Whitney EVM Guide

Rev A: October 14, 2022

This document contains information on a product under development. The parametric information contains target parameters that are subject to change.

Document Revision History

Revision	Date	Description
A	10/14/2022	Initial Draft.

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1 Introduction

Congratulations on your purchase of an Elevate Semiconductor Whitney evaluation system! You will find that it serves as an invaluable development platform to help get your product to market in the shortest possible time. The Whitney evaluation board and GUI (Graphical User Interface) allow the customer to demonstrate and evaluate Whitney performance and functionality.

The Whitney EVM and digital controller board with USB interface are mounted to a baseboard. For detailed assembly instructions, please see the Elevate Whitney Setup Video.

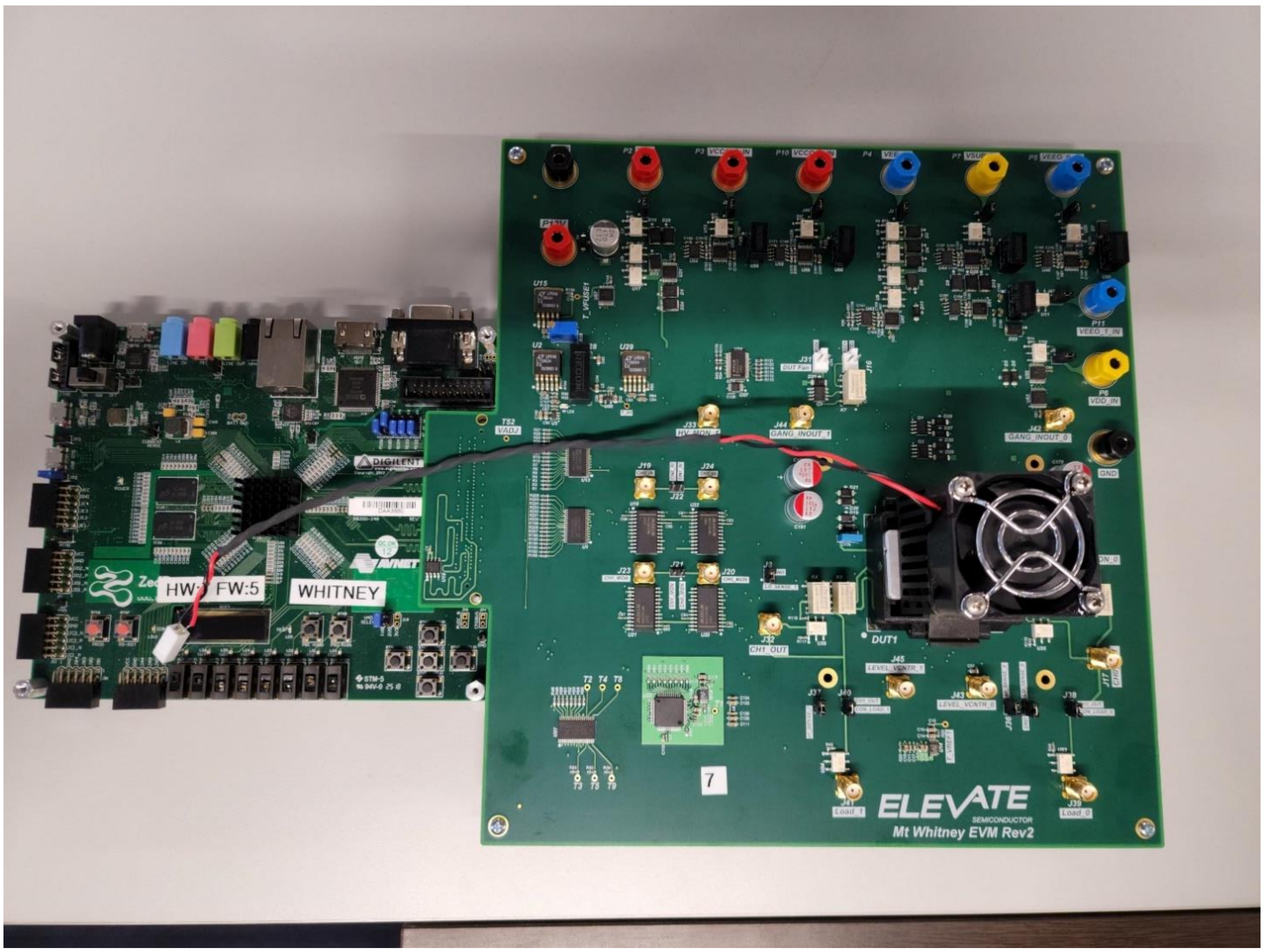


FIGURE 1: EVM AND DIGITAL CONTROLLER BOARD

2 EVM GUI Installation Media

The Whitney EVM ships with self-installing software on the included flash drive. To ensure the evaluation board is correctly recognized when connected to the PC, the software should be installed before connecting the board to the Evaluation PC's USB port. The installation media (flash drive) includes the Installer directory, and a directory with support files and the most recent version of the Whitney EVM GUI.

Name	Date modified	Type
Whitney_EVM_GUI Support Files	10/1/2021 8:44 AM	File folder
Whitney_EVM_GUI_REV_A Installer	10/1/2021 8:44 AM	File folder

FIGURE 2: INSTALLER DIRECTORY

2.1 Software Installation

To begin the installation of the EVM GUI, open the "Whitney_EVM_GUI_REV_A Installer" directory and double-click on "Whitney_EVM_GUI_REV_A_Installer.exe".

Name	Date modified	Type	Size
bin	10/1/2021 8:44 AM	File folder	
license	10/1/2021 8:44 AM	File folder	
supportfiles	10/1/2021 8:44 AM	File folder	
nidist.id	2/27/2021 2:25 PM	ID File	1 KB
Whitney_EVM_GUI_REV_A_Installer.exe	8/30/2019 11:02 AM	Application	5,327 KB
Whitney_EVM_GUI_REV_A_Installer.ini	2/27/2021 2:25 PM	Configuration settings	32 KB

FIGURE 3: INSTALLATION DIRECTORY

The default installation directory is "C:\Program Files(x86)\Whitney_EVM_GUI_REV_A". However, the EVM GUI can be installed to any directory on any drive where the user has full rights to read, write, and modify files. Click Next to begin installation.

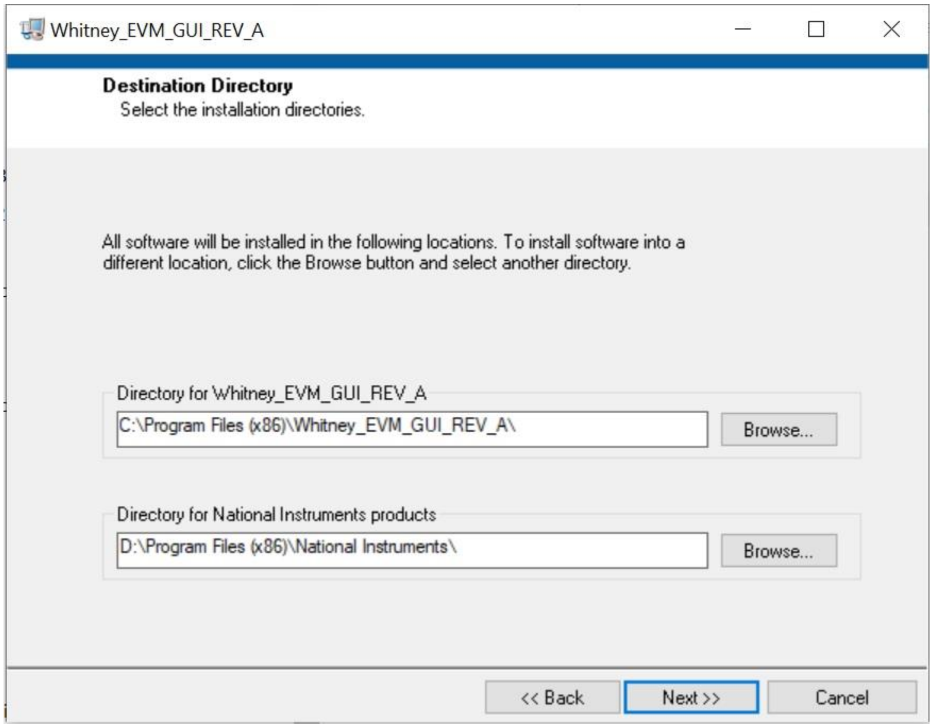


FIGURE 4: GUI DIRECTORY

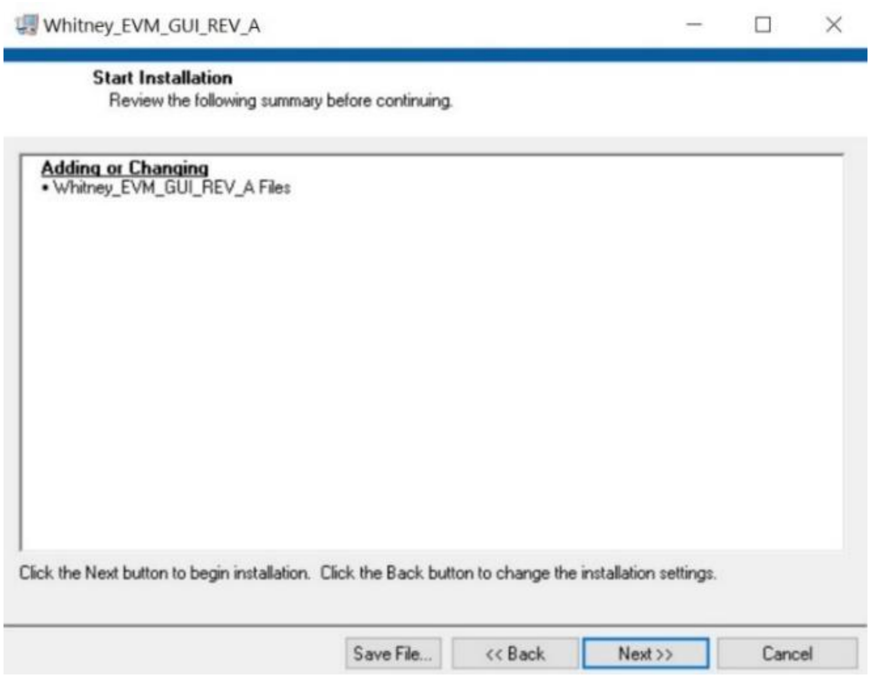
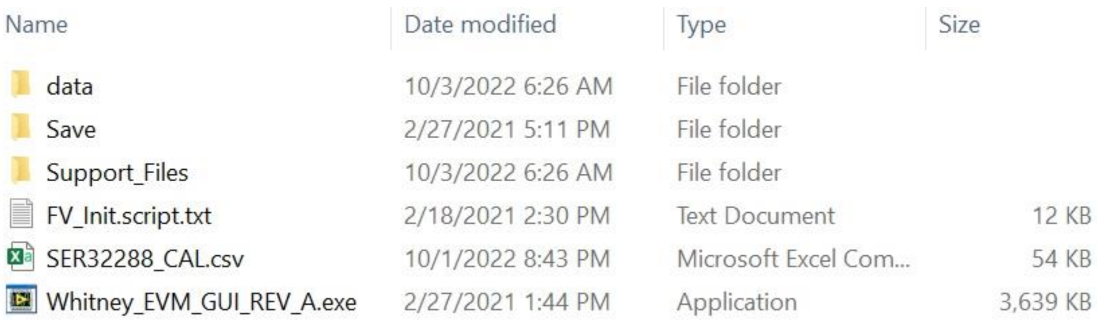


FIGURE 5: GUI INSTALLATION

2.2 Support Files

Following installation, you will be asked to re-boot your computer. After re-booting, navigate to the directory where “Whitney_EVM_GUI_REV_A.exe” has been installed, and copy the files from the “Whitney_EVM_GUI Support Files” directory on the installation media into the same directory. The directory should now contain the files shown below, although there may be additional “SERxxxxx_CAL.csv” files. If you have been provided with additional SERxxxxx_CAL.csv files, copy the files into this directory.

The ”Whitney_EVM_GUI Support Files” directory will also include a more recent revision of the Whitney EVM GUI. Copy this revision (Whitney_EVM_GUI_REV_x.exe) into this directory and delete Whitney_EVM_GUI_REV_A.exe.



Name	Date modified	Type	Size
data	10/3/2022 6:26 AM	File folder	
Save	2/27/2021 5:11 PM	File folder	
Support_Files	10/3/2022 6:26 AM	File folder	
FV_Init.script.txt	2/18/2021 2:30 PM	Text Document	12 KB
SER32288_CAL.csv	10/1/2022 8:43 PM	Microsoft Excel Com...	54 KB
Whitney_EVM_GUI_REV_A.exe	2/27/2021 1:44 PM	Application	3,639 KB

FIGURE 6: SUPPORT FILES

3 Warnings

Whitney is a high voltage part with the ability to source significantly over 200mA of current. Special care must be taken when using this product to ensure the safety of the device, board, and user. Please read the following cautions carefully and make sure that the hardware and software comply with the restrictions listed. Failure to adhere to the restrictions below can result in severe damage to the device. Users must read the datasheet and quick start guide thoroughly. In the event of confusion or uncertainty please reach out to the Elevate Applications Team for guidance. For REVB Silicon see the errata for additional warnings and clarifications.

1) Power supply order MUST be followed exactly. Allow minimum 5mS between supplies. The power up order and minimum time sequence is by default, adhered to by the Whitney EVM power on sequence.

2) Output may NEVER go below VEEO.

3) VSUB must ALWAYS be the lowest supply in the system (as low as VEEO or VEE, whichever is lower).

4) The clamps CANNOT be engaged if the output is already over the clamp limit. Clamps should be set when the part is not outputting (HiZ).

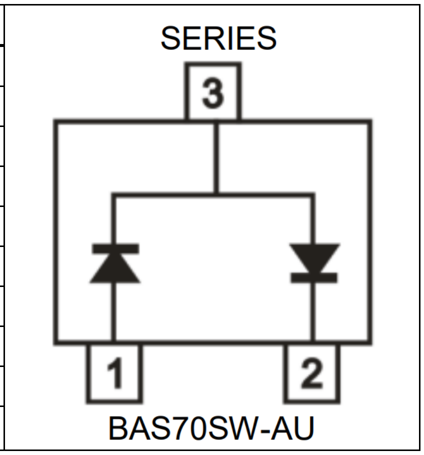
5) Clamps will NOT prevent damage to the Whitney device from an external source, clamps will only limit what the chip itself will try to output. Do not use clamps to limit external current or voltage.

6) Fast transient voltages or currents can damage the output due to a large mismatch between internal and external nodes. Settling time may be needed (or a discharge path) to ensure that there is not a large difference between internal and external voltages.

External Schottky diodes (Elevate recommends something like the BAS70SW-AU_R1_000A1) on high voltage pins may help reduce the possibility of transients or out-of-compliance voltages from damaging the Whitney device and should be considered in design. These diodes are already installed on the Whitney EVM. If using these specific diodes, below is the way the 3 pins should be set up for best protection:

TABLE 1: RECOMMENDED DIODE LOCATIONS FOR THE BAS70SW-AU_R1_000A1

Pin 1 (Left)	Pin 2 (right)	Pin 3 (top)
VEEO_0	VCCO_0	Force0_0 (pin 56, 57)
VEEO_0	VCCO_0	Force1_0 (pin 45)
VEEO_0	VCCO_0	HI_Sense_0 (pin 43)
VSUB	VCCO_0	Lo_Sense_0 (pin 41)
VSUB	VCCO_0	HV_Mon_0 (pin 64)
VSUB	VCCO_1	Lo_Sense_1 (pin 126)
VSUB	VCCO_1	HV_Mon_1 (pin 103)
VEEO_1	VCCO_1	Force0_1 (pin 110,111)
VEEO_1	VCCO_1	Force1_1 (pin 122)
VEEO_1	VCCO_1	HI_Sense_1 (pin 124)



4 Hardware

4.1 Power Supplies

The following power supply settings are a safe condition selected when the Whitney EVM is initially powered up but any rails within the valid operating condition can be powered up to:

1. Common ground return for all supplies (Black Banana jack labeled GND)
2. Whitney VDD and VDDA (+1.8V @ 25mA MAX, Yellow Banana jack labeled VDD)
3. Whitney VCC (+2.75V @ 70mA MAX, Red Banana jack labeled VCC)
4. Whitney VEE (-2.75V @ 95mA MAX, Blue Banana jack labeled VEE)
5. +12V @ 1A (Red Banana Jack labeled +12V, also powers ZED board)
6. Whitney CH1 VEEO (-5V @ 1A MAX, Blue banana jack labeled VEEO_1)
7. Whitney CH0 VEEO (-5V @ 1A MAX, Blue banana jack labeled VEEO_0)
8. Whitney CH1 VCCO (+10V @ 1A MAX, Red banana jack labeled VCCO_1)
9. Whitney CH0 VCCO (+10V @ 1A MAX, Red banana jack labeled VCCO_0)
10. Whitney VSUB (-5V @ 10mA MAX VSUB supply, Yellow banana jack labeled VSUB)

Note: VSUB must always be the most negative supply. Although VEEO can be more positive than VSUB, during initial evaluation this absolute requirement is most easily met by powering VSUB, VEEO_0, and VEEO_1 from the same -5V supply.

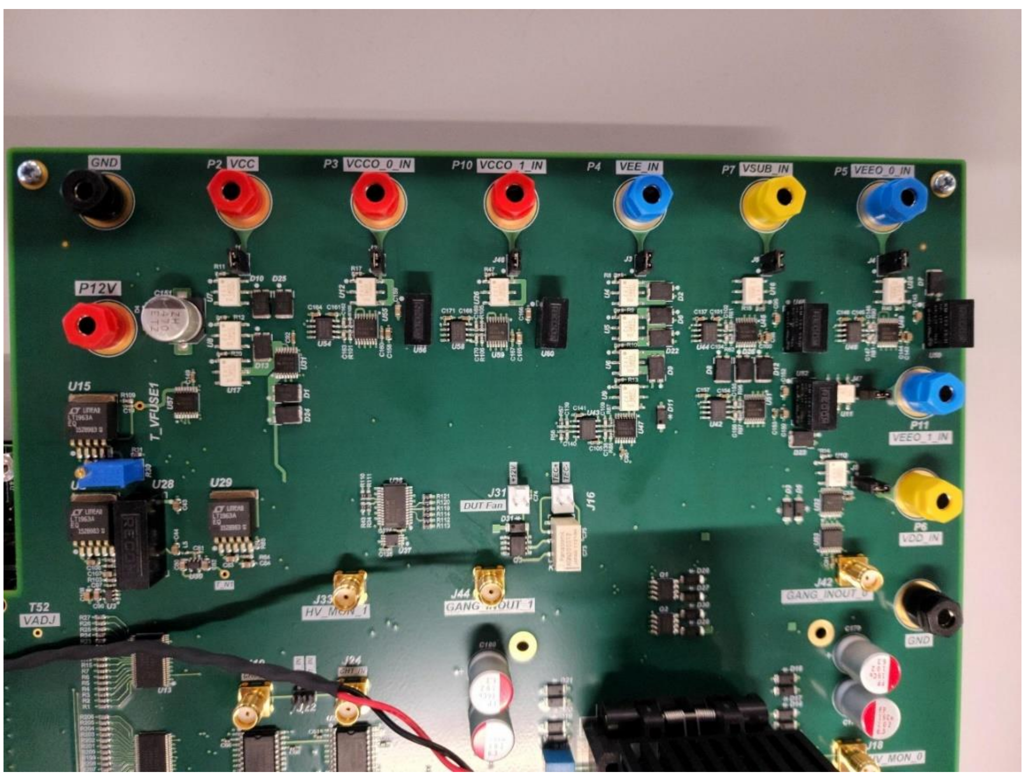


FIGURE 7: EVM POWER SUPPLY BANANA JACKS

4.2 EVM USB Cable

Plug the USB type-A connector of the included USB cable into your computer and carefully plug the Micro-USB connector into the EVM connector UART (J14) as shown below.

Caution: The UART USB connector is soldered to the PCB with small surface mount pads and can be damaged or completely detached from the EVM if the USB cable is accidentally pulled up, down, or sideways.

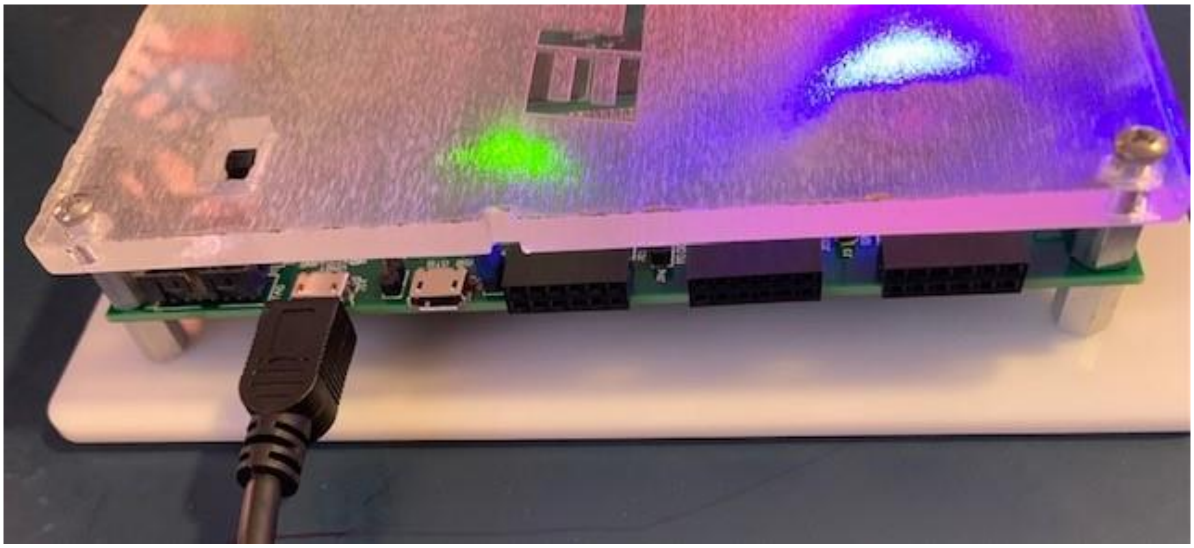


FIGURE 8: MICRO-USB CONNECTOR

4.3 External Hardware Required for GPIB Use

In order to run the Whitney EVM with the GPIB enabled, you are required to have connected:

- 3 BK Precision 9132B- Triple Output Programable DC Power Supplies (for controlling the supplies)
- 1 Agilent 34401A Digital Multimeter (for voltage calibration)
- 1 Keithley 238 High Current Source Measure Unit (for the current calibration)

A subset of these instruments cannot be used. It is all or nothing.

5 GUI Overview

5.1 Starting the GUI

The external supplies should be enabled prior to starting the GUI (the digital controller board is powered from the external +12V supply). Double click on "Whitney_EVM_GUI_REV_[A..Z].exe" to start the GUI. The Whitney EVM GUI initial default display:

GPIB is disabled by default and may not be used unless the instruments in section 4.3 are connected.

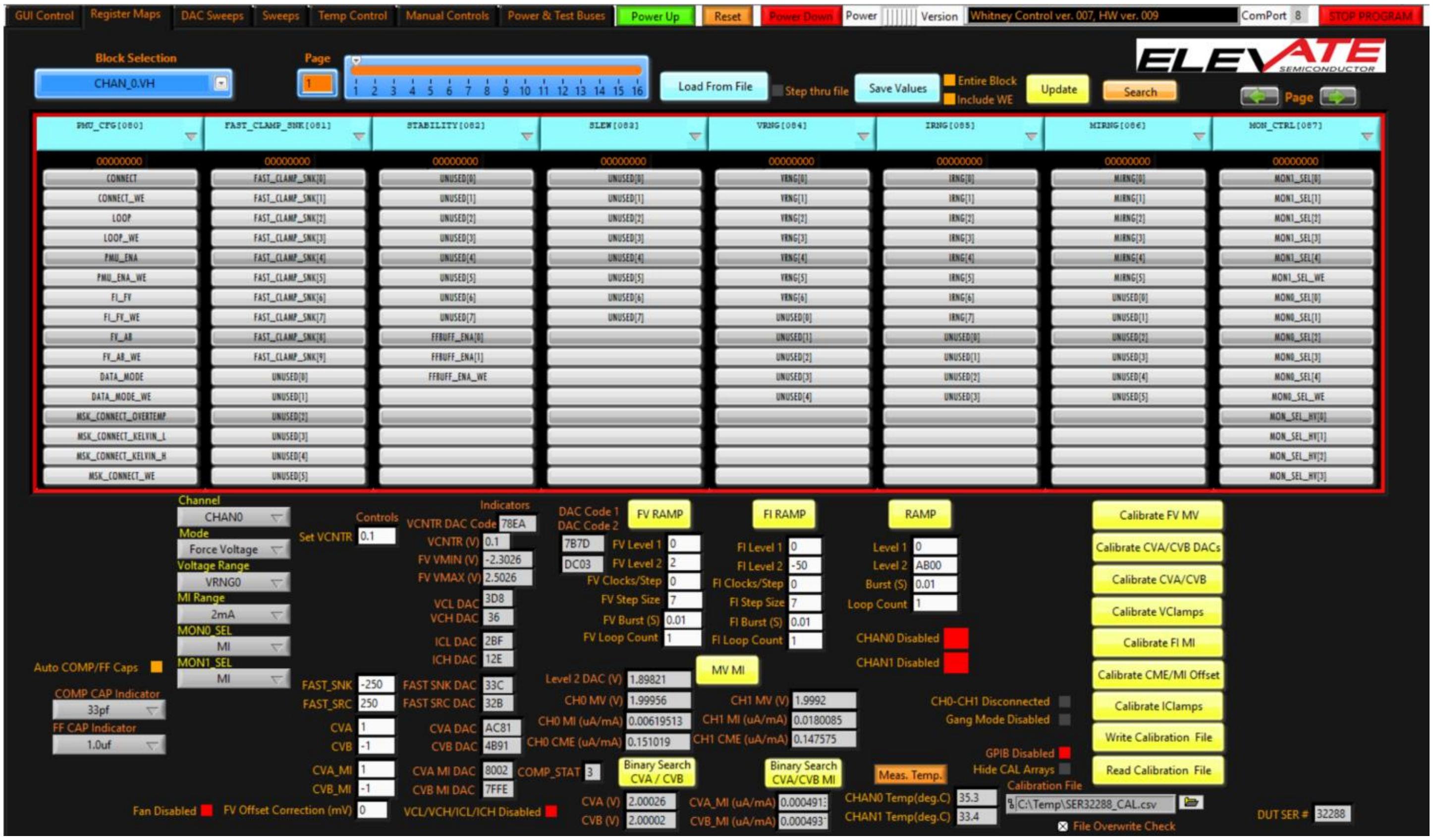


FIGURE 9: GUI STARTUP

5.2 Powering up the Whitney Device

Click on the green "Power Up" button to apply power to the Whitney device:

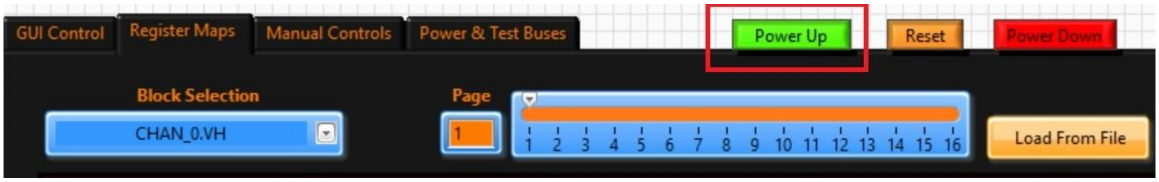


FIGURE 10: POWER UP

Power supply currents should be checked from the front of the power supplies. Please make sure current limits are set as to not cause excessive damage to the EVM in the event of a failure before power up. Whitney EVM initial power supply current (typical values):

IDD (+1.8V): 38mA
VCC (+2.75V): 14mA
VEE (-2.75V): -24mA
VCCO_0 (+10V): 9mA
VCCO_1 (+10V): 9mA
VEEO_0 (-5V): 1mA
VEEO_1 (-5V): 1mA
VSUB (-5V): 13mA
+12V: 600mA

5.3 Channel 0 Register Map Display After Loading Default Register Settings

The default register settings select Voltage Range 0 (VRNG0) and the 2mA current range (IRNG3). Click on the yellow *Update* button to update the display. Click on the *Page* left arrow or *Page* right arrow to scroll horizontally through the Register Map.

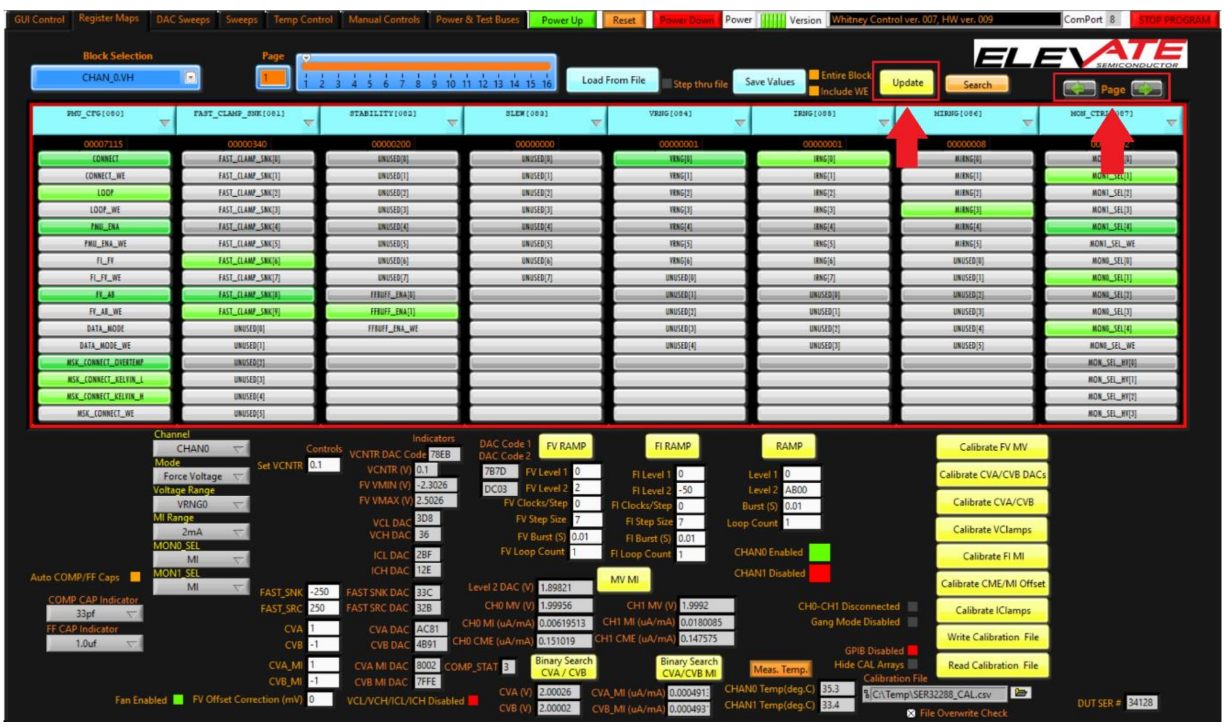


FIGURE 11: DEFAULT REGISTER MAP

5.4 Loading Calibration Factors

Each EVM has a unique set of calibration factors optimized for the Whitney device that was shipped with the EVM. These calibration factors are contained in a file with the name format “SERxxxxx_CAL.csv”, where “xxxxx” is the serial number of the Whitney device shipped with the EVM. The unique Whitney serial number is read from a device register and is displayed as an integer in the lower right-hand corner of the GUI display called “DUT SER #”. If the incorrect calibration factors are loaded or the part is not calibrated, the voltages and currents forced and measured by the EVM will be less accurate. The calibration files are read-only to prevent them from being accidentally over-written. You may find it convenient to copy the “SER_xxxxx_CAL.csv” calibration file associated with your EVM to “c:\temp\”. Type the *Calibration File* name and click the “Read Calibration File” button to load the correct calibration factors for your EVM.

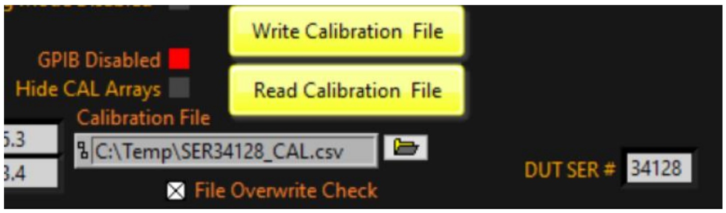


FIGURE 12: LOADING CALIBRATION FILES

5.5 Editing Registers

A bit highlighted in green is a logic high; a bit that is not highlighted is a logic low. Experiment with editing the VRNG and STABILITY registers. All changes are immediately written to the device in real time (there is no risk of damage to the Whitney device at this point as both channels are disabled). The contents of the VRNG and STABILITY registers will be updated automatically whenever the Whitney voltage or current ranges are changed from the GUI front panel. There are two different types of registers, one with write enables and one without; see below to use the two types of registers.

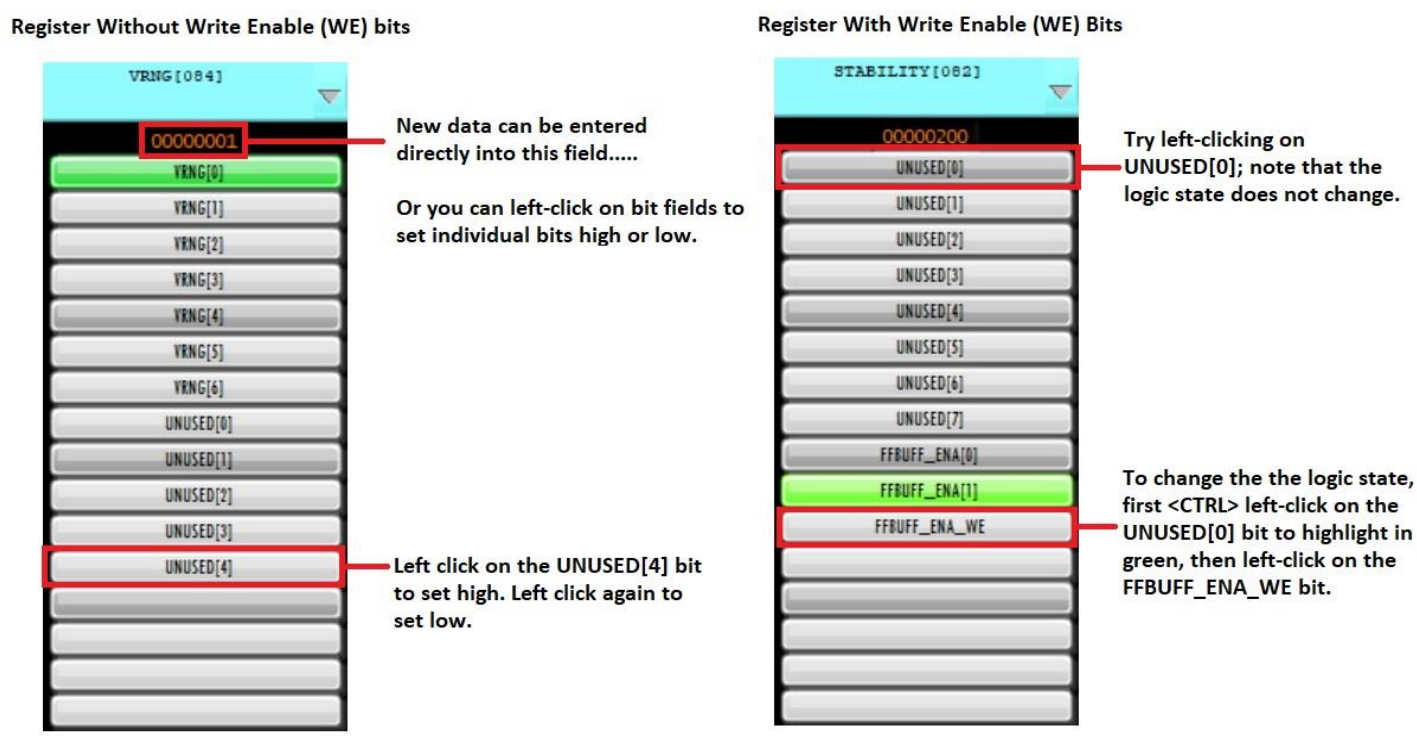


FIGURE 13: REGISTER BITS

6 Initial Default Channel 0 Force Voltage Settings

Connect a voltmeter to Whitney PMU Channel 0 output (SMA connector J17, silkscreen label CHAN0_OUT) and click on the red *CHAN0 Disabled* button. The button color will change from red to green, and the text will be updated to *CHAN0 Enabled*. The voltmeter should now read +2.00V.

FIGURE 14: ENABLE/DISABLE CHANNELS

Click on the yellow *Update* button. Note that the PMU_CFG register bit CONNECT has changed state from a logic low to a logic high (the CONNECT register bit text box is now highlighted in green). The GUI updated this register bit when you clicked on the red *CHAN0 Disabled* button.

FIGURE 15: CHANNEL CONNECT

7 Modifying VRNG and VCNTR

The minimum and maximum Force Voltage and Measure Voltage for the VRNG are calculated by LabView and indicated by *FV VMIN (V)* and *FV VMAX (V)*. The Force Voltage and Measure Voltage range can be shifted up or down by entering a new value into the *Set VCNTR* control and pressing <Enter>; LabView will calculate the required digital offset and update the VCNTR DAC register and the *VCNTR DAC Code* indicator. See the datasheet for how to manually calculate the voltage output based on your VCNTR. If you have a Revision B parts, see the Errata as well.

8 Digital Ramp Function

Whenever the "FV RAMP" button is clicked, the *DAC Code 1* and *DAC Code 2* indicators are updated to reflect the voltage levels set by controls *FV Level 1* and *FV Level 2*. Note that with *Set VCNTR = 0.1, DAC Code 2* is 0xDC03. Change *Set VCNTR* to *2* (+2V) and press <Enter>; *FV VMIN (V)* is updated from -2.3026 to -0.40259, *FV VMAX (V)* is updated from 2.5026 to 4.4026, VCNTR DAC Code is updated from 0x78EA to 0x1D5D, and *DAC Code 2* is now 0x8073 (actual FV and VCNTR DAC codes will vary from device to device, depending on the Force Voltage gain and offset). Note that the voltmeter reading is unchanged at +2.000V; when you modified VCNTR, the LabView code automatically updated Whitney registers to maintain the voltage set by *FV Level 2.* Return *Set VCNTR* to *0.1* and press <Enter> before proceeding to the next step.

Note that with Set VCNTR = 0.1, DAC Code 2 value displayed in Figure 16 is 0xDC03 (actual DAC codes will vary from device to device)

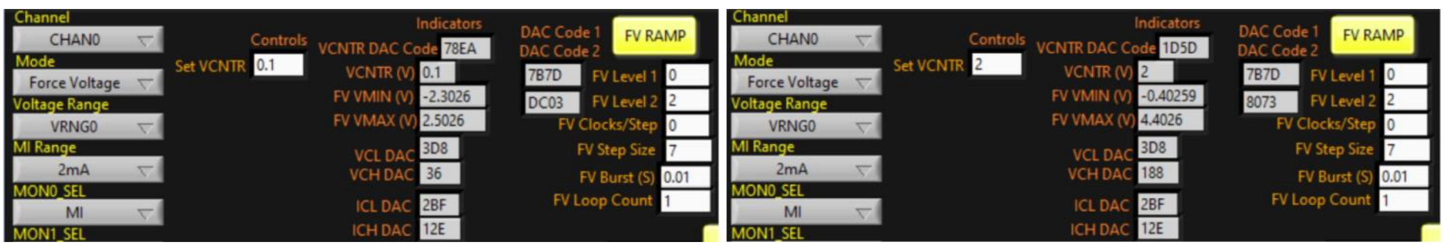


FIGURE 16: FV RAMP

9 Whitney DAC Non-Linearity and Force Voltage Accuracy

The Whitney 16-bit DACs are non-monotonic and require a multi-point calibration to achieve the specified Force Voltage accuracy. The Whitney GUI implements a full multi-point DAC calibration. Note that in Figure 17the scale goes from ± 80mV but in Figure 18, the scale is from ±10mV

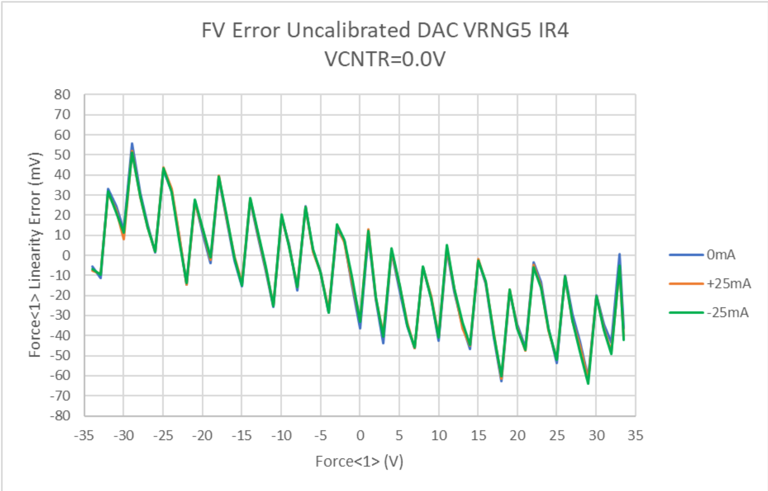


FIGURE 17: UNCALIBRATED DAC

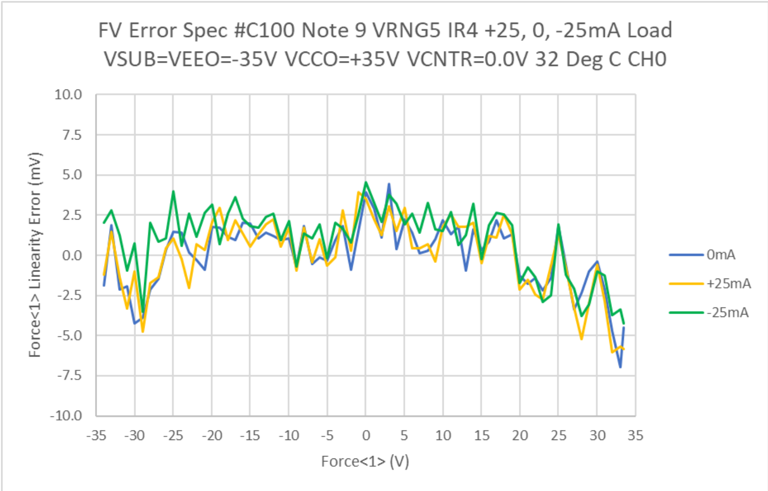


FIGURE 18: CALIBRATED DAC

10 Suggested VCNTR and VRNG Settings for Typical Supply Voltage Ranges

The internal DACs have a nominal range of -2.4V to +2.4V; in VRNG5 the nominal Force Voltage (FV) and Measure Voltage (MV) gain is 16.67. **Use the lowest possible VRNG setting to minimize output noise and improve FV and MV accuracy and drift over temperature.** The chart below demonstrates how VCNTR can be shifted up or down to maximize the coverage of each voltage range. The DAC codes shown are for reference only and will vary from channel to channel and device to device.

Note that the FV DAC code is 0x7FFF when Force Voltage = VCNTR; LabView uses the VCNTR DAC to compensate for any Force Voltage offset.

TABLE 2: VCNTR AND VRNG

VSUB	VEEO	VCCO	VRNG	Usable Range at ±IMAX	Force Voltage	VCNTR	FV DAC Code	VCNTR DAC Code
-6	-6	6	0	VCCO -1.5V	4.5	2.25	0xEC39	0x1361
-6	-6	6	0	((VCCO-VEEO/2)+VEEO	0	0	0x7FFF	0x7F87
-6	-6	6	0	VEEO+1V	-5	-2.5	0x07BF	0xF7B2
-6	-6	7.5	1	VCCO -1.5V	6	3.2	0xF004	0x0405
-6	-6	7.5	1	((VCCO-VEEO/2)+VEEO	0.75	0.75	0x7FFF	0x60CB
-6	-6	7.5	1	VEEO+1V	-5	-2.8	0x2B0A	0xEB4F
-6	-6	13	2	VCCO -1.5V	1.5	5.7	0xF004	0x1182
-6	-6	13	2	((VCCO-VEEO/2)+VEEO	3.5	3.5	0x7FFF	0x3C0B
-6	-6	13	2	VEEO+1V	-5	-2	0x460E	0xA660
-16	-16	16	3	VCCO -1.5V	14.5	7.3	0xEF40	0x0ECE
-16	-16	16	3	((VCCO-VEEO/2)+VEEO	0	0	0x7FFF	0x7FB6
-16	-16	16	3	VEEO+1V	-15	-7.3	0x0904	0xF09E
-30	-30	30	4	VCCO -1.5V	28.5	14.6	0xEB5B	0x0ED5
-30	-30	30	4	((VCCO-VEEO/2)+VEEO	0	0	0x7FFF	0x7FB4
-30	-30	30	4	VEEO+1V	-29	-14.6	0x10C6	0xF093
-5	-5	65	5	VCCO -1.5V	63.5	30	0xE109	0x28B7
-5	-5	65	5	((VCCO-VEEO/2)+VEEO	30	30	0x7FFF	0x28B7
-5	-5	65	5	VEEO+1V	-4	30	0x1D82	0x28B7
-64	-64	6	5	VCCO -1.5V	4.5	-29	0xE109	0xD3C9
-64	-64	6	5	((VCCO-VEEO/2)+VEEO	-29	-29	0x7FFF	0xD3C9
-64	-64	6	5	VEEO+1V	-63	-29	0x1D82	0xD3C9

11 Optional control: Open and Close EVM Relays

Navigate to the "Manual Controls" tab (located in the upper left-hand corner). EVM relays can be opened or closed by selecting or de-selecting a relay name and clicking on the green "Enables" button. Relays are selected or de-selected by clicking on the box the right of the relay name until the box color changes from black to white (de-selected) or until the color changes from white to black (selected). The following relays were automatically closed when you clicked on the "Power Up" button:

CON_F0_SMU0: Connects the Whitney FORCE_HI_0 output and SENSE_HI_0 input to the center pin of SMA connector J17.

CON_F0_SMU1: Connects the Whitney FORCE_HI_1 output and SENSE_HI_1 input to the center pin of SMA connector J32.

CON_LOAD_0: Connects the center pin of SMA J39 to the center pin of SMA J17 to allow the controlled connection of external loads.

CON_LOAD_1: Connects the center pin of SMA J41 to the center pin of SMA J32 to allow the controlled connection of external loads.

CON_FF: Closes relays K2 and K5 to connect the 100nf and 1µf feed-forward capacitors. Also connects the CH0 and CH1 high current FORCE_HI_# outputs to the low current FORCE_LI_# outputs. Opening K2 and K5 to disconnect the feed-forward capacitors in the 2µA and 20µA current ranges allows for faster measure current settling time and will also reduce the HiZ leakage by a small number of nanoamps. **The GUI will open and close relays K2 and K5 automatically depending on the current range selected.**

CON_CH0_CH1: Closes relay K3, connecting FORCE_HI_0 output to FORCE_HI_1. This relay can also be controlled by clicking on *CH0-CH1 Disconnected* or *CH0-CH1 Connected*

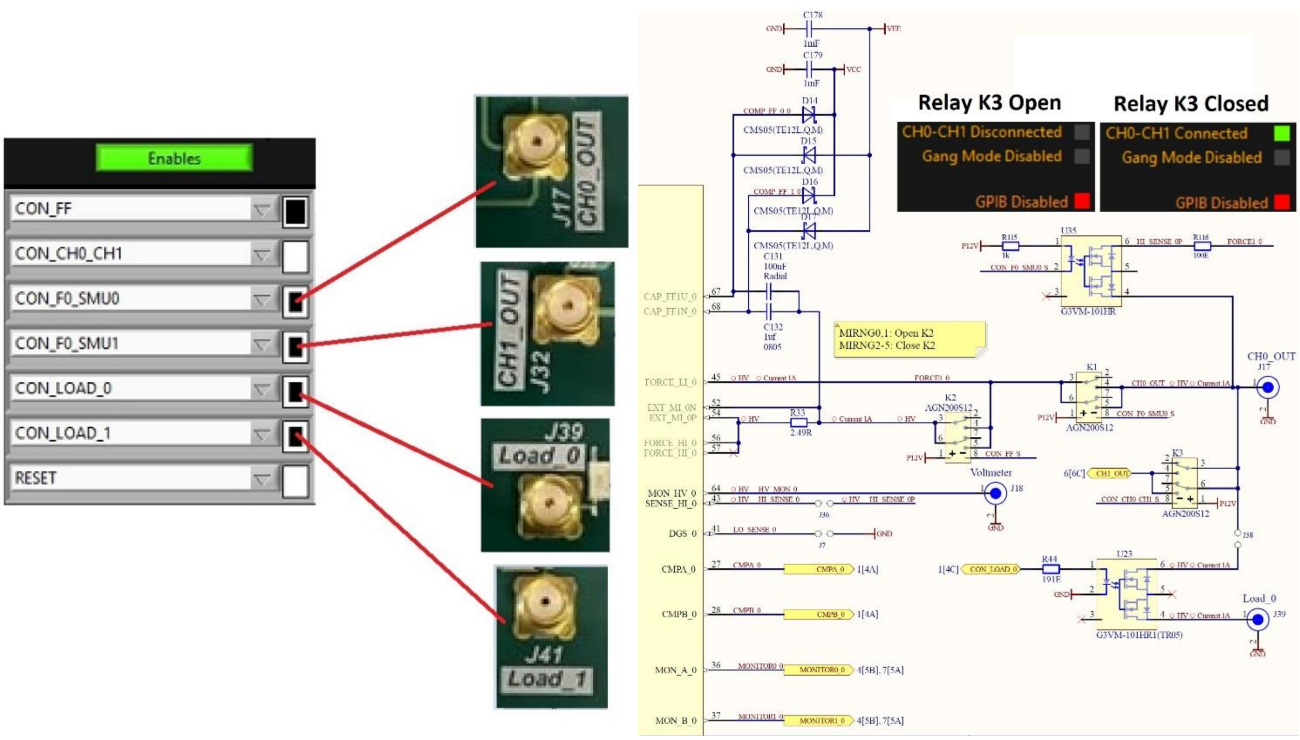


FIGURE 19: EVM RELAYS

12 Measure Voltage

Navigate back to the “Register Maps” tab (located in the upper left-hand corner). CH0 is enabled; your voltmeter should read +2.0V.

1. The *FV Offset Correction (mV)* control can be used to “null out” any residual Force Voltage offset on a per-voltage range basis. For example, if your voltmeter reads +1.3mV when *FV Level 2* is set to 0.0, enter 1.3 into *FV Offset Correction (mV)* and press <Enter>. The offset correction will be applied, and you should now read 0.0mV on your voltmeter.

2. Click the “MV MI” button; the *CH0 MV (V)* indicator will update to the measured voltage at SENSE_HIGH_0. The *CH1 MV (V)* indicator will also update to the measured voltage at SENSE_HIGH_1 However, CH1 is not enabled, so the reading will be invalid.

3. Click on the “Binary Search CVA / CVB” button to perform binary searches of the CVA and CVB comparator thresholds; the *CVA (V)* and *CVB (V)* indicators will be updated accordingly and should read the same as the external DMM.

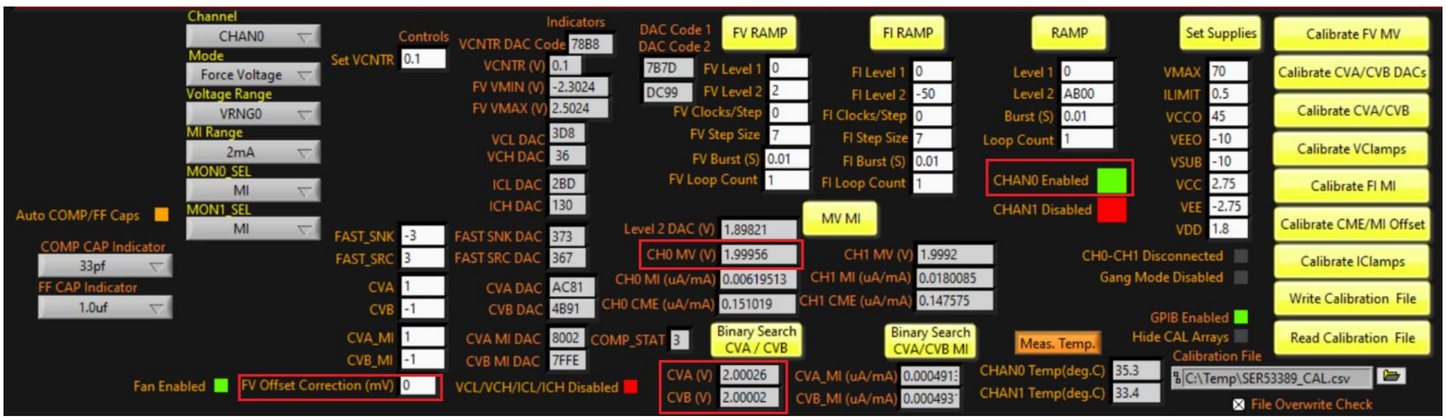


FIGURE 20: MEASURE VOLTAGE

13 Calibration

13.1 Manual Calibration of Whitney EVM

The latest versions of the EVM GUI include support for calibration of the 16-bit Force Voltage (FV_A and FV_B), VCNTR, CVA, and CVB DACs, which significantly improves accuracy. Whitney EVM calibration under full GPIB control requires an Agilent E34401A Digital Multimeter and a Keithley Model 238 or Model 2461 Source Meter. However, it is possible to calibrate the Whitney without these GPIB instruments. You can use your own instruments instead. While executing certain calibration routines you will be prompted to enter voltage or current readings manually into a LabView control field. Click on “Write Cal File” after verifying each calibration was successful.

FIGURE 21: CALIBRATION

The calibration routines should be executed in this order for each channel. Each channel will need to be selected manually from the GUI as the calibration is not fully automatic:

1. Calibrate FV MV – Calibrates the FV_A and VCNTR DACs, and the Force Voltage, VCNTR, and Measure Voltage gain and offset in each voltage range. Requires an accurate voltmeter, such as the Agilent 34401.

2. Calibrate CVA/CVB DACs – Calibrates the CVA/CVB DACs. Uses the calibrated PMU Force Voltage to perform binary searches of the comparator thresholds. No external instruments required.

3. Calibrate CVA/CVB (Comparator) – Calibrates the CVA/CVB gain and offset in each voltage range. Uses the calibrated PMU Force Voltage to perform binary searches of the comparator thresholds. No external instruments required.

4. Calibrate VClamps – Calibrates the gain and offset of the accurate voltage clamps VCL and VCH in each voltage range. Uses the calibrated Measure Voltage. No external instruments required.

5. Calibrate FI MI – Calibrates the gain and offset of the Force Current and Measure Current functions in each current range. Requires current meters capable of accurate current measurements ranging from nanoamps to 200mA.

6. Calibrate CME/MI Offset – Determines factors to correct for common mode Measure Current error in all current ranges. Also nulls the Measure Current offset in each current range. No external instruments required.

7. Calibrate IClamps – Calibrates the gain and offset of the accurate current clamps ICL and ICH and the fast current clamps with the PMU output shorted to ground. Uses the calibrated Measure Current. No external instruments required.

13.2 Verifying DAC Calibration Accuracy – Uncalibrated DAC

The latest versions of the EVM GUI include a "DAC Sweeps" tab. Functions are available to sweep DAC register settings and plot the DAC output voltages and sweep and plot calibrated FV_A, FV_B, FI, VCNTR, VCH, VCL, ICH, and ICL DAC voltages as measured through the MON_A/B_# outputs. A 16-bit ADC located on the Whitney EVM is used to measure the voltages. In the example below, the uncalibrated FV_A DAC is swept from code 32746 to code 32800. To execute the sweep shown in Figure 22, select the DAC Sweep Channel, update the Averages control to 32 and press <Enter>, update the DAC Reg Start control to 32746 and press <Enter>, update the DAC Reg Stop code to 32800 and press <Enter>, update the DAC Reg Stop code to 1 and press enter, and click on the button "FV_A Register Sweep. Note the differential linearity error of approximately 8mV (May very from device to device) at the transition from code 32767 Note: you may need to right click in the Y axis area and enable "Auto scale Y".

FIGURE 22: DAC VERIFICATION UNCALIBRATED

13.3 Verifying FV_A DAC Calibration Accuracy

The latest versions of the EVM GUI also include a "Sweeps" tab. In the example below the calibrated FV_A DAC is swept from -2.4V to +2.4V in 10mV steps (select VRNG0 to set the graph limits to +-1mV, press <Enter>, and then click on button "FV_A DAC Calibrated Voltage Sweep" It will take approximately 30 seconds for the 16-bit EVM ADC to acquire 480 readings). The peak-to-peak absolute error over this range is ~ 400µV. The accuracy of the calibrated DAC is primarily limited by the accuracy and resolution of the EVM 16-bit ADC.

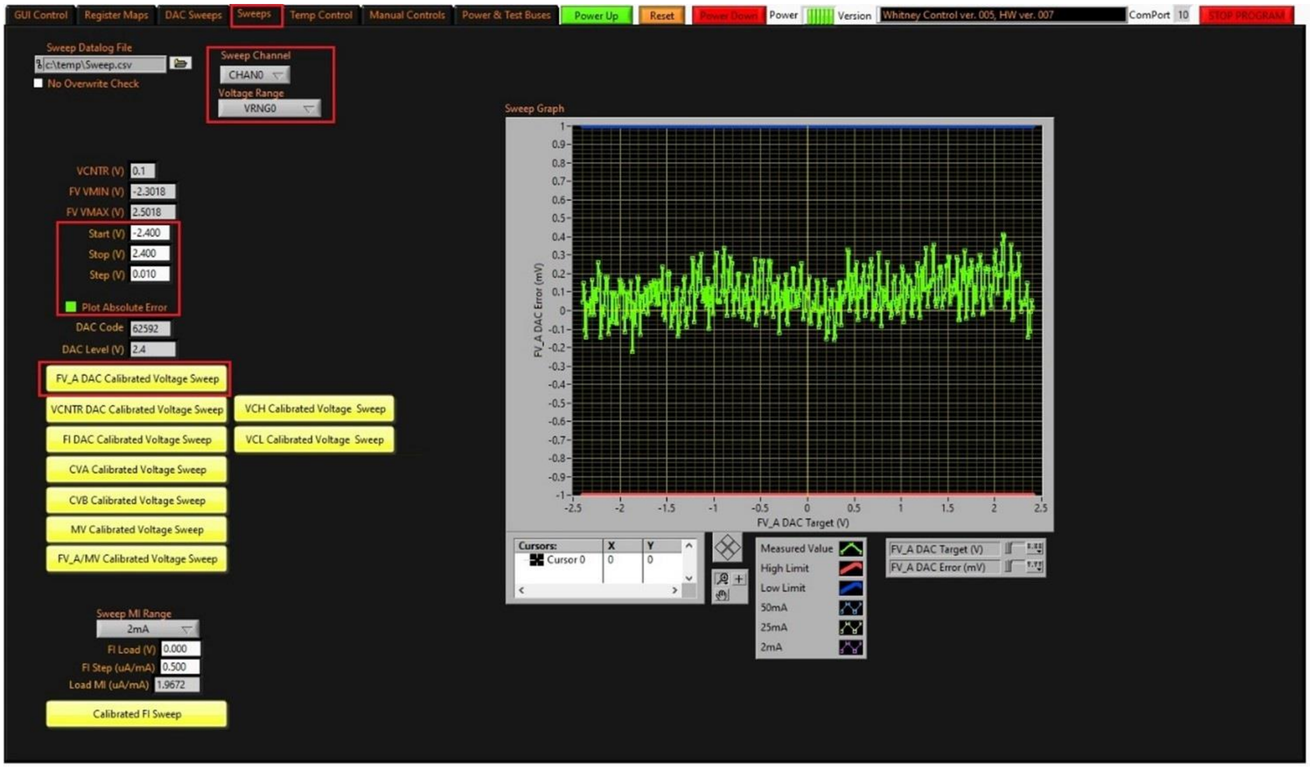


FIGURE 23: DAC CALIBRATION VERIFICATION

13.4 Verifying FV and MV Calibration Accuracy

In the example below the calibrated Force Voltage is swept from -7.0V to +7.0V in 10mV steps while the Measure Voltage is measured through the MON_A/B_# outputs (first select VRNG3, set the Start, Stop, and Step levels, then click on button "FV_A/MV Calibrated Voltage Sweep"). It will take approximately 5 minutes for the EVM 16-bit ADC to acquire the 1,400 FV_A and 1,400 MV samples. The combined FV/MV absolute error over this range is approximately ±1.3mV.

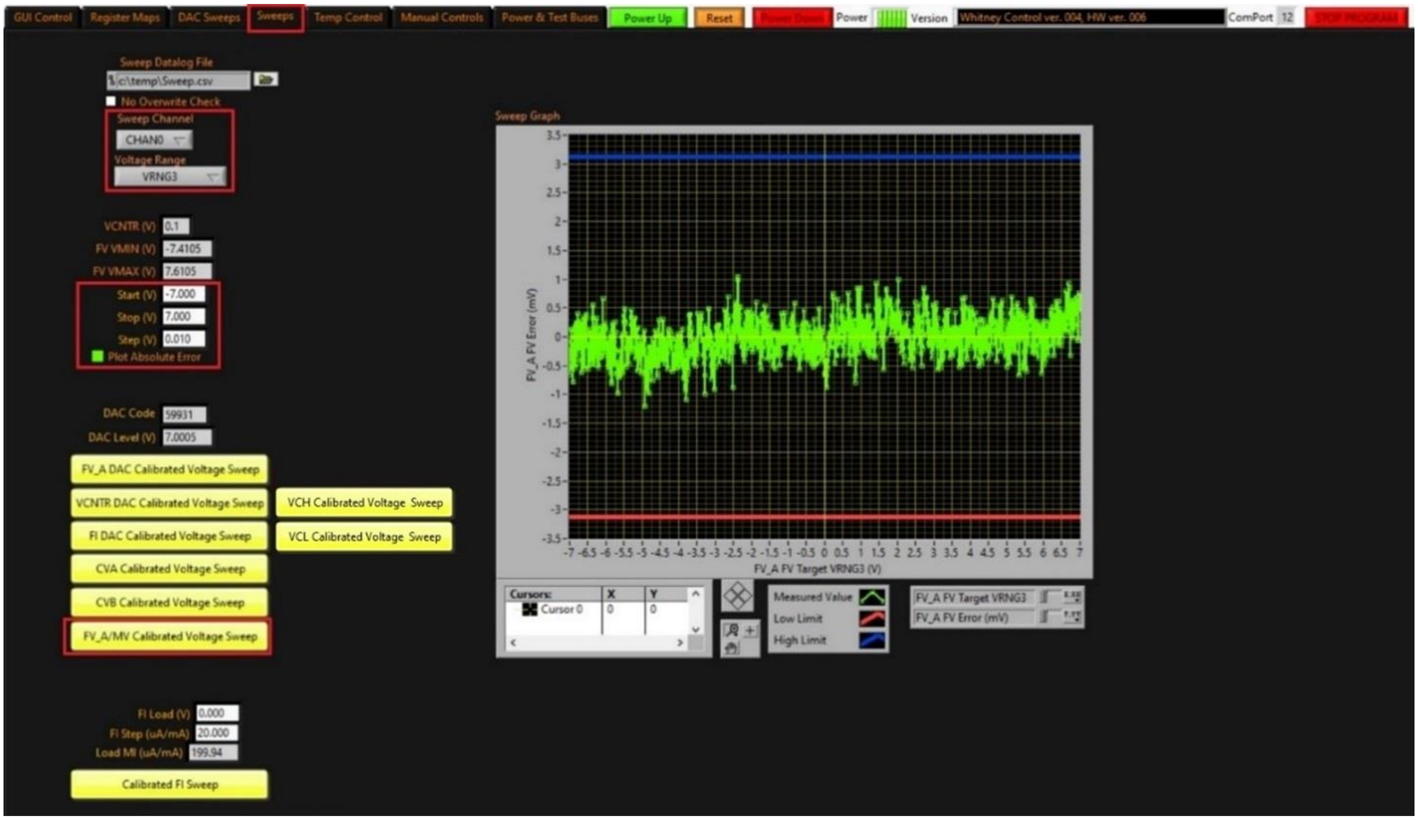


FIGURE 24: FV AND MV VERIFICATION

13.5 Verifying FI and MI Calibration Accuracy

In the example below the CH0 calibrated Force Current is swept from -2.000mA to +2.000mA in 20µA steps while the CH1 Measure Current is measured through the MON_A/B_# outputs (CH0 is automatically set to Force Current mode while CH1 is automatically set to Force Voltage mode). The CH0 and CH1 PMU outputs are first connected by clicking on *CH0-CH1 Disconnected* (the displayed text will change to *CH0-CH1 Connected*). Select the 2mA MI Range on the Register Maps tab, then set the FI Load (V) and FI Step levels on the Sweeps tab (FI Load (V) is the CH1 Force Voltage level while Voltage Range is the CH1 VRNG). When ready click on button "Calibrated FI Sweep". The combined CH0 FI/CH1 MI error over this range is approximately ±2µA. Set Sweep Channel to CHAN1 to sweep CH1 FI while measuring CH0 MI.

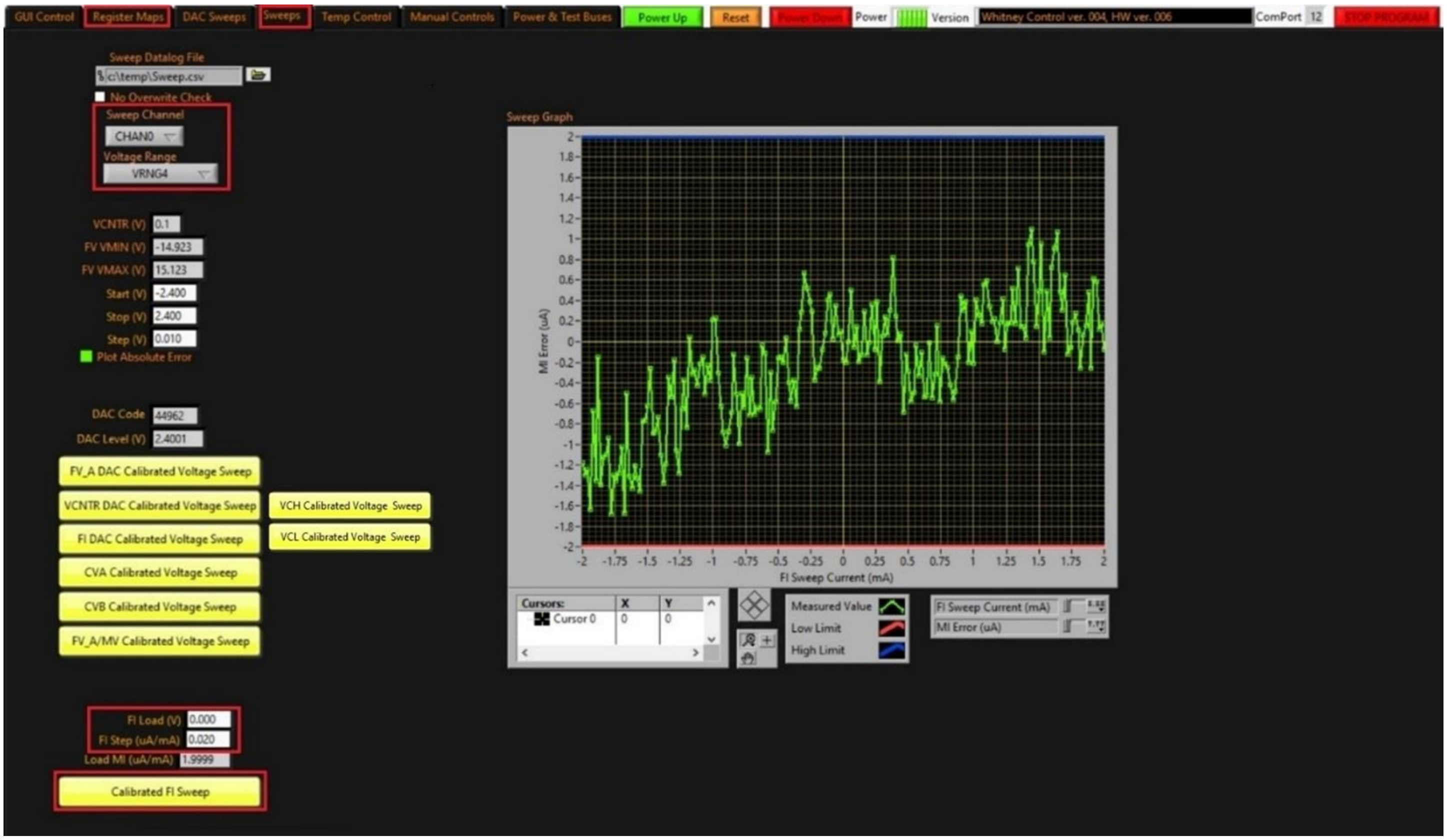


FIGURE 25: FI AND MI CALIBRATION VERIFICATION

14 Connect MON_A_0 (CH0 Monitor Output) to SMA Connector J20

Navigate to the "MUX and Switches" tab under the "GUI Control" tab and click the "Set Switches" button. Connect one high impedance input of an oscilloscope to J20 and another high impedance oscilloscope input to SMA connector J17 (CH0 PMU output) to enable real-time monitoring of the Force Voltage ramp at J17 and Measure Current at J20.

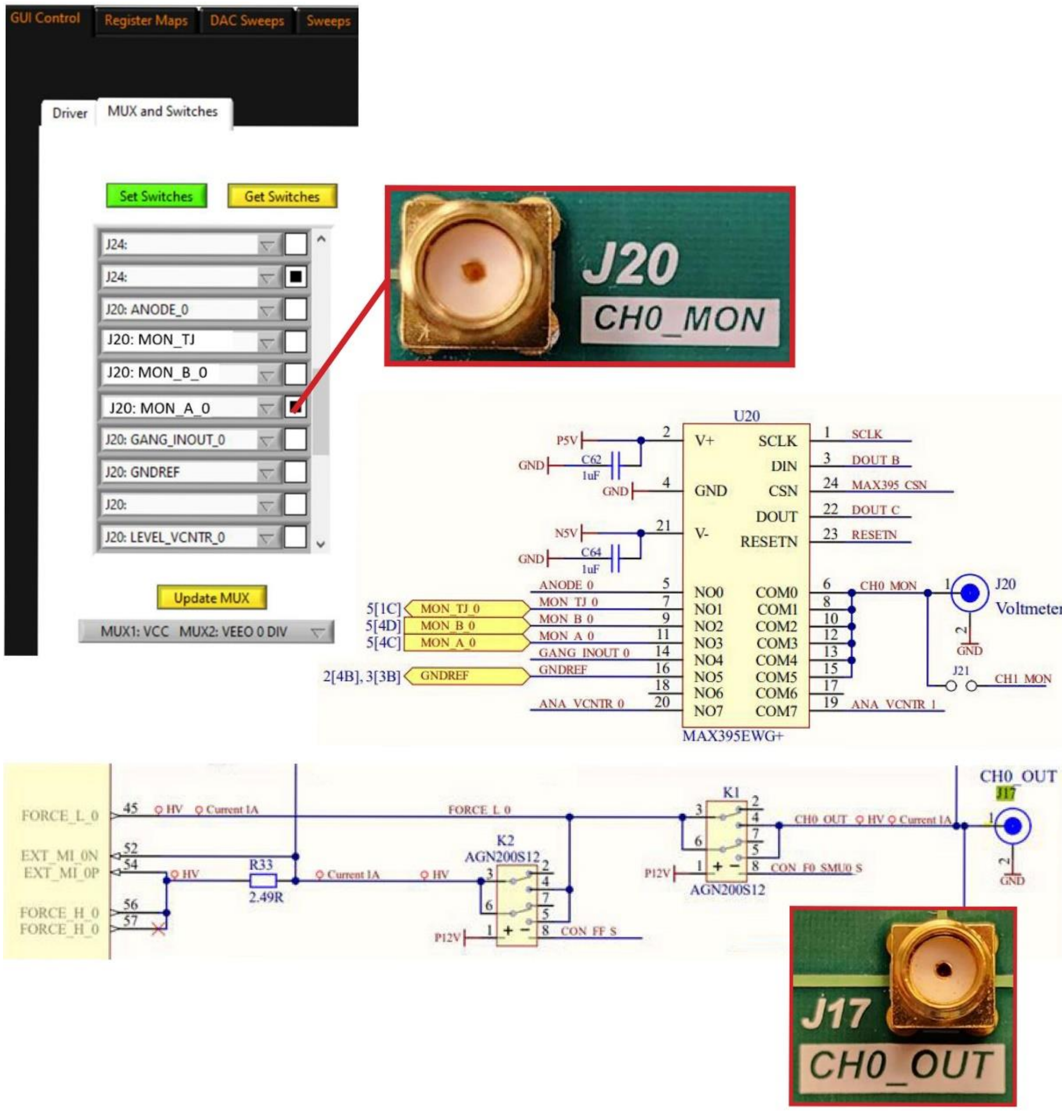


FIGURE 26: CONNECT MON_A_0 TO SMA

15 Force Voltage Slew Rate Control and Measure Current Monitoring

15.1 Step 1: FV Slew Rate and MI Monitoring

Navigate back to the "Register Maps" tab. **MONO_SEL** should already be set to **MI** (measure current). Set the Voltage Range to VRNG2, and the MI Range to 20mA. FAST_SNK will be automatically set to -25mA, and FAST_SRC to 25mA. Set the oscilloscope to trigger on the rising edge of the Force Voltage waveform and average 16 waveforms. Set *FV Level 2 to 3 (3V), FV Step Size to 8, and FV Loop Count to 16*. Click on the "FV RAMP" button; you should see waveforms that match Figure 27, with FV rise time of approximately 115µS and over-shoot of approximately 70mV (no external capacitive load was connected).

Set *FV Step Size to 6* and click on the "FV RAMP" button; you should see waveforms that match Figure 28, with FV rise time of approximately 250µS and over-shoot of approximately 40mV.

In both cases a 33pf compensation capacitor and 1µf feed-forward capacitor were automatically selected when the MI Range was set to 20mA. The automatically selected values may not always be optimal for the desired slew rate and external capacitive loading.

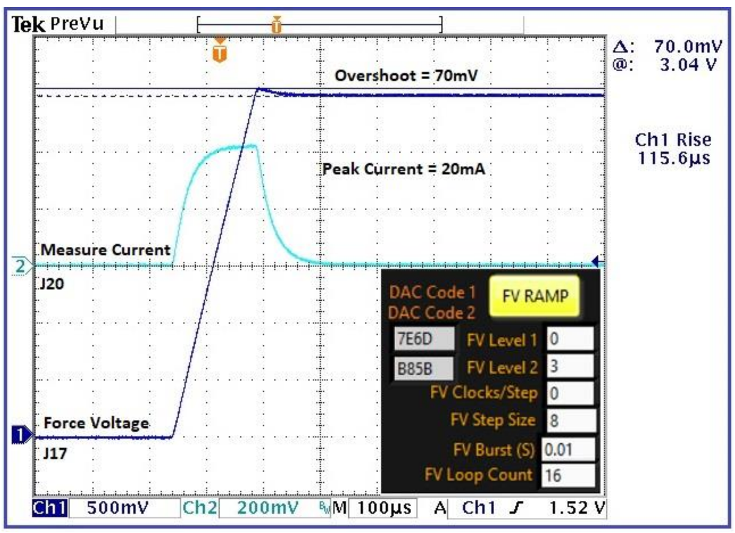


FIGURE 27: FV RAMP STEP SIZE 8

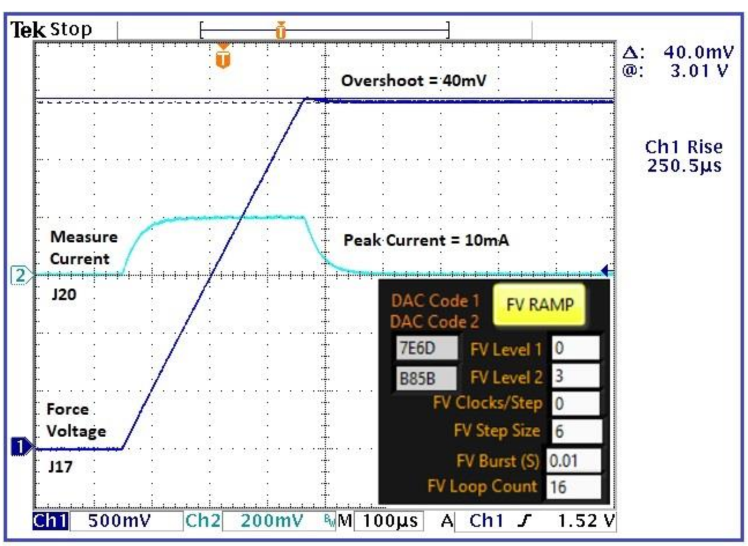


FIGURE 28: FV RAMP STEP SIZE 6

15.2 Step 2: FV Slew Rate and MI Monitoring

After executing *FV RAMP* the FV_A_RAMPENA bit of the FV_A_RAMP register will be set. This will “lock-out” the FV_A register; changing the contents of the FV_A register will have no effect. If you wish to bypass the FV ramping feature and write the FV_A register directly to control the Force Voltage level, it will be necessary to first clear the FV_A_RAMPENA bit.

Note: The FV_A_STOP_VAL register setting of 0x9ED9 shown below is for a Force Voltage of +2.000V in VRNG3 with VCNTR set to 0.0V. The register setting for +2.000V will vary from device to device.

FIGURE 29: FV RAMP REGISTER BITS

16 Automatic vs. Manual Selection of Compensation and FF Caps

By default, compensation and feed-forward capacitance values are selected automatically by LabView according to the current range and mode of operation (Force Voltage or Force Current). The default values are selected to enable stable operation with no external capacitive loading. The automatically selected values may not be optimal under all operating conditions and capacitive loads.

Automatically selected values *(Auto COMP / FF Caps).*

TABLE 3: RECOMMENDED COMP AND FF CAPS

	Compensation Capacitance						Feed-Forward Capacitance					
	2µA	20µA	200µA	2mA	20mA	200mA	2µA	20µA	200µA	2mA	20mA	200mA
Force Voltage	47nf	47nf	33pf	33pf	33pf	33pf	0nf	0nf	100nf	1µf	1µf	1µf
Force Current	47nf	47nf	220pf	33pf	33pf	33pf	0nf	0nf	100nf	1µf	1µf	1µf

The automatic selection can be disabled by clicking on *Auto COMP / FF Caps*; the text will change to *Manual COMP / FF Caps* and the box color will change from orange to grey. It will now be possible to manually select compensation and feed-forward capacitance values. In the example below, the default 33pf compensation capacitance in the 20mA range has been reduced to 0pf, resulting in almost no overshoot with a rise time of ~100µS. Note: 0pf COMP and 100nf FF is unstable.

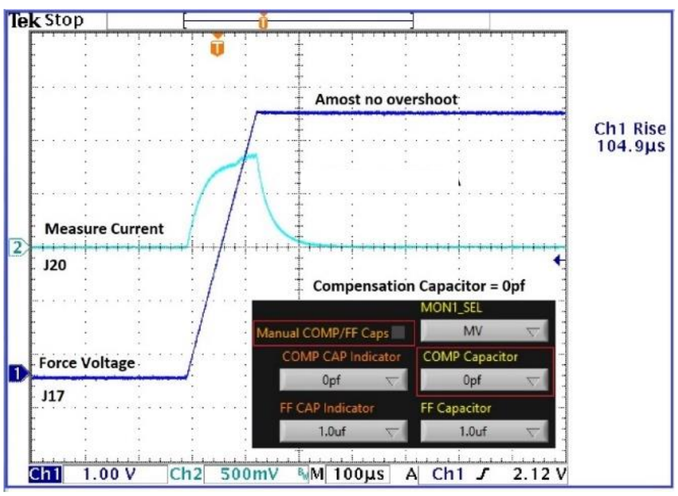


FIGURE 30: COMPENSATION CAPACITOR

17 Force Current Slew Rate Control and Measure Current Monitoring

17.1 Step 1: FI Slew Rate Control and MI Monitoring

Disable CH0 by clicking on *CHAN0 Enabled* and set *Mode* to *Force Current*. Set the *MI Range to 2mA* and then set the *MI Range* back to *20mA* to initialize internal LabView variables. Set *FI Level 2* to *0* (0mA), *FI Step Size* to *11, FI Loop Count* to *16*, manually set *COMP Capacitor* to *33pf* and *FF Capacitor* to *100nf* and click on the “FI Ramp” button. Connect an oscilloscope channel with a 50Ω input impedance to connector J17. Click on *CHAN0 Disabled* to enable CH0. The Force Current should now be 0mA. Set *FI Level 2* to *20 (20mA)* and click on the “FI Ramp” button. Click on the “MV MI” button; *CH0 MV (V)* should read ~1V and *CH0 MI (μA/mA)* should read ~20mA. Click on the “Binary Search CVA / CVB MI” button; *CVA_MI (μA/mA) and CVB_MI (μA/mA)* should read ~ 20mA.

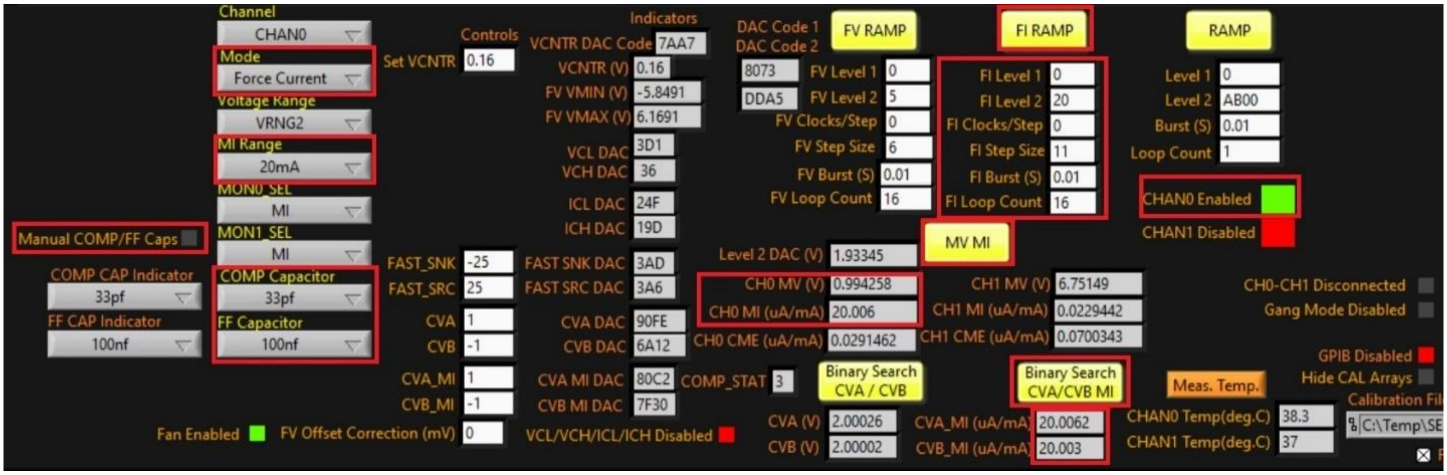


FIGURE 31: FI SLEW RATE CONTROL AND MI MONITORING

17.2 Step 2: FI Slew Rate Control and MI Monitoring

Remove the capacitive loading of the CHAN1 feed-forward capacitors by clicking on *CH0-CH1 Connected* (the displayed text will change to *CH0-CH1 Disconnected*). Set the oscilloscope trigger to 500mV and click on the "FI Ramp" button to capture FI and MI waveforms that match those shown below in Figure 32. Manually set the *FF capacitor to 1μf* and click on the "FI Ramp" button to capture waveforms that match those shown below in Figure 33. Note: a *COMP Capacitor* value of *0pf* and/or *FF Capacitor* value of *0nf* are unstable. When you are done viewing the waveforms disable CH0 by clicking on *CHAN0 Enabled*, disconnect the 50Ω oscilloscope input from connector J17, and click on *CH0-CH1 Disconnected* (the displayed text will change to *CH0-CH1 Connected*).

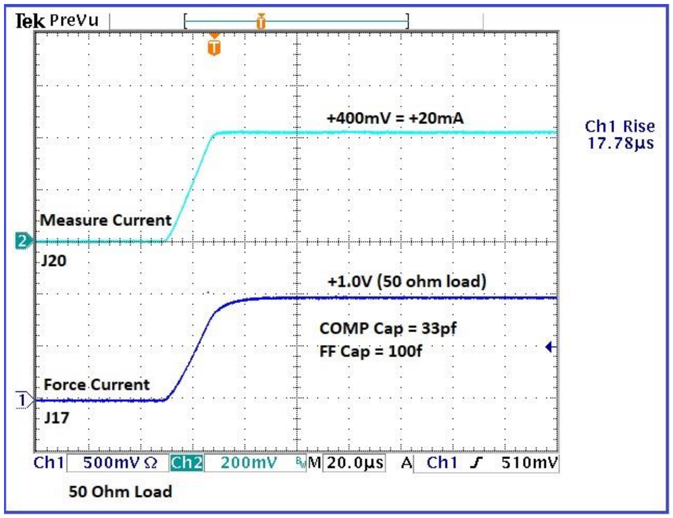


FIGURE 32: FEED FORWARD CAPACITOR 100NF

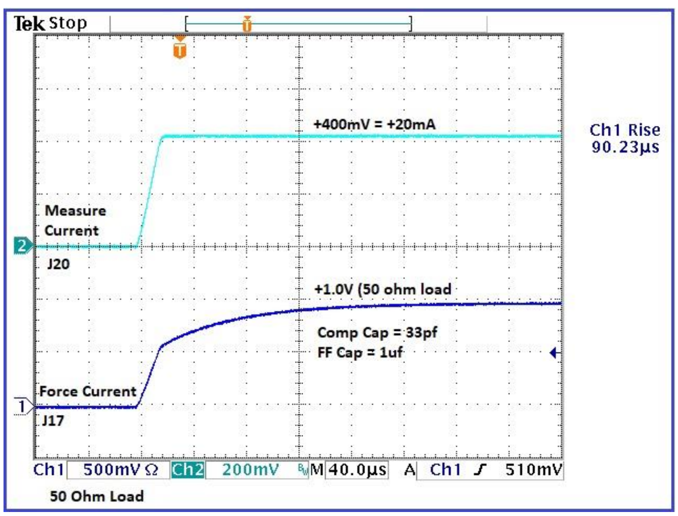


FIGURE 33: FEED FORWARD CAPACITOR 1μF

17.3 Step 3: FI Slew Rate Control and MI Monitoring

After executing *FI RAMP,* the FI_RAMPENA bit of the FI_RAMP register will be set. This will "lock-out" the FI register; changing the contents of the FI register will have no effect. If you wish to bypass the FI ramping feature and write the FI register directly to control the Force Current level, it will be necessary to first clear the FI_RAMPENA bit.

Note: The FI_STOP_VAL register setting of 0x96D3 shown below is for a Force Current of +20mA in the 20mA range and will vary from device to device.

FIGURE 34: REGISTER BITS FI RAMP

18 Enabling and Setting Accurate Voltage Clamps

18.1 Step 1: Enabling and Setting Accurate Voltage Clamps

Disable CH0 by clicking on *CHAN0 Enabled* and set *Mode* to *Force Current* in *MI Range 20mA*. Click on *VCL/VCH/ICL/ICH Enabled* until the controls for the voltage and current clamps appear (you may have to click more than once). With the *Voltage Range* set to *VRNG0 Set VCNTR* to *0.1* (0.1V), *VCL* to *-0.8* (-0.8V), *VCH* to *+0.8* (+0.8V), *ICL* to *-25* (-25mA), *ICH* to *25* (+25mA), *FAST_SNK* to *-25* (-25mA), and *FAST_SRC* to *25* (+25mA). Set *FI Level 1* to *-20* (-20mA), *FI Level 2* to 20 (+20mA), manually set the *FF Capacitor* to *100nf* and the *COMP Capacitor* to *220pf* (Whitney voltage clamps in the 20mA range are unstable with a *33pf COMP Capacitor*).

Click on the “FI Ramp” button to initialize internal LabView variables. Connect an oscilloscope channel with a 50Ω input impedance to connector J17. Enable CH0 by clicking on *CHAN0 Enabled*. Click on the “MV MI” button; *CH0 MV (V)* should match the VCH level of +0.8V and *CH0 MI (µA/mA)* should read approximately 15.9mA. Click on the “Binary Search CVA / CVB MI” button; *CVA_MI (µA/mA)* and *CVB_MI (µA/mA)* should read approximately 15.9mA.

Note: the *CH1 MV (V)* voltage reading will not match the *CH0 MV (V)* voltage reading when relay K3 is open (*CH0-CH1 Disconnected*).

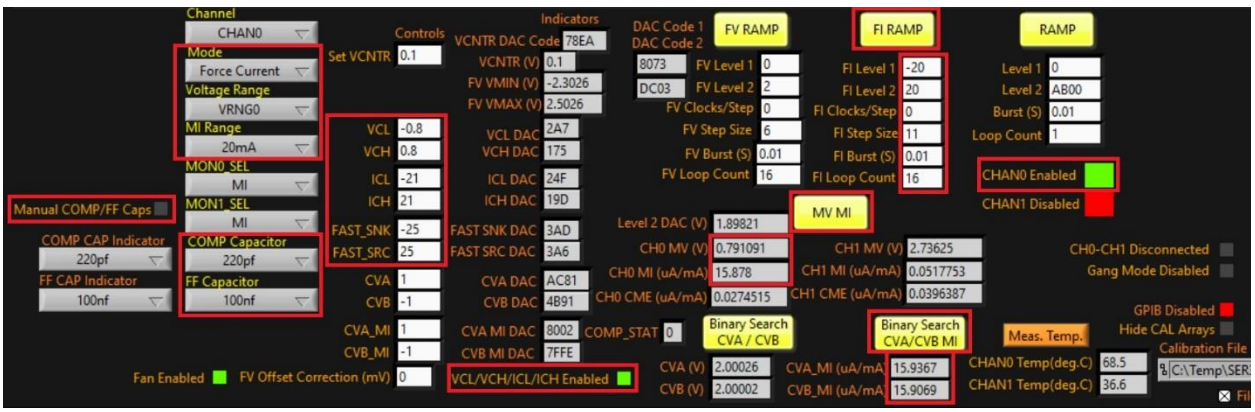


FIGURE 35: VOLTAGE CLAMPS

18.2 Step 2: Enabling and Setting Accurate Voltage Clamps

Remove the capacitive loading of the CHAN1 feed-forward capacitors by clicking on *CH0-CH1 Connected* (the displayed text will change to *CH0-CH1 Disconnected*). Set the oscilloscope trigger to 0V and click on the "FI Ramp" button to capture rising and falling Force Current waveforms with the voltage levels clamped to +-800mV. The waveforms should match those shown below in Figure 36. Click on *VCL/VCH/ICL/ICH Enabled* to disable the voltage clamps and click on the "FI Ramp" button to capture rising and falling Force Current waveforms with the voltage clamps disabled shown in Figure 37. When you are done viewing the waveforms disable CH0 by clicking on *CHAN0 Enabled*, disconnect the 50Ω oscilloscope input from connector J17, and click on *CH0-CH1 Disconnected* (the displayed text will change to *CH0-CH1 Connected*).

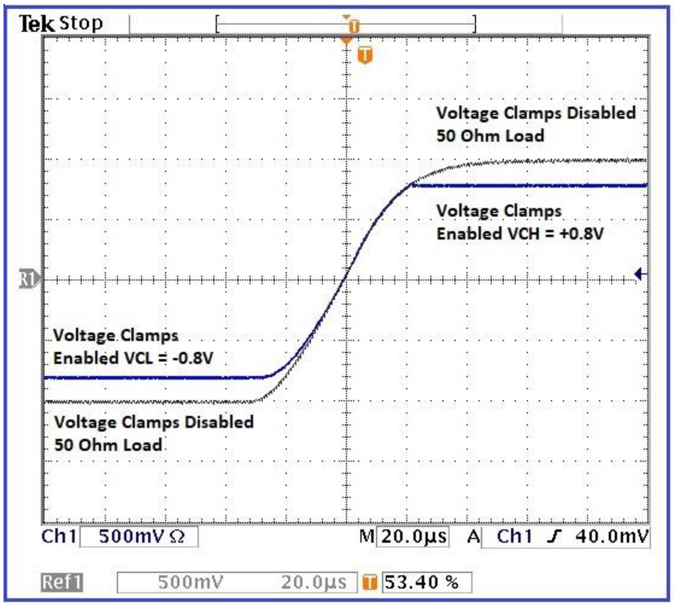


FIGURE 36: RISING FORCE CURRENT

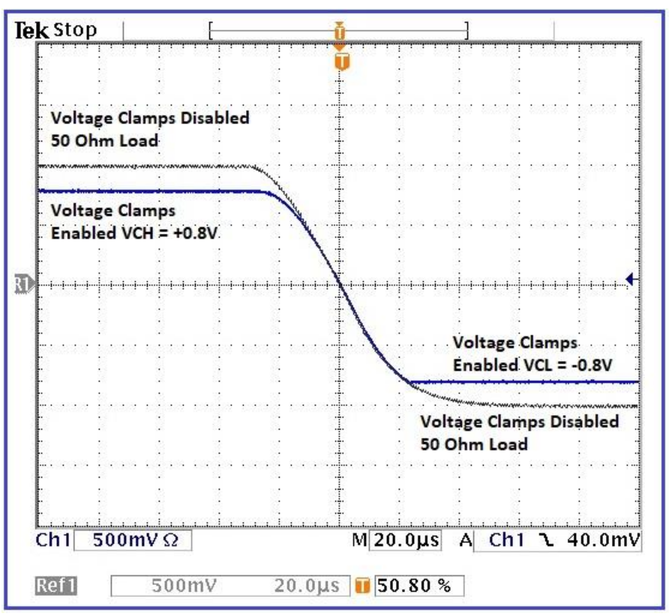


FIGURE 37: FALLING FORCE CURRENT

19 Enabling and Setting Accurate Current Clamps

19.1 Step 1: Enabling and Setting Accurate Current Clamps

Disable CH0 by clicking on *CHAN0 Enabled*. Set *Mode* to *Force Voltage* and *MI Range* to *20mA*. Set *Voltage Range* to *VRNG3* and then back to *VRNG2* to initialize internal LabView variables. Click on *VCL/VCH/ICL/ICH Enabled* until the controls for the voltage and current clamps appear (you may have to click more than once). Set *VCL* to *-5* (-5V), *VCH* to *+5* (+5V), *ICL* to *-15* (-15mA), *ICH* to *15* (+15mA), *FAST_SNK* to *-25* (-25mA), *FAST_SRC* to *25* (+25mA), and *Set VCNTR* to *0.1* (0.1V). Set *FV Level 1* to *-1.0* (-1.0V), *FV Level 2* to *1.0* (+1.0V), *FV Step Size* to *9, FV Loop Count* to *16*, and manually set *COMP Capacitor* to *220pf* and *FF Capacitor* to *100nf*.

Click on the “FV RAMP” button to initialize internal LabView variables. Connect an oscilloscope channel with a 50Ω input impedance to connector J17. Enable CH0 by clicking on *CHAN0 Enabled*. Click on the “MV MI” button; *CH0 MV (V)* should read approximately 0.73V and *CH0 MI (μA/mA)* should read approximately 15mA. Click on the “Binary Search CVA/CVB MI” button; *CVA_MI (μA/mA)* and *CVB_MI (μA/mA)* should read approximately 15mA. Note: the *CH1 MV (V)* voltage reading will not match the *CH0 MV (V)* voltage reading when relay K3 is open (*CH0-CH1 Disconnected*).

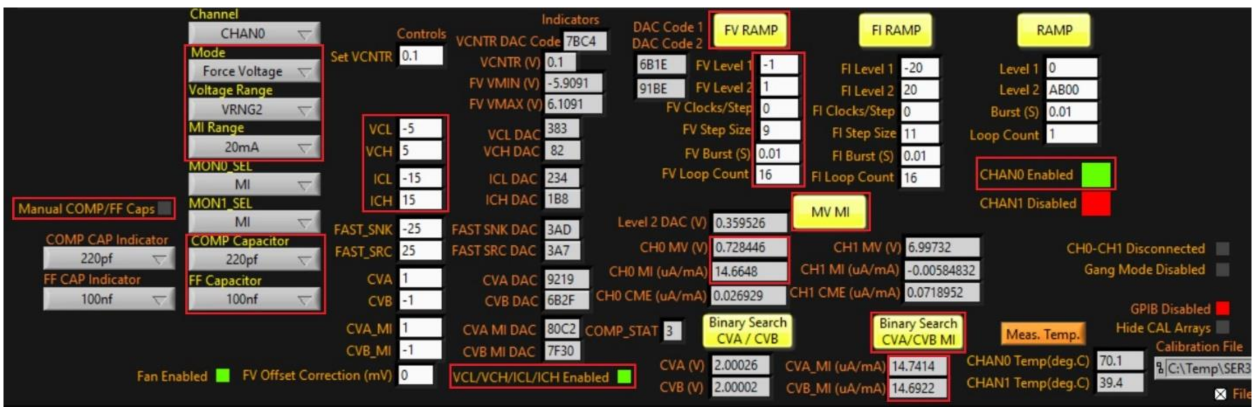


FIGURE 38: GUI CURRENT CLAMP CONTROL

19.2 Step 2: Enabling and Setting Accurate Current Clamps

Remove the capacitive loading of the CHAN1 feed-forward capacitors by clicking on *CH0-CH1 Connected* (the displayed text will change to *CH0-CH1 Disconnected*). Set the oscilloscope trigger to 0V and click on the "FV Ramp" button to capture rising and falling Force Voltage waveforms with the current levels clamped to ±15mA. The waveforms should match those shown below in Figure 39. Click on *VCL/VCH/ICL/ICH Enabled* to disable the current clamps and click on the "FV Ramp" button to capture rising and falling Force Voltage waveforms with the current clamps disabled shown in Figure 40. When you are done viewing the waveforms disable CH0 by clicking on *CHAN0 Enabled*, disconnect the 50Ω oscilloscope input from connector J17, and close relay K3 by clicking on *CH0-CH1 Disconnected* (the displayed text will change to *CH0-CH1 Connected*).

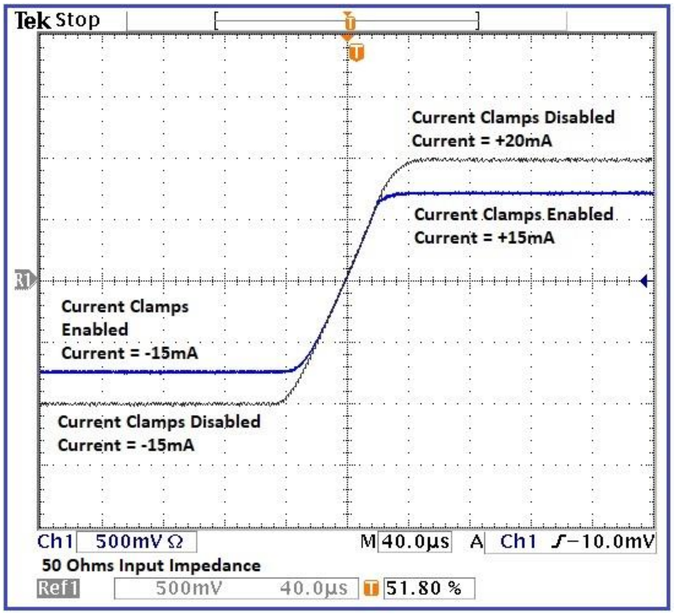


FIGURE 39: RISING FV

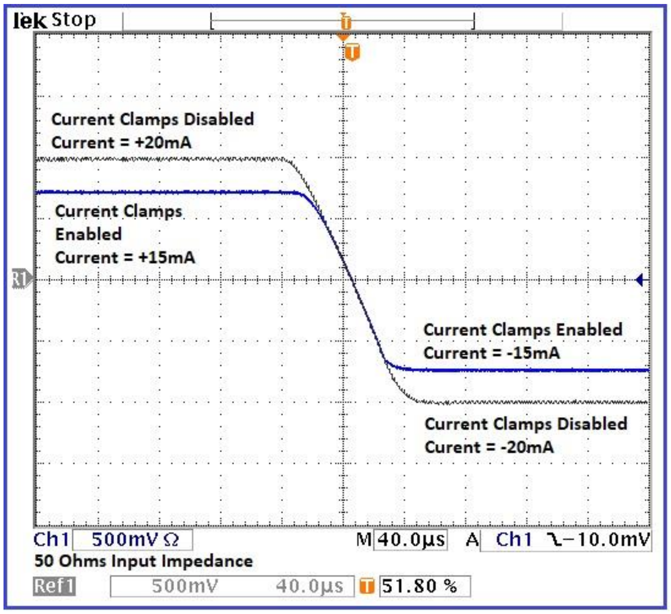


FIGURE 40: FALLING FV

20 Force Voltage Ganging and Measure Current Monitoring

20.1 Step 1: FV Ganging and MI Monitoring

Set *Channel* to CHAN0, *Voltage Range* to VRNG0, *MI Range* to *200mA*. Manually set *COMP Capacitor* to *33pf* and *FF Capacitor* to *1uf*. Set *FV Level 2* to 0 and click on the "FV RAMP" button. Click on the "MV MI" button; *CH0 MV (V)* should read 0.0V and *CH0 MI (µA/mA)* should read 0mA.

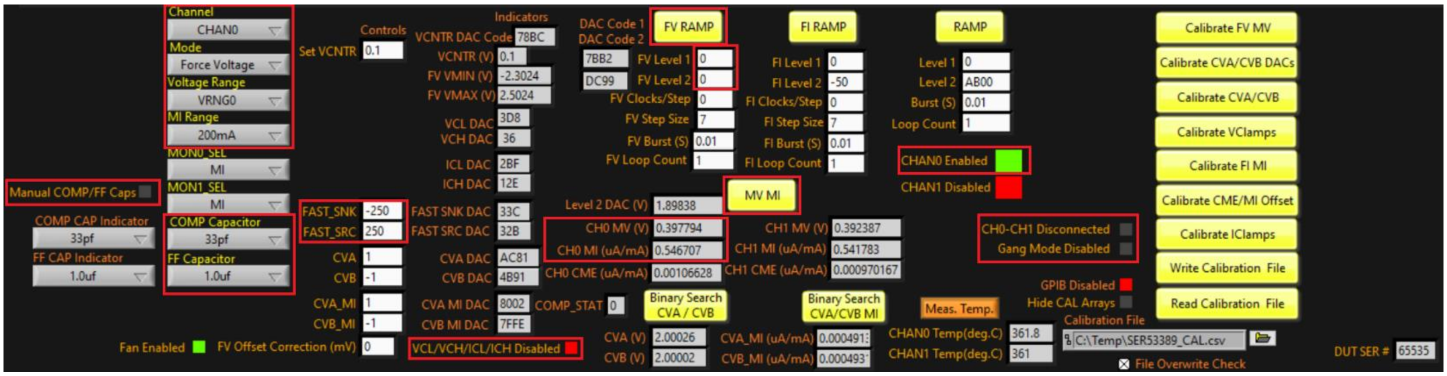


FIGURE 41: FV GANGING AND MI MONITORING STEP 1

20.2 Step 2: FV Ganging and MI Monitoring

Click on *Gang Mode Disabled*; Slave Mode will be enabled for CHAN1, and relay K3 will be closed (*CH0-CH1 Connected*). Click on OK to close the pop-up box. CHAN 1 is now enabled.

FIGURE 42: FV GANGING AND MI MONITORING STEP 2

20.3 Step 3: FV Ganging and MI Monitoring

Connect a resistive load to SMA connector J39 that is capable of dissipating 400mA; the resistor value is not critical. Set *FV Step Size* to *2* and *FV Level 2* to a voltage that will yield a 400mA current through the resistive load (in this example, 1.85V for a 4.625Ω load) and click the “FV RAMP” button.

Click on the “MV MI” button; *CH0 MV (V)* should read approximately 1.85V, *CH0 MI (µA/mA)* should read approximately 200mA, and *CH1 MI (µA/mA)* should read approximately 200mA

The CHAN0 and CHAN1 measure currents should be roughly equal. If necessary, adjust FV Level 2 and click “FV RAMP” until the total static measure current is 400mA.

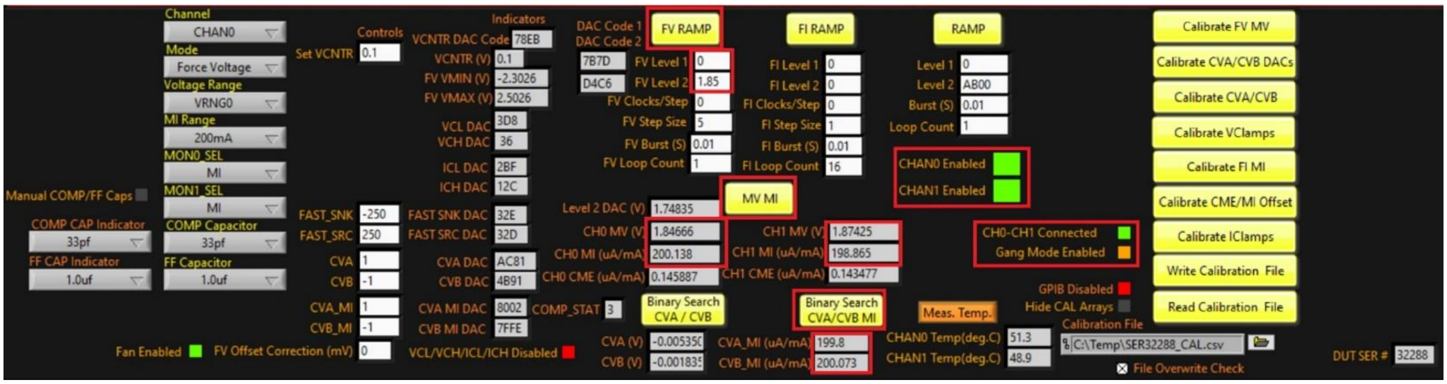


FIGURE 43: FV GANGING AND MI MONITORING STEP 3

20.4 Step 4: FV Ganging and MI Monitoring

Connect J17, J20, and J23 to high impedance oscilloscope inputs to enable monitoring of Force Voltage at J17, CH0 MI at J20, and CH1 MI at J23. Set the oscilloscope trigger to the 50% point of the Force Voltage and click on the “FV RAMP” button to capture waveforms that should resemble those shown below in Figure 44. Set *FV Level 2* to 0 and click “FV RAMP” to minimize the load current. Click on *Gang Mode Enabled* to disable gang mode. CHAN1 will be disabled, and relay K3 will be opened (*CH0-CH1 Disconnected*).

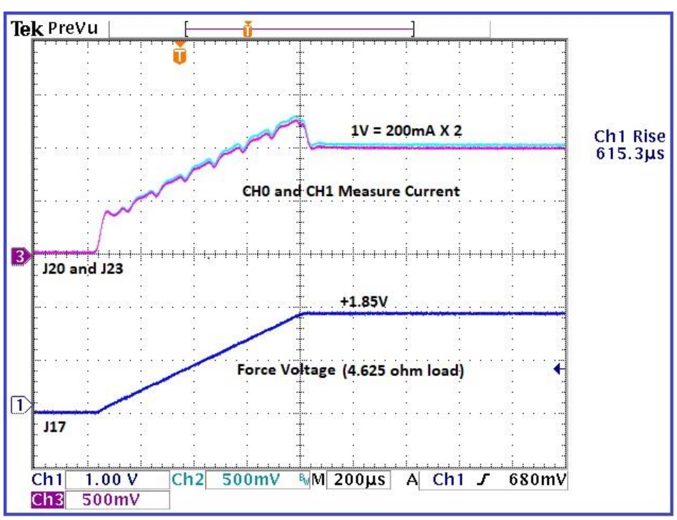


FIGURE 44: FV GANGING AND MI MONITORING STEP 4

21 Measuring Die Temperature

Click on the "Meas. Temp." button to measure CHAN0 and CHAN1 die temperatures (first, remove any external connections to J20 and J23; even a high resistive load such as the 10MΩ input impedance of a voltmeter will impact the accuracy of the die temperature measurements).

FIGURE 45: MEASURE TEMP

22 Experimenting with Higher Supply Voltages

At this point, you should feel confident enough to increase the Whitney supply voltages (to a maximum of (VCCO – VSUB) =< 70V) and experiment with higher current loads and larger voltage swings in VRNG4 or VRNG5 (use the Force Voltage digital ramp to minimize overshoot and limit the dynamic output current to safe levels). Be careful not to exceed a total power dissipation of 10W, and while varying supply voltages VSUB should always be the most negative supply. Prior to large changes in supply voltages, you should first set Force Voltage to 0V and Force Current to 0.0A and disable both channels. This procedure should also be followed prior to connecting or disconnecting external instruments or loads. Reference Table 2 for examples on how to set higher supplies.

23 Conclusion

23.1 Additional Support

For any additional support, please refer to the Datasheet, Device Guide, or Calibration Guide. If you require applications support, please reach out by email to support@elevatesemi.com or submit a question on Zendesk.

