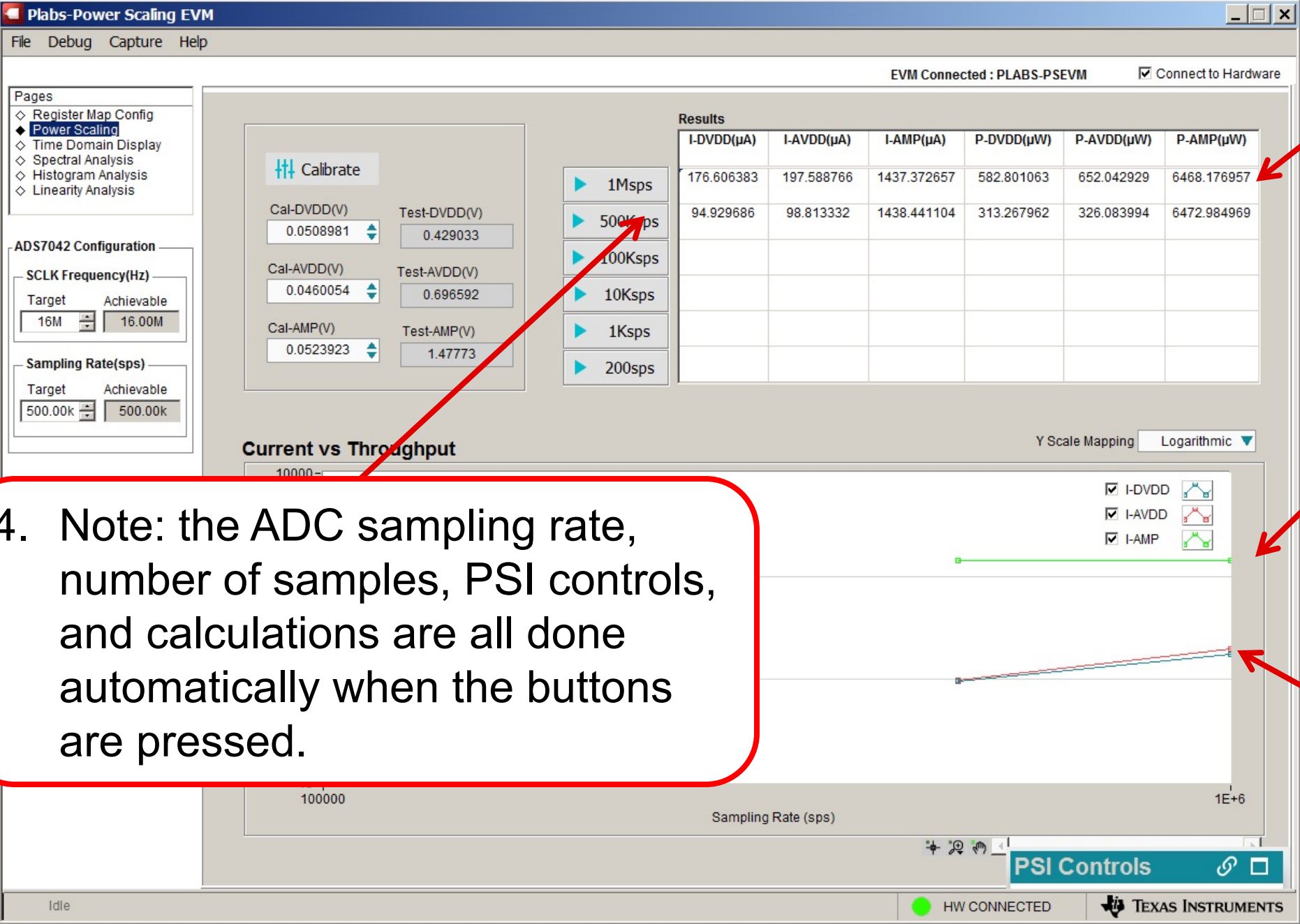
2. Change the jumpers as shown. Install the OPA320_Good_filter2 device.

3. Press continue to measure power at the specified sampling rate.

The screenshot displays the 'Plabs-Power Scaling EVM' software interface. The main window shows a 'Results' table with columns for I-DVDD(μA), I-AVDD(μA), I-AMP(μA), P-DVDD(μW), P-AVDD(μW), and P-AMP(μW). A 'Jumper Settings' dialog box is overlaid, showing a schematic of the EVM board with various jumper configurations. The 'Connect PSI' jumper is set to '2.5V'. The 'DC_IN' jumper is set to '1.5V'. The 'AC_IN' jumper is set to '0.1V'. The 'Current' jumpers for AVDD-AMP, AVDD-ADC, and DVDD-ADC are all set to 'HIGH'. The 'CAL' jumpers for all three are set to 'LOW'. The 'Precision Host Interface (PHI)' is connected to a USB port. The 'Continue' button is highlighted with a red arrow. A 'PSI Controls' panel is visible at the bottom right of the main window.

I-DVDD(μA)	I-AVDD(μA)	I-AMP(μA)	P-DVDD(μW)	P-AVDD(μW)	P-AMP(μW)

Expected results for OPA320



1. Your power measurements should be in the same range as these. When running at full speed power is in the hundreds of μW to mW .

2. Notice that the amplifier current is constant and not dependent on sampling rate.

3. ADC current scales with sampling rate.

4. Note: the ADC sampling rate, number of samples, PSI controls, and calculations are all done automatically when the buttons are pressed.

Measure TLV313 at 100ksps

1. Start by measuring system power at 100ksps. At these sampling rates we will use the TLV313.

Plabs-Power Scaling EVM

File Debug Capture Help

EVM Connected : PLABS-PSEVM Connect to Hardware

Pages

- Register Map Config
- Power Scaling

Test-DVDD(V) 0.125548

Test-AVDD(V) 0.175534

Test-AMP(V) -2.048

Sampling Rate

- 1Msps
- 500Ksps
- 100Ksps
- 10Ksps
- 1Ksps
- 200sps

I-DVDD(μA)	I-AVDD(μA)	I-AMP(μA)	P-DVDD(μW)	P-AVDD(μW)	P-AMP(μW)
176.606383	197.588766	1437.372657	582.801063	652.042929	6468.176957
94.929686	98.813332	1438.441104	313.267962	326.083994	6472.984969

Throughput

Current (uAmps)

1000

100

10

100000

Sampling Rate (sps)

1E+6

PSI Controls

Idle

HW CONNECTED

TEXAS INSTRUMENTS

Jumper Settings

ADS8860

DAQ Channel 2

Connect PSI

2.5V

1.5V

1.0V

0.1V

DC_IN

AC_IN

LOW CAL

HIGH Current

AVDD-AMP

AVDD-ADC

DVDD-ADC

TLV313

ADS7042

DAQ Channel 3

Install TLV313_Low Power

Precision Host Interface (PHI)

USB

Kindly connect the Jumper settings as shown above and click Continue.

Continue

Measure TLV313 at 10ksp/s

1. Press 10ksp/s for the second TLV313 experiment.

2. Change the jumpers according to the figure below.

The screenshot displays the 'Plabs-Power Scaling EVM' software interface. The 'Calibrate' section includes fields for 'Cal-DVDD(V)', 'Test-DVDD(V)', 'Test-AVDD(V)', and 'Test-AMP(V)'. A speed selection menu on the right has '10Ksp/s' highlighted. Below this is a 'Current vs Throughput' graph with a logarithmic y-axis (Current in uAmps) and a logarithmic x-axis (Throughput). A 'Jumper Settings' window is overlaid, showing a diagram of the TLV313 sensor and its connections. The diagram includes a 'Precision Host Interface (PHI)' with a USB port, a 'DAQ Channel 3' connected to the TLV313 (ADS7042), and a 'DAQ Channel 1' connected to the ADS8860. The jumper settings for the TLV313 are: DC_IN (2.5V), AC_IN (1.5V), and three current measurement channels (AVDD-AMP, AVDD-ADC, DVDD-ADC) all set to 'LOW'. A 'PSI Controls' button is visible at the bottom right of the software interface.

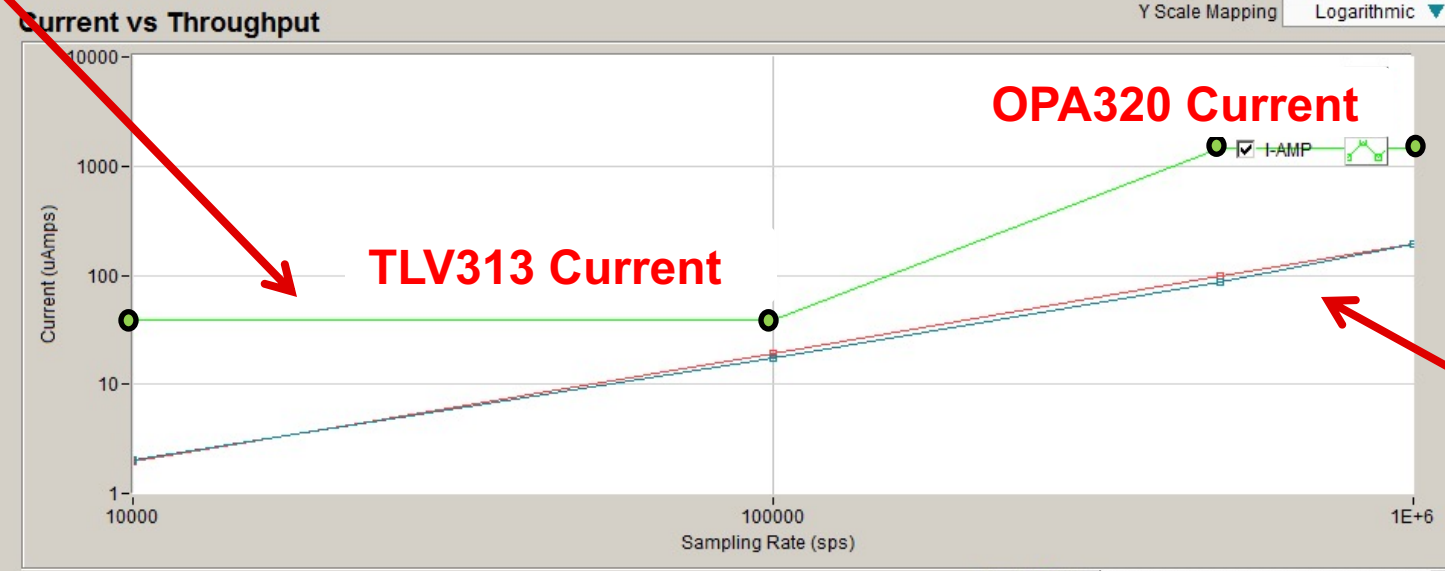
I-DVDD(μA)	I-A
190.950438	195
62.827527	96
13.421431	19

Expected results for TLV313

1. Your power measurements should be in the same range as these. When running at medium speed the power is in the tens to hundreds of μW .

2. Notice that the amplifier current is constant and not dependent on sampling rate.

	I-DVDD(μA)	I-AVDD(μA)	I-AMP(μA)	P-DVDD(μW)	P-AVDD(μW)	P-AMP(μW)
1Msps	193.808854	195.478048	1435.975040	639.569219	645.077557	1461.887679
500Ksps	85.564323	97.561323	1437.350482	282.362265	321.952265	6468.077177
100Ksps	17.498567	19.425690	39.352317	57.745272	64.104777	177.085428
10Ksps	2.021783	1.968628	39.319610	6.671884	6.496474	176.938244



3. ADC current scales with sampling rate.

Measure LPV811 at different sampling rates

1. Start by measuring system power at 1ksp/s and 200sp/s. At these sampling rates we will use the LPV811.

The screenshot displays the 'Plabs-Power Scaling EVM' software interface. The 'Calibrate' section shows settings for DVDD, AVDD, and AMP. The 'Results' table provides power consumption data at various sampling rates. A 'Current vs Throughput' graph shows a linear relationship. The 'Jumper Settings' diagram illustrates the physical hardware configuration, including the LPV811 component and various jumpers.

I-DVDD(μA)	I-AVDD(μA)	I-AMP(μA)	P-DVDD(μW)	P-AVDD(μW)	P-AMP(μW)
193.808854	195.478048	1435.975040	639.569219	645.077557	6461.887679
85.564323	97.561323	1437.350482	282.362265	321.952366	6468.077171
17.498567	19.425690	39.352317	57.745272	64.104777	177.085428
2.021783	1.968628	39.319610	6.671884	6.496474	176.938244

Calibrate Settings:
Cal-DVDD(V): 0.0535995, Test-DVDD(V): 0.0975078
Cal-AVDD(V): 0.0503391, Test-AVDD(V): -2.048
Cal-AMP(V): 0.0467506, Test-AMP(V): 0

Sampling Rate Selection: 1Msps, 500Ksp/s, 100Ksp/s, 10Ksp/s, 1Ksp/s, 200sp/s

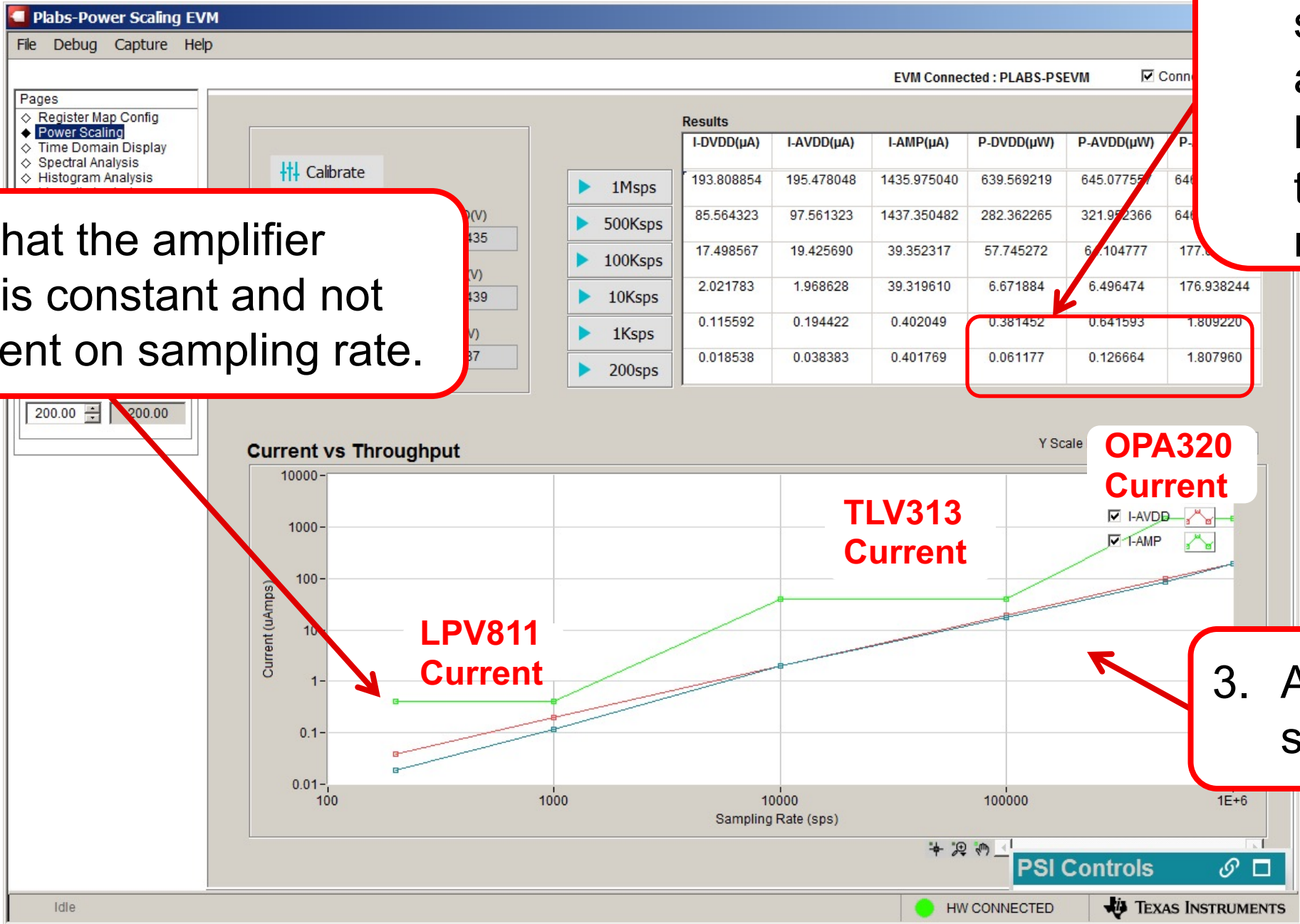
Current vs Throughput Graph: Y-axis: Current (uAmps) from 1 to 10000. X-axis: Throughput from 1 to 10000.

Jumper Settings Diagram: Shows connections for DC_IN, AC_IN, and various current measurement points (AVDD-AMP, AVDD-ADC, DVDD-ADC) with jumpers set to LOW, HIGH, or CAL. Includes a Precision Host Interface (PHI) and USB connection.

Expected results for LPV811

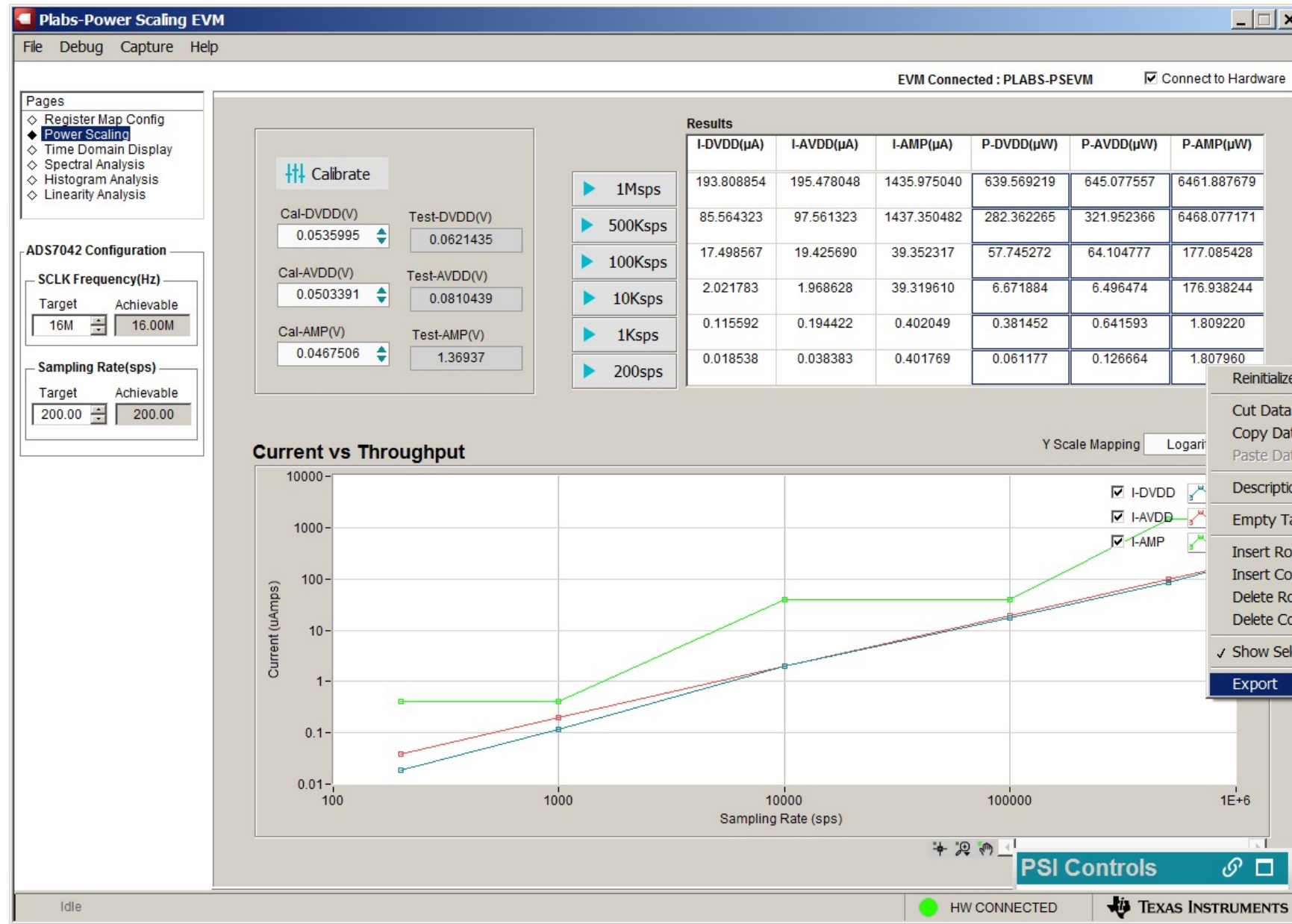
1. Your power measurements should be in the same range as these. When running at lowest speed the power is in the hundreds of nW to μ W range.

2. Notice that the amplifier current is constant and not dependent on sampling rate.



3. ADC current scales with sampling rate.

Compare final test results to calculated values



	A	B	C	D
1	639.569219	645.077557	6461.887679	
2	282.362265	321.952366	6468.077171	
3	57.745272	64.104777	177.085428	
4	6.671884	6.496474	176.938244	
5	0.381452	0.641593	1.80922	
6	0.061177	0.126664	1.80796	

Select the "Power" cells in the measured table. Right click and "Export Data to Excel".

Measured vs Expected Results

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

		Calculated				Example Measurements			
Amp	Sampling Rate	P _{DVDD} (μ W) Max	P _{AVDD} (μ W) Max	P _{Q_Amp} (μ W) Max	P _{TOTAL} (μ W) Max	P _{DVDD} (μ W)	P _{AVDD} (μ W)	P _{Q_Amp} (μ W)	P _{TOTAL} (μ W)
OPA320	1M	1306.80	690.00	7875.00	9871.80	639.57	645.08	6461.89	7746.53
OPA320	500k	653.40	345.00	7875.00	8873.40	282.36	321.95	6468.08	7072.39
TLV313	100k	130.68	69.00	405.00	604.68	57.75	64.10	177.09	298.94
TLV313	10k	13.07	6.90	405.00	424.97	6.67	6.50	176.94	190.11
LPV811	1k	1.31	0.69	2.43	4.43	0.38	0.64	1.81	2.83
LPV811	200	0.26	0.14	2.43	2.83	0.06	0.13	1.81	2.00

Measured vs Expected Results

		Calculated				Your Measurements			
Amp	Sampling Rate	P _{DVDD} (μ W) Max	P _{AVDD} (μ W) Max	P _{Q_Amp} (μ W) Max	P _{TOTAL} (μ W) Max	P _{DVDD} (μ W)	P _{AVDD} (μ W)	P _{Q_Amp} (μ W)	P _{TOTAL} (μ W)
OPA320	1M	1306.80	690.00	7875.00	9871.80				
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TLV313	100k	130.68	69.00	405.00	604.68				
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LPV811	1k	1.31	0.69	2.43	4.43				
LPV811	200	0.26	0.14	2.43	2.83				

Thanks for your time!