FIRST TEST STATION TEST STRATEGY

The test strategy involves connecting various source instruments to corresponding measurement instruments. The measurement instruments will validate the sources, and vice versa.

- Digital Input/Output (I/O) will be paired and tested in a loopback configuration.

- Open-collector transistors will have their voltage measured in both the driven and non-driven states.

- Relays will be tested by measuring current when the contact is open or closed.

- Communication protocols will be tested by performing communication between two devices.

- Digital I/O and open-collector transistors will be used to activate relays on the self-test board.

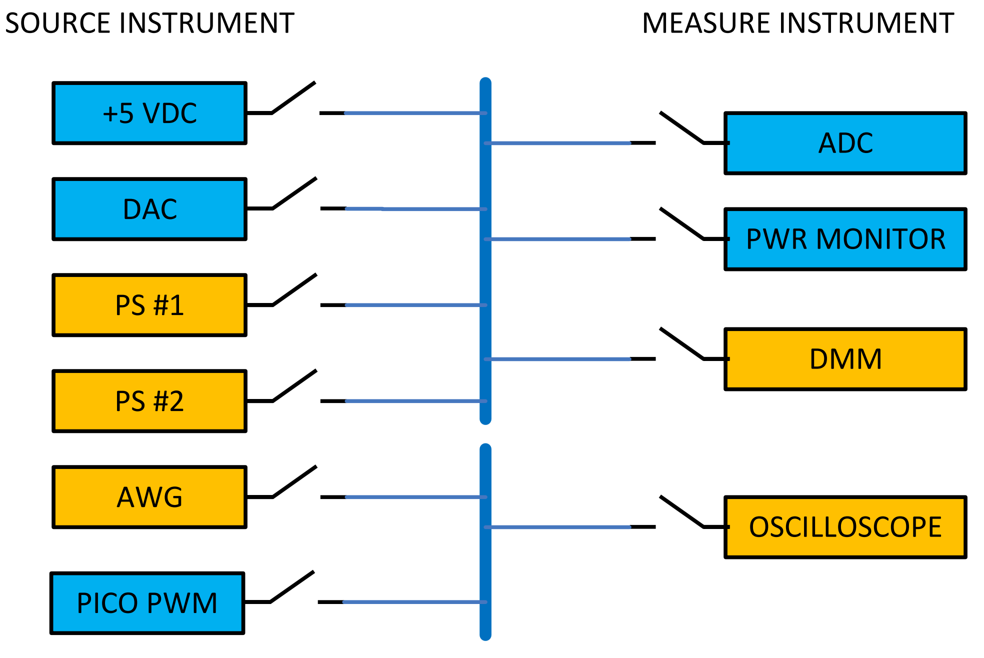
- The 4-wire ohmmeter will be tested using low-value resistors to simulate the resistance of long wires.

1- Instrument Test Strategy
The source instruments, whether internal or external, will be connected to the measurement instruments using a relay multiplexing scheme.

Two buses have been defined:

- DC bus for DC sources
- AC bus for AC sources
- The DC source will be tested using DC measurement instruments.
- The AC source will be tested using an oscilloscope.

The relay multiplexing scheme will be adapted to include the current input (I) of the digital multimeter (DMM) and enable testing of the DMM ohmmeter mode in both 2-wire and 4-wire configurations.



1- Communication Test Strategy
Each communication protocol will be tested using equivalent or compatible devices connected to the Selftest board.

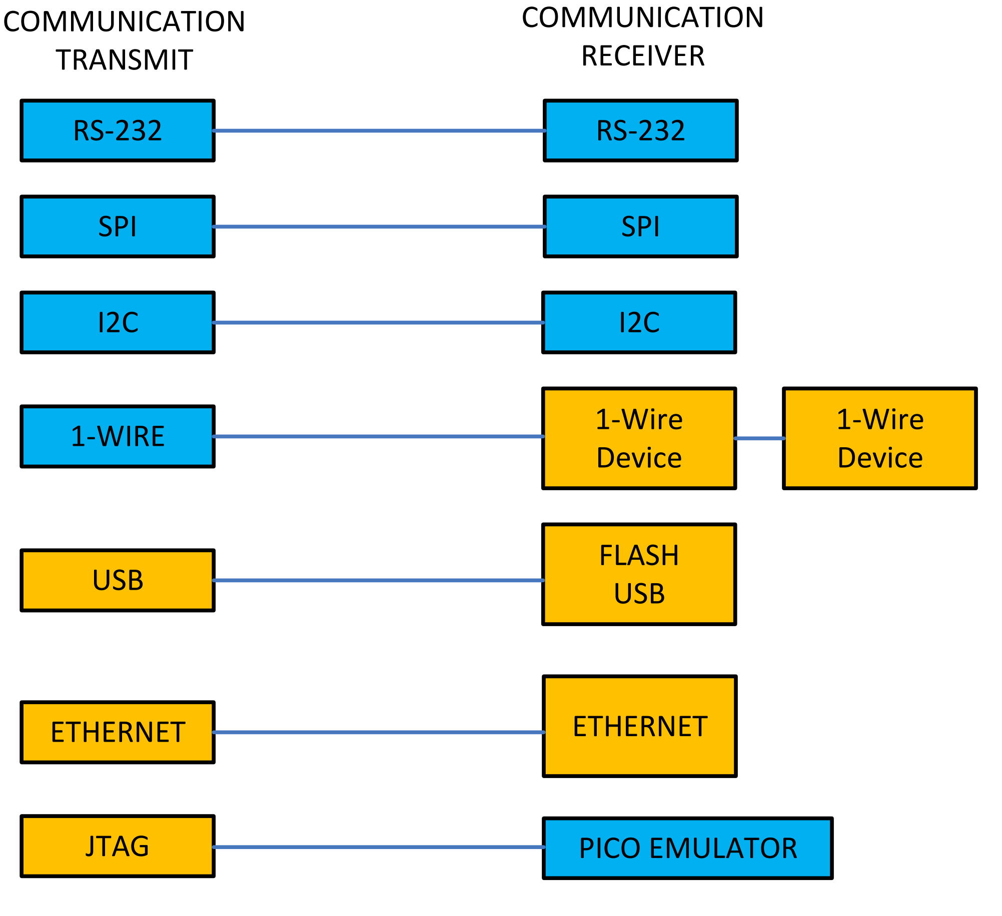
Basic communication protocols (I2C, SPI, and Serial) will be validated using equivalent communication channels on the Pico controller.

The 1-Wire reader will be tested using 1-Wire devices located on the Selftest board.

The USB link from the back panel of the Interconnect IO Box to the Selftest USB connector will be tested by inserting a USB device into the Selftest USB connector. In our case, a USB flash drive will be used to perform read/write operations.

The Ethernet link will be tested by connecting an Ethernet source to the back panel of the Interconnect IO Box and an Ethernet device to the Ethernet connector on the Selftest board. In our case, a router cable will be connected to the Interconnect IO Box, and a computer will be connected to the Selftest board's Ethernet connector. An internet speed test will be used to validate the link.

The JTAG protocol will be tested in software using a Pico emulator. The emulator code is TBD.



RELAY TESTING STRATEGY

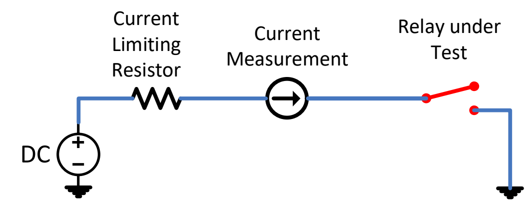
1- Basic Relay Test Strategy

The relay test strategy uses current measurement instead of voltage measurement. A DC source is applied to a current-limiting resistor and the relay under test. A current measurement instrument is placed in series with the relay contact to capture the current flowing through the relay.

When the relay contact is open, the current is 0, and when the relay is activated, the contact closes, and the current is defined by:

$$I = \frac{\text{DC Source}}{\text{resistor + shunt resistor + relay contact resistance}}$$

The DC source, resistor and shunt resistor are constant and do not vary; the only variable is the relay contact resistance. By setting an accurate limit, the test can detect deterioration of the relay contact and trigger replacement before failure.

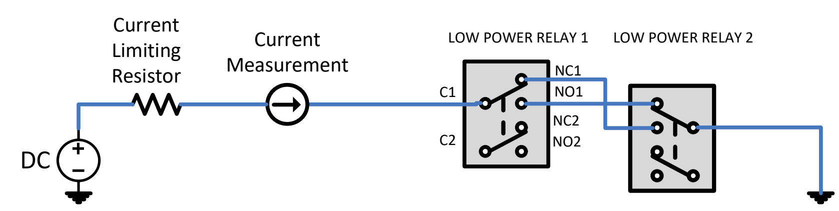


2- First Test Station Low Power Relay Test Strategy

To reduce the number of resources required to verify low-power relays, the test strategy connects two low-power relays in series, allowing both to be tested simultaneously.

A high contact resistance will be detected through current measurement, but the defective relay could be either one. To identify the faulty relay, the technician must replace them one at a time.

Testing each relay individually would be ideal, but the selected test strategy offers a practical compromise between efficiency and accuracy.



3- Relay Bank Test Strategy

The relay bank test strategy follows the same approach as the low-power relay test. Each relay bank is connected to the other, with the DC source connected to the COM relays of one bank and GND connected to the COM relays of the other bank.

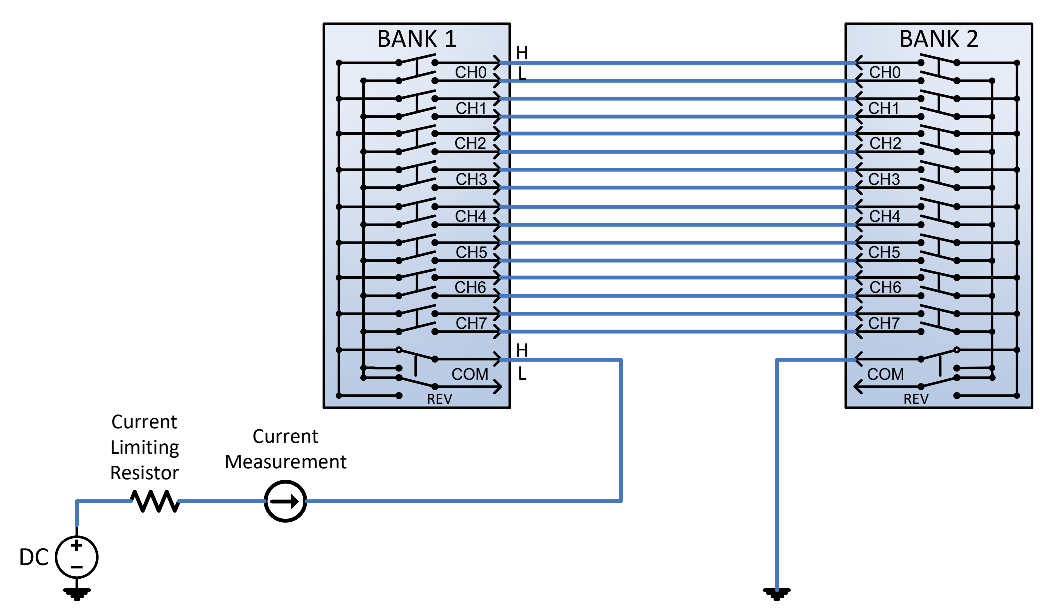
In this setup, four relays are in the current path:

1. COM relay of the first bank
2. CHx relay of the first bank
3. CHx relay of the second bank
4. COM relay of the second bank

Although four relays are involved, identifying a faulty relay remains straightforward because the COM relays are always in the current path.

- If the current is out of limits for CH0, CH1, etc., we know the COM relay is faulty.

- Conversely, if the issue appears on CH0 but not on CH1, the problem is with the channel relay, not the COM relay.

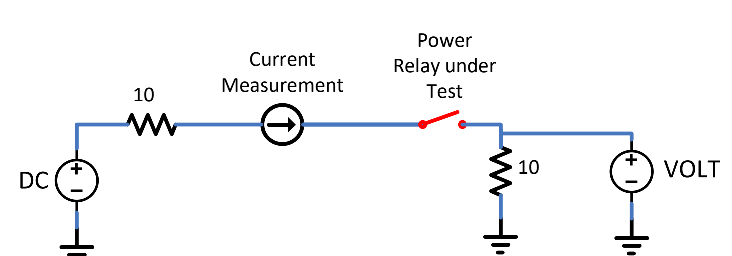


4- High Power Relay Test Strategy

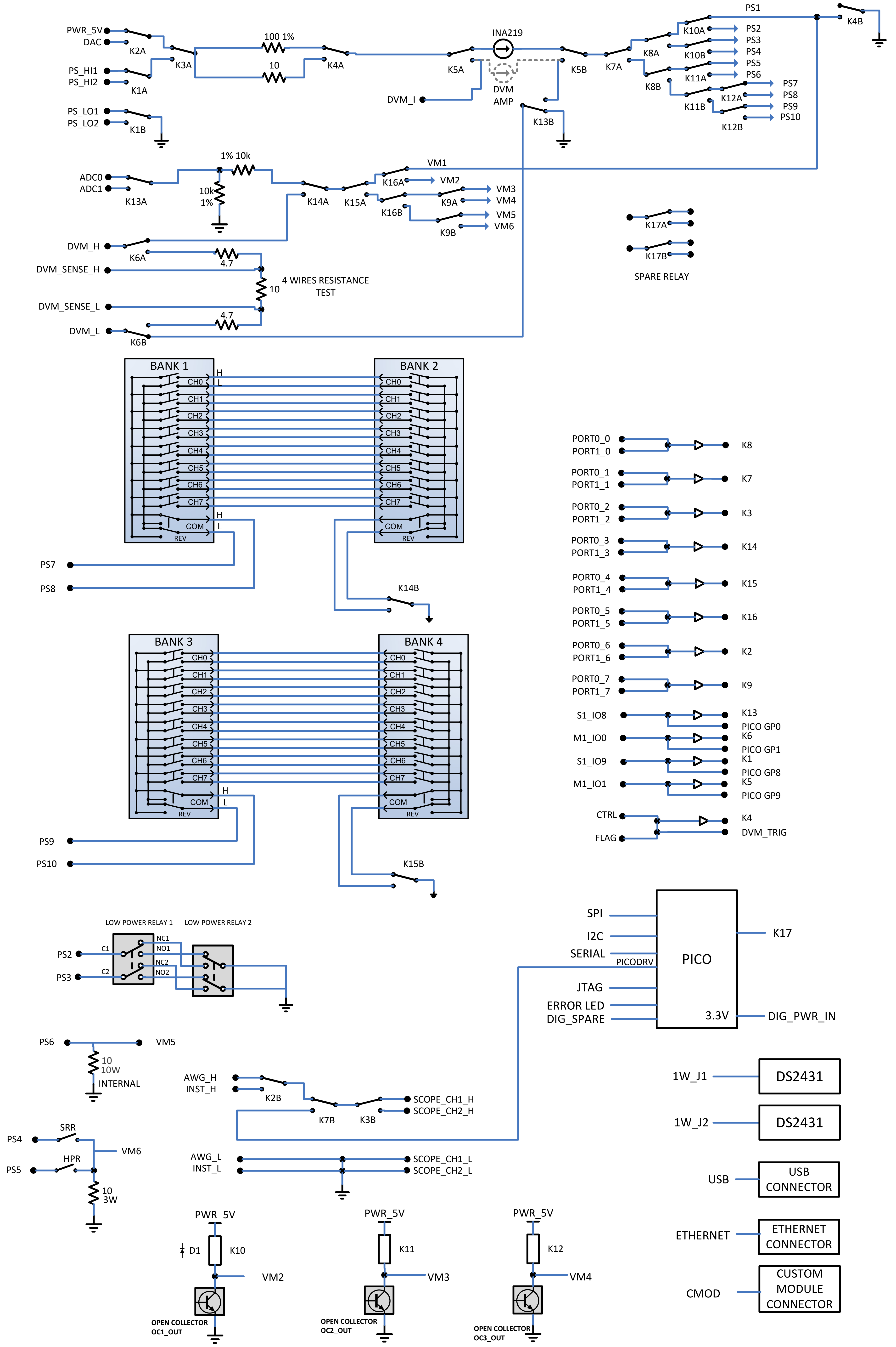
The high-power relay and solid-state relay will be tested individually using the same current measurement strategy. The test current will be higher to match the higher capacity of these relays.

A 10-ohm resistor has been added to the circuit at the relay's output to limit the maximum current to a safe level and prevent PCB trace damage.

A voltmeter is placed in parallel with this additional resistor to measure voltage and achieve better precision in current measurement.



SELFTEST BOARD BLOCK DIAGRAM

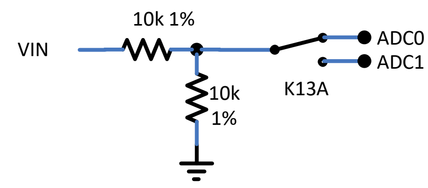


BLOCK DIAGRAM COMMENTS

Voltage Divider (Division by 2)
The ADC input is limited to 3V DC. To enable the measurement of 5V DC, a voltage divider with a 2:1 ratio has been added before the ADC.

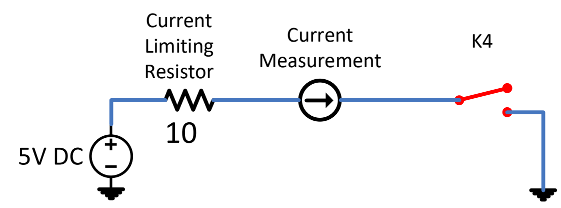
With this setup:

A 5V DC input will be reduced to 2.5V DC at ADC0 or ADC1.



Current Limiting Resistor
The 10Ω current-limiting resistor is validated by applying a 5V DC voltage source and closing K4 to ground the signal.

The current through the 10Ω resistor is then measured to ensure that the resistance value falls within the acceptable limits.



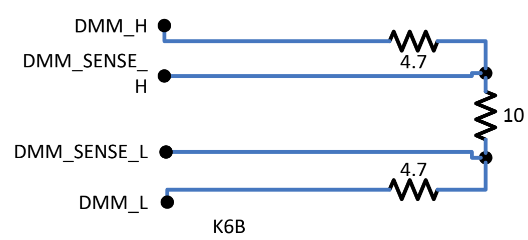
DMM 2-Wire and 4-Wire Test
By placing three resistors in series and connecting the DMM ohmmeter as shown in the diagram, we can validate both 2-wire and 4-wire measurement modes.

2-Wire Mode: Measures the total resistance in the circuit, including the three resistors in series:

4.7Ω + 10Ω + 4.7Ω = 19.4Ω

4-Wire Mode: Simulates long wires by placing 4.7Ω resistors on both the positive and negative sides of the DMM. The DMM sense wires are connected directly to the 10Ω resistor (resistance under test), eliminating lead resistance.

The DMM measurement in 4-wire mode will read 10Ω.

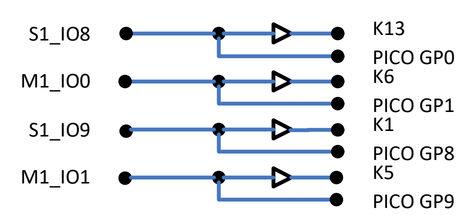


GPIO Test
For certain GPIOs where loopback testing (connecting two GPIOs together) is not possible due to resource limitations, an alternative testing method will be used.

The GPIO function will be tested by connecting the signal to a GPIO on the Selftest Pico Controller.

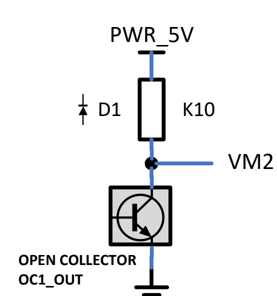
A command will be sent to the Selftest Pico Controller to read the GPIO state (high or low) and report the value.

This approach ensures that the GPIO operation is properly validated even when loopback testing is not feasible.



Open Collector Transistor Test
The open collector transistor test involves measuring the voltage at the collector when the transistor is actuated or not actuated.

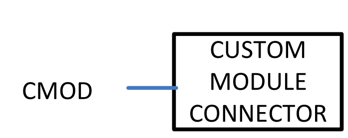
However, on the Selftest board, due to limited resources, the open collector transistors are also used to control relays on the Selftest board. This dual functionality must be considered when performing the test.



Custom Module
A dedicated space has been reserved on the Selftest board for adding custom modules.

In the future, this space can be used to integrate additional resources or incorporate new instruments into the First Test Station.

Having an open area for future expansions ensures flexibility and allows for easy upgrades as needed.



Loopback Test
The J23 and J26 connectors, located at the back of the InterconnectIO Box, can be validated using a custom-made loopback connector.

The picture on the right illustrates the required electrical wiring needed to build the loopback connector.