**2. Internal Signal Transfer and Data Manipulation Subsystem:**

***2.1. Subsystem Introduction:***

The internal signal and data manipulation subsystem (ISDMS) is designed to pass multiple digital signals across an isolation barrier from a 5 volt power side to a 3.3 volt power side. The 5volt side is also the side which connects to the fuel cells

***2.2. Subsystem Details:***

The ISDMS of two ADS8344N/1k analog to digital converters, two ACSL6400-50TE opto-isolators, and one MAX6037\_41 Voltage reference . The analog to digital converters receive the analog signal from the differential opamps and sends the digital value back to the microcontroller through the opt Isolators. See Figure One below for high level circuit diagram.

***Diagram, schematic

Description automatically generated***

Figure . High Level ISDMS High Level Circuit Schematic.

***2.3. Subsystem Validation:***

Validation of the ISDMS was done on a bread board using an Arduino as the microcontroller and an oscilloscope to confirm the signal transfer on the isolated side of the circuit.

***2.3.1 Signal Transfer Validation:***

The signal from the micro processor was successfully passed from the microcontroller to the ADC as depicted in figure 2. The maximum achievable

frequency was using the current design is one megahertz before the signal appears undefinable.

A screen shot of a computer

Description automatically generated with low confidence

Figure . Oscilloscope View Of Signal Transfer Through Opto-Isolator.

***2.3.2 ADC Control and Feedback:***

Control of the ADC as well as receiving a signal from the ADC was not validated. See section 2.4. for further explanation and discussion.

***2.4. Failed Validation Action Plan:***

The following sections outline possible contributing factors in the failure of the ADC validation

***2.4.1 Output Resistor Values:***

PROBLEM: The resistors on the output of the opto-isolators have current values of ten kilo Ohms. During the initial testing of the circuit, the resistor for the clock frequency was changed to one kilo Ohm and produced a signal which more closely resembled that of a square wave than the clock signal depicted in purple in figure 2. Further testing is necessary to determine if distortion in the signal is the cause of the malfunction.

SOLUTION: Change each output resistor in the circuit to one kilo Ohm and retest for ADC controllability.

***2.4.2 Arduino Serial Peripheral Interface (SPI) Set Up:***

PROBLEM: The Arduino microcontroller has a SPI system which requires the user to choose the parameters such as bit read direction, clock frequency, and edge trigger. The parameters must match the expected parameters of the device for the device to function properly. These parameters can be determined from the device data sheet but are not in terms of the Arduino IDE syntax.

SOLUTION: The current Arduino SPI parameters must be changed one at a time and the circuit retested for each change. Differences in each test must be annotated and tracked until the necessary configuration is achieved.

***2.5. Subsystem Conclusion:***

The ability of the circuit to transfer a digital signal was validated for frequencies of 250 Kilohertz to 1 Megahertz. The ability of the circuit to control the ADC was unsuccessful and requires more testing and circuit design adjustments. The possible problems and solution from section 2.4 will be the first to be tested for design validation. If neither of these solutions proves effective, consultation with experienced engineers will be pursued for possible design solutions.