MAXREFDES185# Universal IO Quick Start Guide

Rev 0; 6/21

Introduction

The MAXREFDES185# reference design provides the following functions on a universal IO (UIO), 4-way terminal block (J12):

- Precision Analog Voltage Output, 0 to 10V (+25% overrange)
- Precision Analog Current Output, 0 to 20mA (+25% overrange)
- Precision Analog Voltage Input, 0 to 10V (+25% overrange)
- Precision Analog Current Input, 0 to 20mA (+25% overrange)
- Digital Input, Type 1, Type 2 or Type 3
- Digital Output, 500mA current limit setting
- Precision Temperature Measurement, (external PT100/PT1000/Thermocouple Type K)

This Quick Start Guide will explain how to:

- Power-up the board
- Perform a fully automated calibration
- Measure/source in each mode
- Monitor channels

Required Equipment

Supplied by Maxim Integrated
- MAXREFDES185# with a 24V AC-to-DC power adapter

User Supplied
- MAXREFDES185# GUI software (free download)
- Windows® 10 PC with a USB port
- USB2PMB2# USB adapter with USB Cable
- Digital multimeter (at least 6.5-digit DMM is recommended if the user wants to measure precision signals to correlate with 24-bit ADCs on MAXREFDES185#)

Setup Procedure

Initial Power-Up

1. Connect a 24V barrel-connector supply to MAXREFDES185# (**Figure 1**).
2. Connect USB2PMB2# to MAXREFDES185#.

3. Power up the 24V supply.

4. Connect the USB cable between the PC and the USB2PMB2#.

Figure 1. 24V barrel-connector supply to MAXREFDES185#.

5. Once connected, your setup should look like **Figure 2**.

Figure 2. USB cable between the PC and the USB2PMB2#.
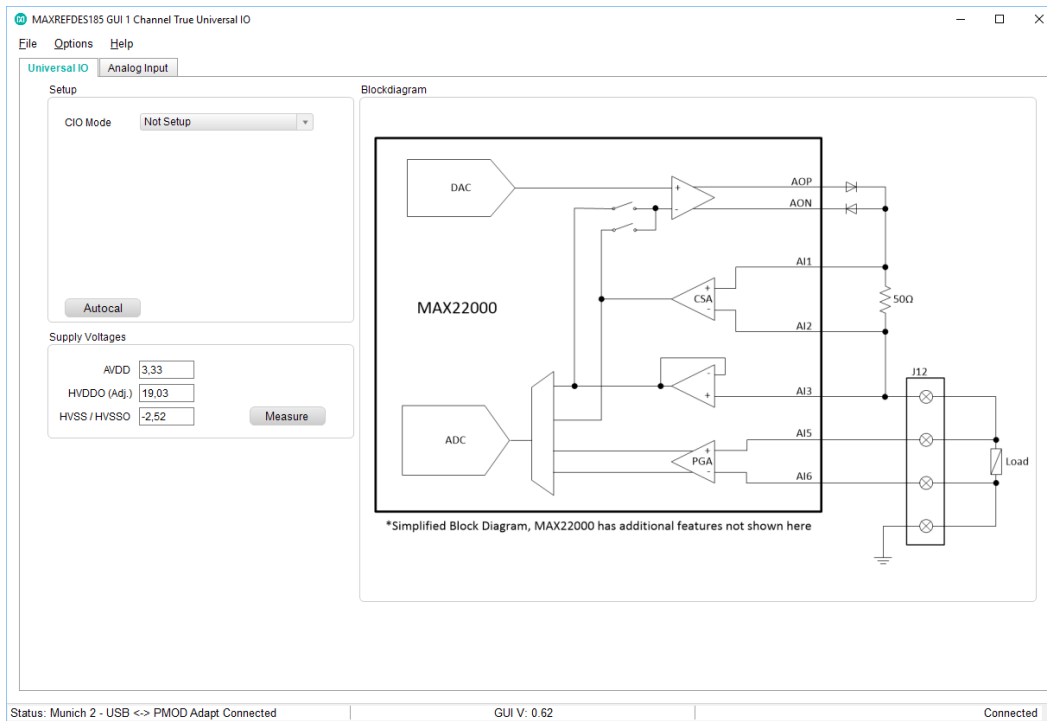
6. Open the MAXREFDES185# GUI (**Figure 3**).

Figure 3. MAXREFDES185# GUI.

7. Observe that the Status says Munich 2 -USB <-> PMOD Adapt Connected. Confirm the supply voltages measure: AVDD approximately 3.3V, HVDDO (Adj.) between 4.2V and 19V depending upon the mode, and HVSS/HVSSO approximately -2.5V.

Fully Automated Calibration

The ADC and the DAC in the MAX22000 need a two-point (gain and offset) calibration (**Figure 4**). Note the MAXREFDES185# board does not have onboard nonvolatile memory to store the calibration.

The MAX22005 is factory-calibrated and can accurately measure voltage. This means the MAX22000 DAC can produce a voltage at two points and can accurately measure the exact voltage from the DAC. It calculates gain and offset error this way. For detailed information, refer to the MAX22000 datasheet
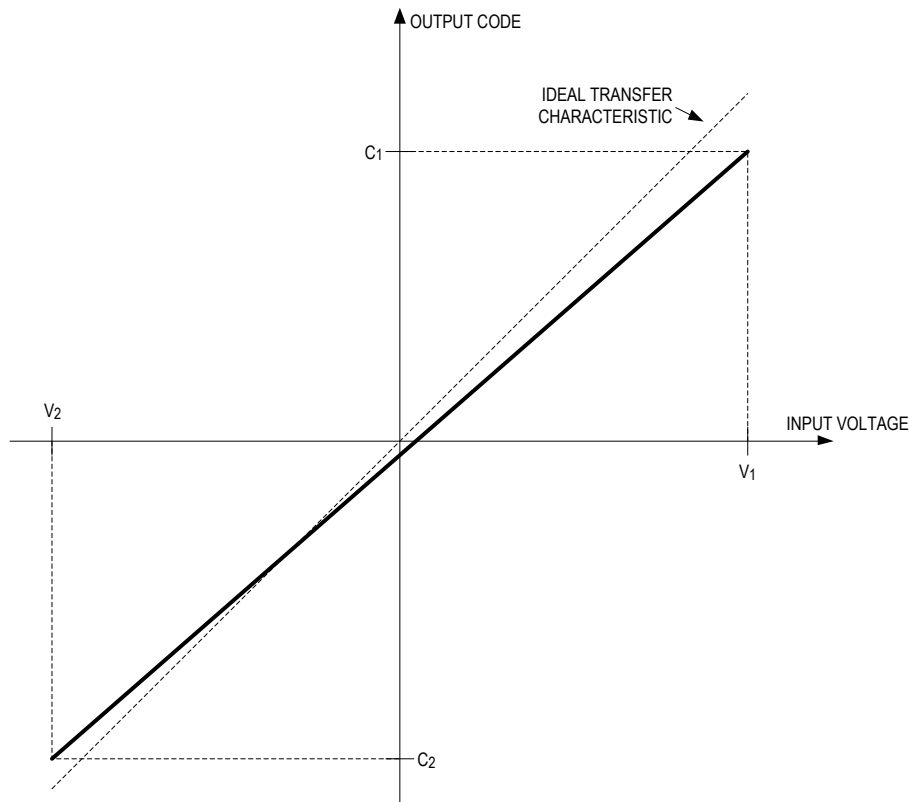

Figure 4. Two-point calibration of MAX22000.

Using the appropriate full-scale range voltage, calculate the gain and offset as:

$$GAIN = 1.5 \times \frac{V_1 - V_2}{\left(\dfrac{C_1 - C_2}{2^{23}}\right) \times V_{FS}}$$

$$OFFSET = C_2 - \frac{1.5}{GAIN} \times \frac{V_2}{V_{FS}} \times 2^{23}$$

This entire process is implemented as an automated calibration in the MAXREFDES185# GUI.

8. Ensure CIO mode is set to "Not Setup", then click **Autocal**. A new window will appear and allow the user to select specific calibrations to go through.

9. To calibrate everything, leave all checkboxes checked. Click the button, "Do a Fully automated Calibration".

10. A message box will appear (**Figure 5**) indicating that the SNS+ and SNS- pins (J12 pin 2 and pin 3) need to be connected to the DAC and GND. The easiest way to do this is by closing JP1 and JP2 with shunts.
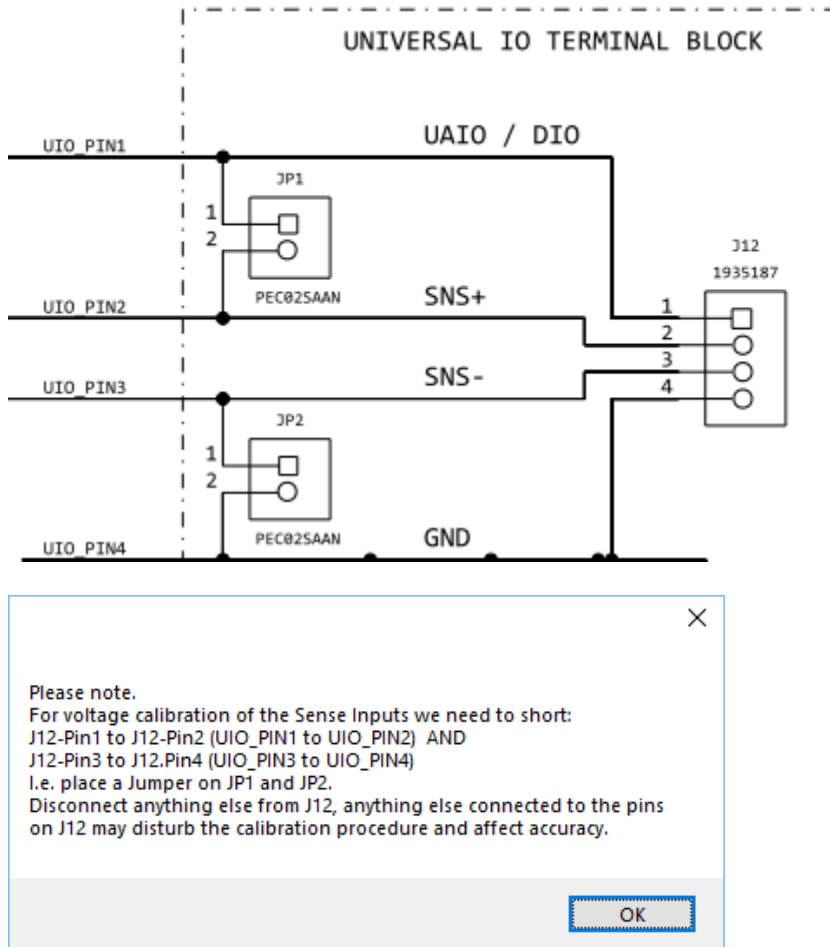

Figure 5. MAXREFDES185 IO terminal block.

11. Close the jumpers JP1 and JP2 (**Figure 6**), making sure nothing else is connected that could affect the measurement, and click **OK**.
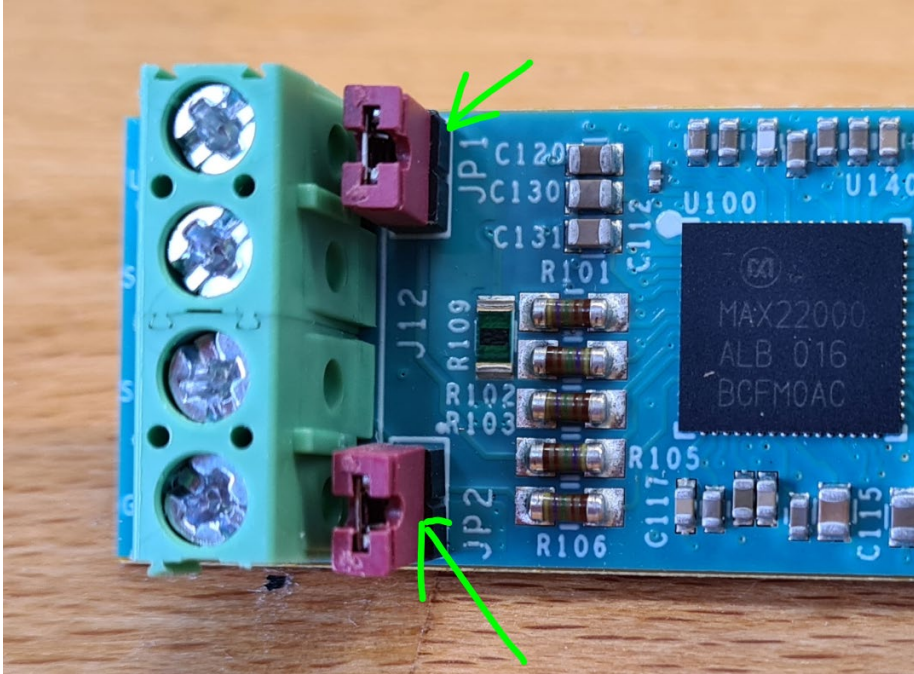
Figure 6. JP1 and JP2 closed.

12. The DAC will now generate a nominal 10V and a nominal 100mV DC, which will be sampled by the MAX22005. The correct voltages measured by MAX22005 will differ slightly. The GUI will calculate the appropriate gain and offset error including the coefficients that need to be sent to the DAC. A log of the procedure with the measurements and the results is shown in the Autocal Window (**Figure 7**).

```
Calibrating DAC. Please wait... The measurements take a few seconds.
Calibrating DAC high-point (nominal  10,00004V)
Measured MAX22005 AI3 SE: 10,1365, using this as the reference (factory calibrated)
Calibrating DAC low-point (nominal 0,10004V)
Measured MAX22005 AI3 SE: 0,0044, using this as the reference (factory calibrated)
Results:
V-out DAC gain 0,9770958597
DAC offset 0,0980V
DAC-Gain Coefficient 0x00fa22c0
DAC-Offset Coefficient 0x0000fac0V
DAC calibration written!
```

Figure 7. Autocal Window procedure log.

13. Once this is complete, the DAC is calibrated and can produce accurate voltages, and with its high linearity, even low voltages will be still accurate. The DAC will now be used as the reference for the ADC high-voltage and low-voltage ranges.

14. For the 0 to 10V range, the DAC will again produce 10V nominal and -100mV nominal and will measure the MAX22000 ADC result and calculate gain and offset error (**Figure 8**).

Maxim Integrated

```
Calibrating ADC High-Voltage ranges. Please wait... The measurements take a few
seconds.
Results:
Voltage Input High Measurement @10.000V : 10,1235
Voltage Input low Measurement   @-0.1V : 0,1014
AI3 Gain   error: 1,4817
AI3 Offset error: 24,6493
Results:
Voltage Input High Measurement @10.000V : 10,1205
Voltage Input low Measurement   @-0.1V : 0,1008
AI5/6 Gain   error: 1,4821
AI5/6 Offset error: -55,6776
```

Figure 8. MAX22000 ADC Calibration Window procedure log.

15. The same procedure is completed for the PGA ranges in the MAX22000 (AI5 and AI6).

16. Once the voltage calibration is finished, the GUI asks the user to remove the jumpers on JP1 and JP2 and to short the UIO (pin 1) to GND (pin 4, in order to perform current calibration). This can be either done on the J12 terminal-block with a short wire or with a jumper-wire on the jumpers (**Figure 9**):

Please Short the DAC output to GND.
I.e. Short UIO_PIN1 to UIO_PIN4 (J12-Pin1 to J12-Pin4)
Also, please make sure to remove the short between UIO_Pin1-2 and UIO_pin3-4.

OK
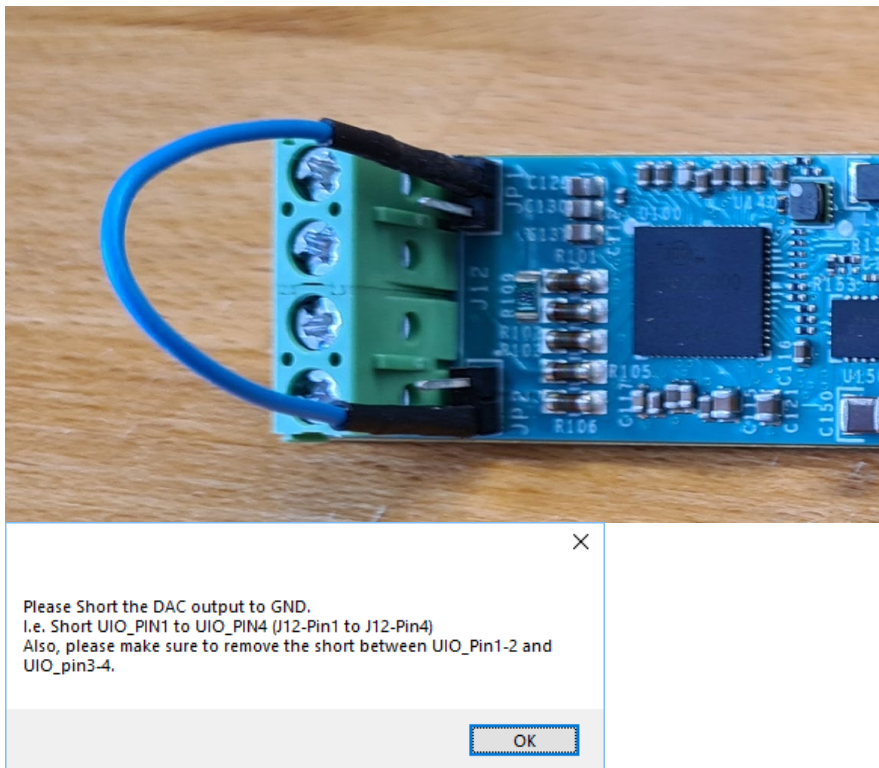
Figure 9. Short output.

17. The MAX22000 DAC will produce a nominal 20mA, which will be measured by the MAX22000 ADC followed by a nominal 100μA. The GUI will calculate the gain and offset errors as well as the DAC calibration coefficients and write them to the MAX22000 DAC.

18. Once this is done, the DAC can produce accurate currents.

19. Next, the DAC will be used to calibrate the MAX22000 ADC input for the current measurement.

20. This entire procedure takes a couple of seconds and once it is finished, the user can close the Autocal Window.

21. The calibration coefficients will be saved to the user's PC with the GUI settings. If the same board is used, it will not need to be calibrated the next time the GUI is opened. If you use a different MAXREFDES185# board or a different PC, you must run Autocal every time.

How to Measure/Source in Each Mode

The main tab in the GUI is the Universal IO tab, which has a CIO Mode drop-down menu (**Figure 10**) for the user to select the desired mode of operation for the MAX22000 and MAX14914A.
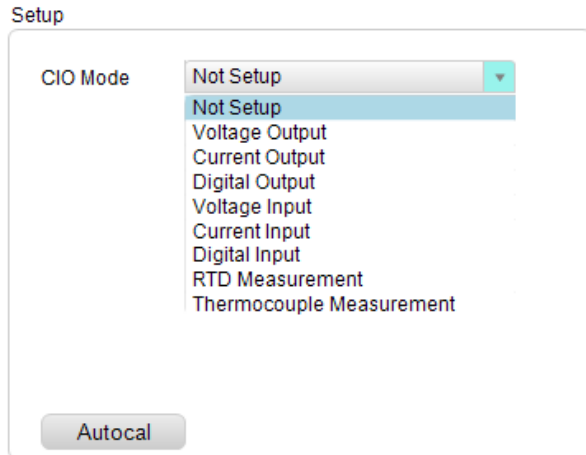
Figure 10. CIO Mode drop-down menu.

22. **Voltage Output**: The GUI will show how both the DAC is driving the voltage and the feedback is driving the voltage at the pin on J12 (**Figure 11**). Enter any voltage between 0V and 10V.
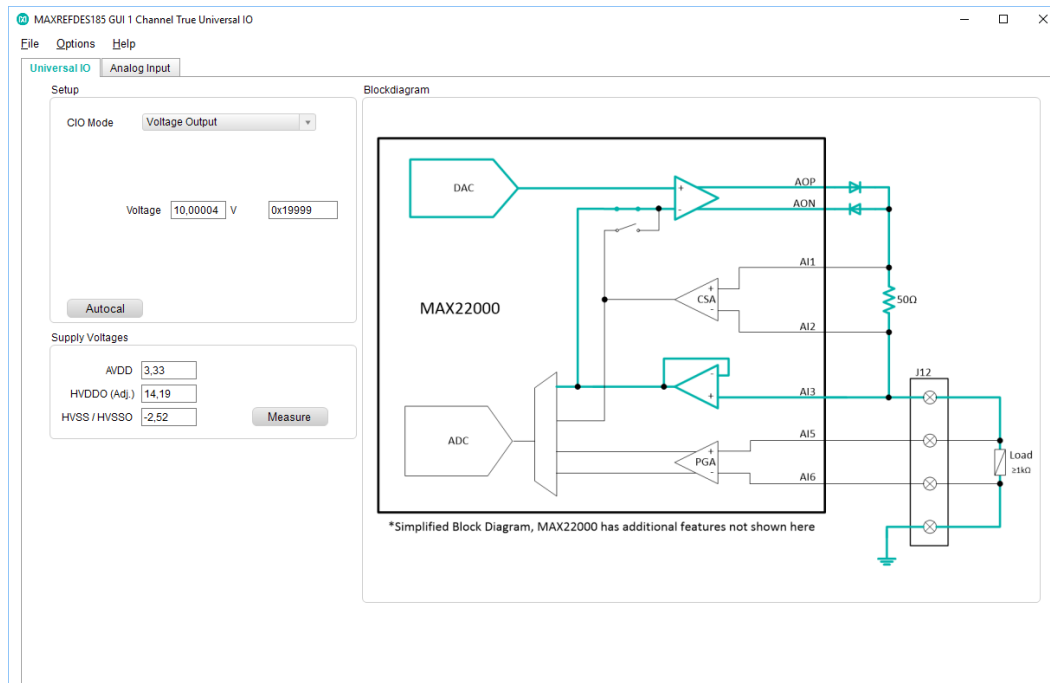
Figure 11. CIO Mode voltage output.

Measure the voltage on J12 Pin 1 to Pin 4 with a precision voltmeter (6.5 digits or higher) it should be within ±1mV.

23. **Current Output**: The GUI (**Figure 12**) will show how both the DAC is driving the current and the feedback is reading current into J12. Enter any current between 0and 20mA.
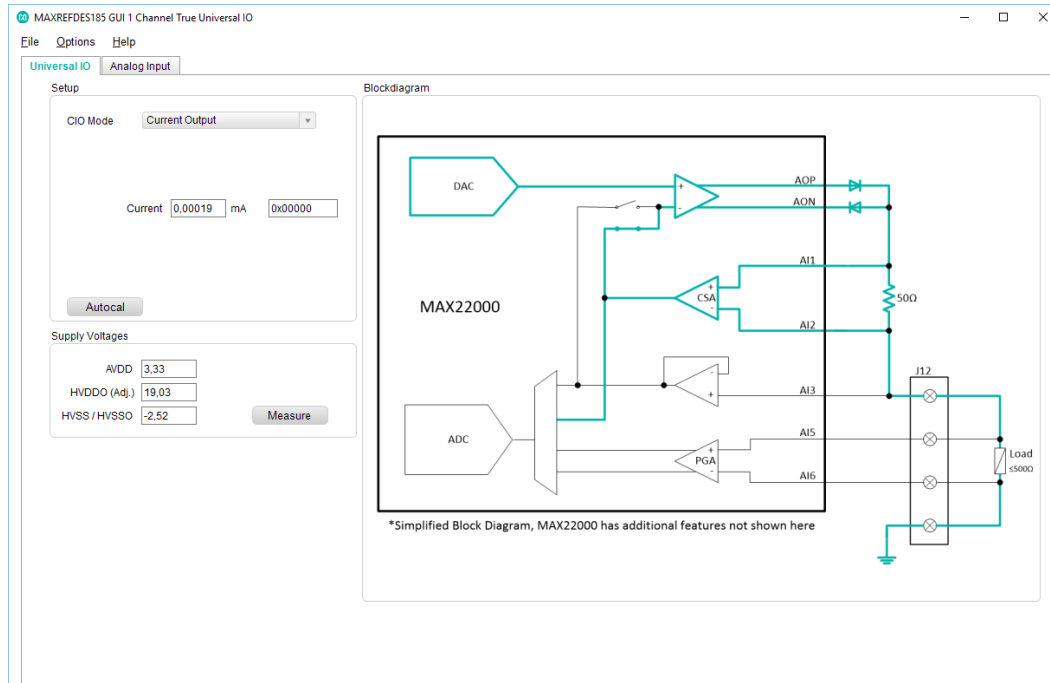
Figure 12. CIO Mode current output.

Connect a load resistor (< 500Ω) in series with a current meter, or short the output straight with a current meter, the current should be accurate within ±5µA.

24. **Digital Output**: The MAX14914A digital output (**Figure 13**) is set to limit the current to 500mA. It allows either high-side switching or push-pull switching, including support for inductive loads with a SafeDemag™ feature that provides fast and safe magnetic discharge of unlimited inductive loads.
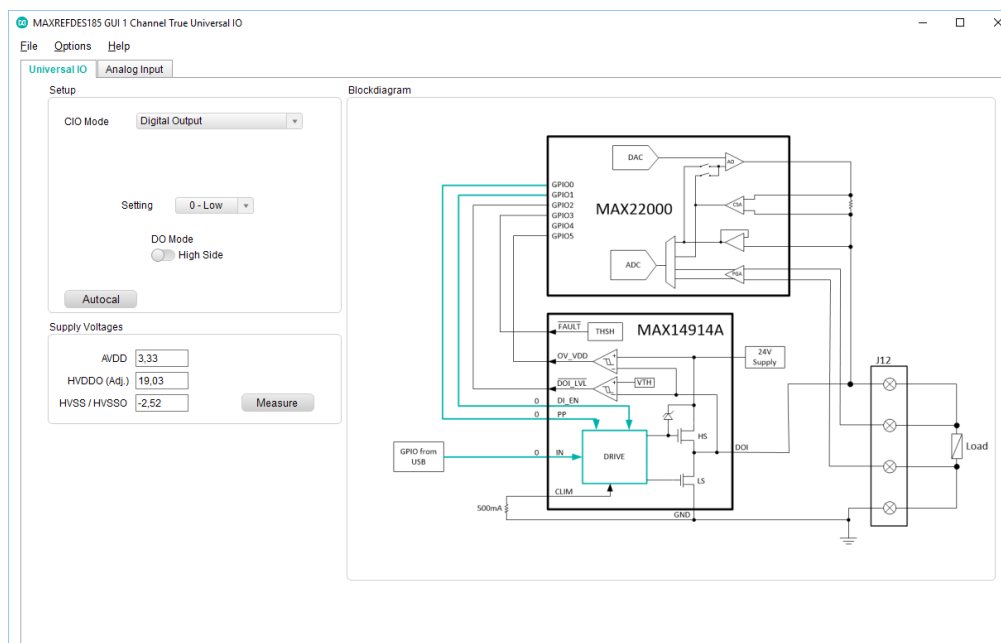
Figure 13. CIO Mode digital output.

To drive the output high, set the setting to "1 – High" using the drop-down menu. Connect a load between pin 1 and pin 4 of J12 and switch it on and off.

For push-pull mode, flip the switch to "DO Mode", then the MAX14914A will drive the DO pin to GND if it is set to "0 – Low" (**Figure 14**).
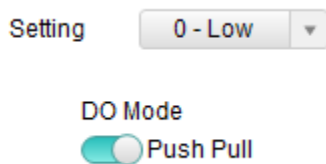
Figure 14. DO Mode.

25. **Voltage Input**: In voltage input mode, the MAX22000 measures the voltage between J12's pin 1 and pin 4. Apply a voltage and observe that the correct voltage is shown for "Reading" (**Figure 15**).
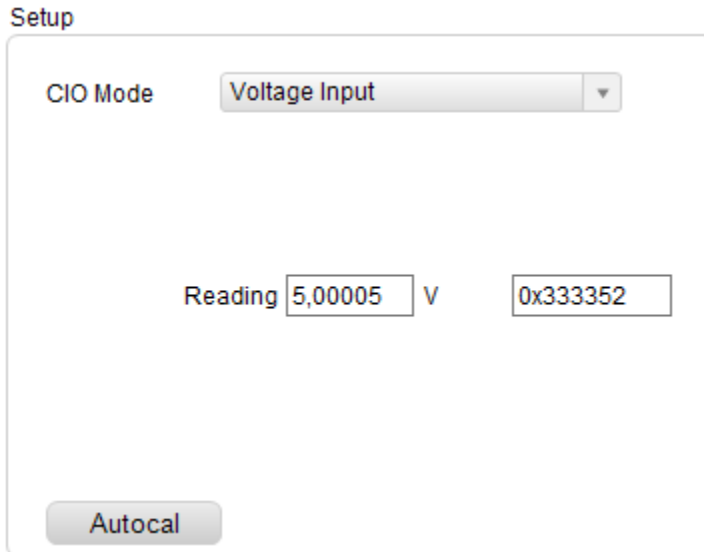
Figure 15. CIO Mode voltage input.

26. **Current Input**: Drive a current into pin 1 on J12 and observe that the reading shows the correct value (**Figure 16**).
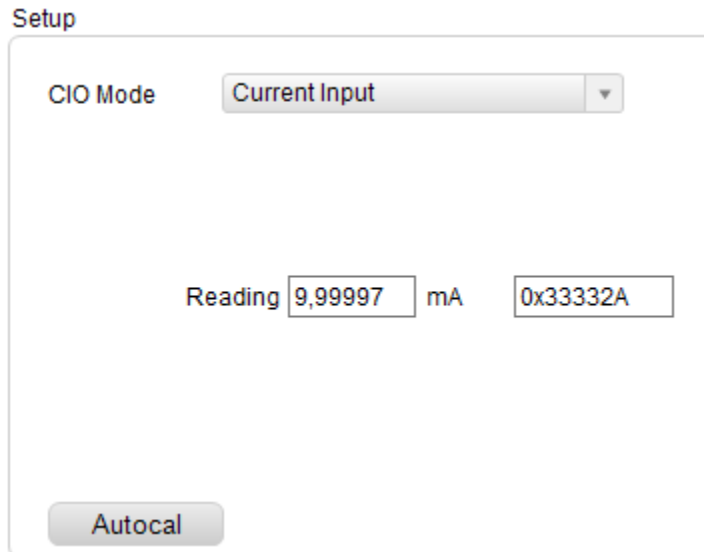
Figure 16. CIO Mode current input.

In normal mode, the current input acts like a 50Ω shunt resistor to GND and current driven with an external source is measured. However, it is also possible to connect a 4-20mA sensor directly between J12 pin 1 and pin 4. In this case, the UIO pin will provide the sensor supply of 19V. To enable this mode, toggle the switch to enable the sensor supply (**Figure 17**).
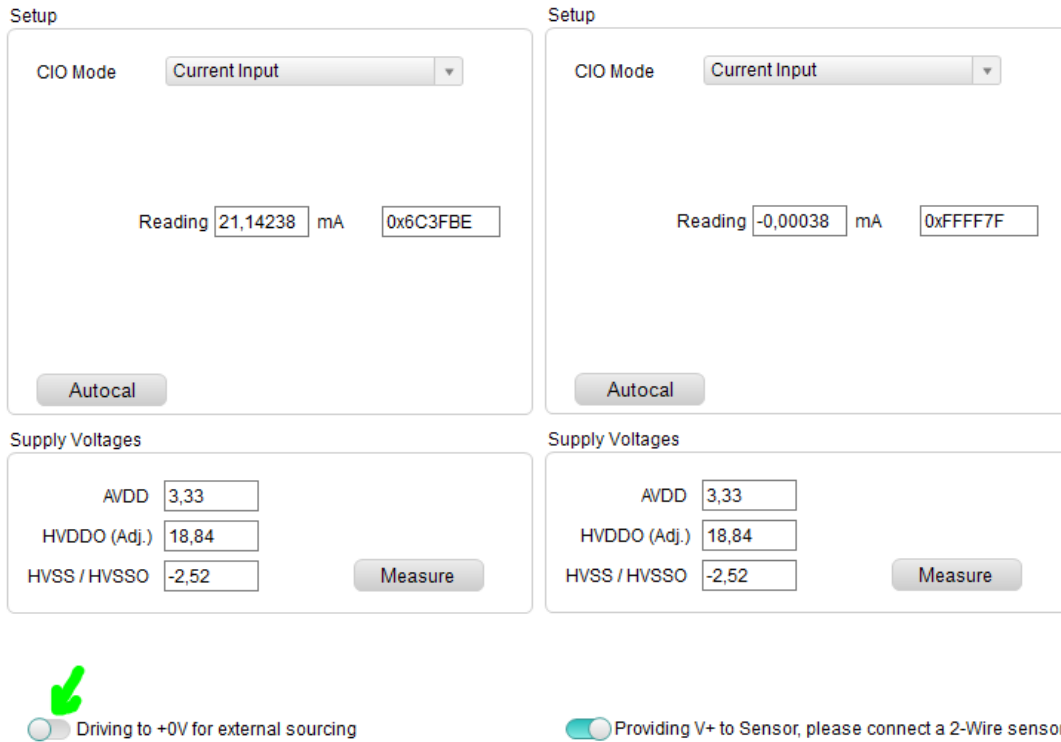
Figure 17. Sensor supply.

27. **Digital Input**: In digital input mode, the voltage between J12 pin 1 and pin 4 is evaluated according to IEC 61131-2 digital input standard utilizing MAX14914A. If the voltage is above the threshold, the "Reading" will show "High". If the voltage is below the threshold, the "Reading" will show "Low". The DI type can be selected between "Type 1/3" or "Type 2" using the switch "DI Type" (**Figure 18**).
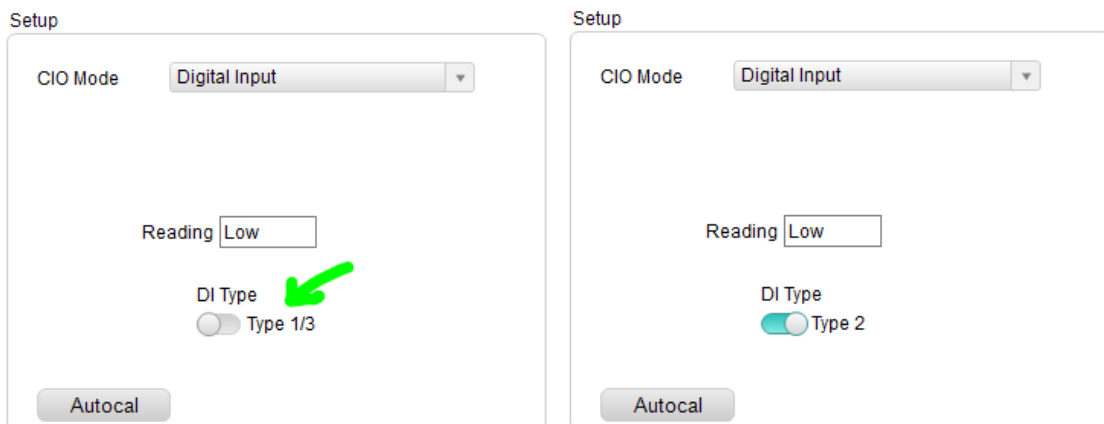
Figure 18. Digital Input type selection.

28. **RTD Measurement**: RTD measurement allows a PT100 or PT1000 temperature sensor to be used. The MAX22000 DAC output to J12 Pin 1 drives current through the sensor to GND (J12 Pin 4). The voltage is measured using the SNS+ and SNS- inputs, J12 Pin 2 and Pin 3. For this mode of operation, remove any shunts on JP1 and JP2 (**Figure 19**).
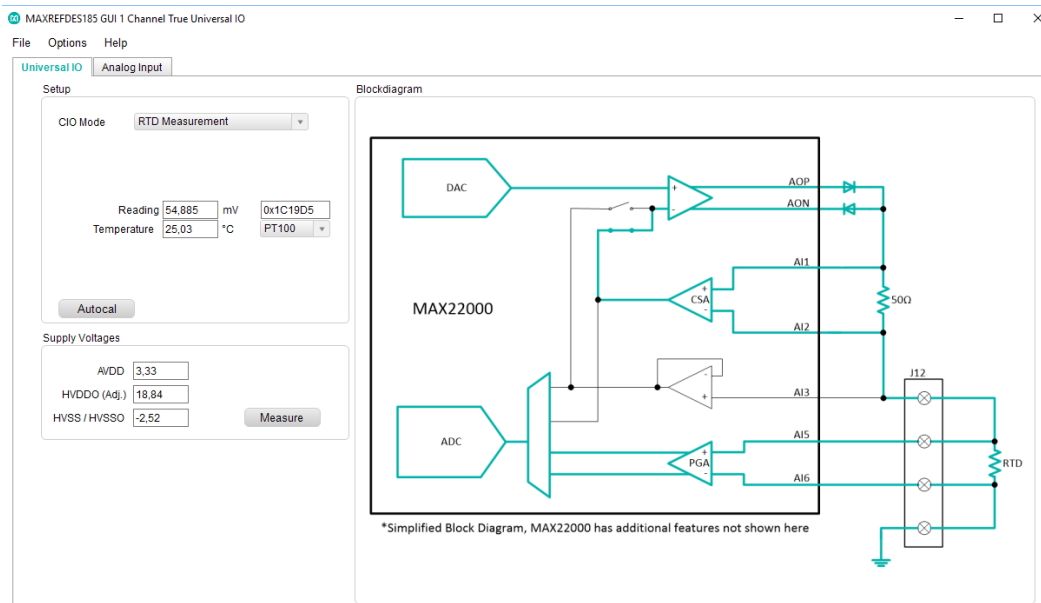

Figure 19. RTD measurement.

29. The GUI will display the voltage as well as the calculated temperature (**Figure 20**). The drop-down menu allows the user to select between PT100 and PT1000 sensors.
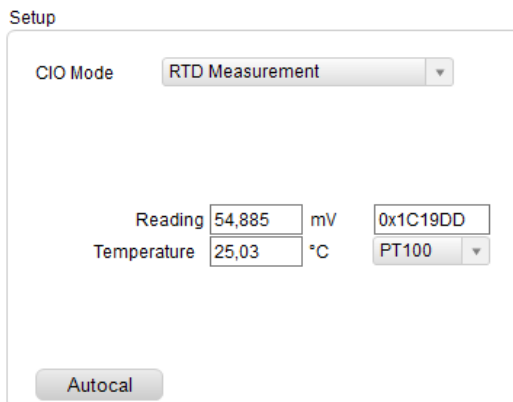
Figure 20. Close up of RTD measurement.

30. **Thermocouple Measurement**: In this mode, the temperature can be measured using a thermocouple Type K sensor (**Figure 21**). The GUI will display the voltage between the SNS+ and SNS- inputs (J12 Pin 2 and Pin 3). For this mode of operation, remove any shunts on JP1 and JP2.
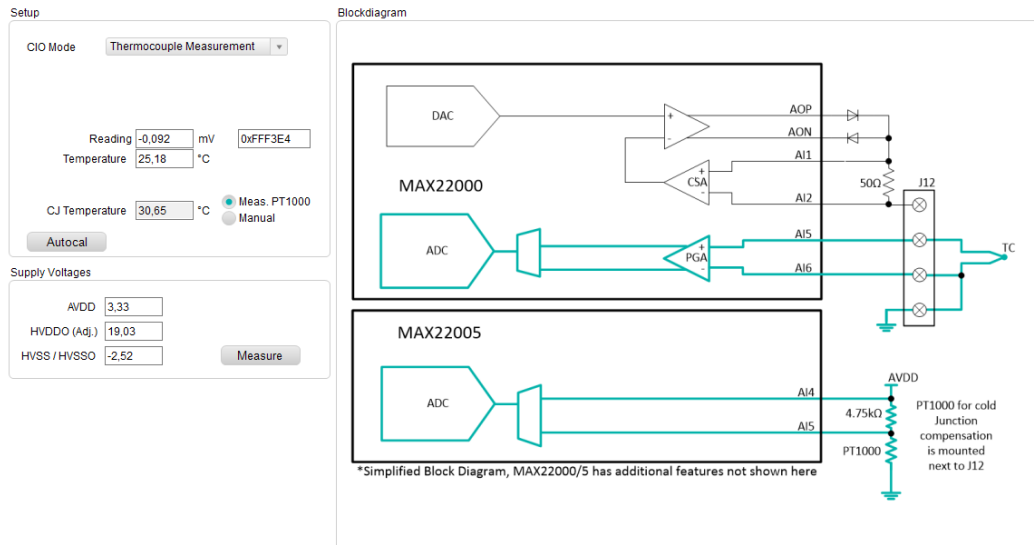
Figure 21. Thermocouple measurement.

31. The GUI also measures the terminal block temperature (cold junction temperature or CJ) using a PT1000 sensor, which is placed under the terminal-block J12. To measure the PT1000 temperature, the MAX22005 measures both the voltage AVDD (AI4) and the voltage across the PT1000 (AI5). It then calculates the current ($I = V/R$). Knowing the current and the voltage across the PT1000 sensor allows the GUI to evaluate the temperature. The CJ temperature and the TC voltage is used to calculate the real temperature at the thermocouple temperature sensor. This temperature is displayed in the GUI as well. The CJ temperature can also be entered manually (i.e., no automated CJ measurement) by selecting the "Manual" radio button.

Monitoring Channels

32. **Analog Input Tab**: This tab measures all voltages and currents on the Universal IO (J12) and displays them. There are two independent measurements, the upper three measurements by MAX22000, and the lower three measurements by MAX22005 (monitoring the primary device, MAX22000).

33. For example, connect a 1kΩ load between J12 pin 1 and pin 3. From the Universal IO tab, set the voltage output mode to 10V.

34. Next, go to the Analog Input tab and click the "Read All" button (**Figure 22**). If the jumpers JP1 and JP2 are closed, then all voltages should show 10.000V and the current should show 10mA.

35. This demonstrates the high accuracy of MAX22005 and how it closely correlates to the MAX22000 readings.

Figure 22. Analog Input tab.

Revision History

REVISION NUMBER	REVISION DATE	DESCRIPTION	PAGES CHANGED
0	06/21	Initial release	—