*LIGO Laboratory / LIGO Scientific Collaboration*

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**aLIGO ISC QPD Transimpedance Amplifier Test Procedure**

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# Overview

This test procedure applies to ISC QPD Transimpedance Amplifier circuit board LIGO-D1001974-v2 and v3 contained within chassis assembly D1002481. A block diagram of the ISC QPD Transimpedance circuit board is shown in Figure 1. Two such QPD Transimpedance Amps and one ISC QPD Transimpedance Amplifier Interface are packaged in one chassis.



Figure 1 QPD Transimpedance Amplifier Circuit Block Diagram

# Testing

Each production chassis must be functionally tested and the results recorded in Section 4. It is assumed that the person using this procedure is familiar with Dynamic Signal Analyzers, and rudimentary test equipment including oscilloscopes and multimeters.

**Serial Number Data**

* Record all serial number data in Table 1

**DC Tests**

Apply +/- 18, +/-200 mV Volts DC to the chassis under test and record front panel LED operation, total positive and negative power supply current, internal regulator output voltage and individual circuit board power supply currents as required in Table 2.

# Reference for chassis front and rear panel layout

Figure 2: QPD Transimpedance Amplifier Chassis Front Panel



Figure 3: QPD Transimpedance Amplifier Chassis Rear Panel



# Test Data Tables

## General Information

|  |  |  |  |
| --- | --- | --- | --- |
| **Tested By** |  | **Date** |  |

Table Serial Number Data

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Chassis Serial Number** | **DC PWR Board**  **PCB Serial #** | **Amplifier 1**  **PCB Serial #** | **Amplifier 2**  **PCB Serial #** | **Interface Board**  **PCB Serial #** | |  |  | |
|  |  |  |  | |  | | |

## DC Power Supply Data

Total chassis and individual circuit board quiescent current draw is recorded in Table 2. For the individual circuit boards, unplug all but one board at a time and record the chassis current draw of the +/- 18VDC supply. Use caution in believing the digital readouts of laboratory triple output power supplies. Their meters are not highly accurate. When in doubt, use a multimeter on the appropriate scale in series with the supply to be measured.

Table 2, Record of DC Test Data

|  |  |  |  |
| --- | --- | --- | --- |
| **Parameter** | **Typical Value** | **Allowable Range** | **Measured Value** |
| Front Panel +/- 15VDC Power LEDs | Both Lit | N/A |  |
| Rear Panel +/- 15VDC  Power LEDs | Both Lit | N/A |  |
| +18VDC, +/-0.2VDC **TOTAL** supply current | 270 mA | +/- 50mA |  |
| -18VDC, +/-0.2VDC **TOTAL** supply current | 240 mA | +/- 50mA |  |
| Regulated Internal DC Voltage under full load (both boards) | 15 VDC | +/- 0.5VDC |  |
| Regulated Internal DC Voltage under full load (both boards) | -15 VDC | +/- 0.5VDC |  |

## DC Offsets on Each Differential Output

As a general measure of the health, the DC offset must be measured at the differential outputs for each channel, and the rear panel SUM output. The input connector is to be left open. Record the results as measured by a multimeter in Table 3.

Table 3, Differential Output DC Offset

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| ***Differential DC Measurement Point*** | ***Typical DC Offset*** | ***Allowable Range*** | ***Measured DC Offset*** | |
| **Amplifier 1** | **Amplifier 2** |
| Channel 1 | 0VDC | +/- 5mV |  |  |
| Channel 2 | 0VDC | +/- 5mV |  |  |
| Channel 3 | 0VDC | +/- 5mV |  |  |
| Channel 4 | 0VDC | +/- 5mV |  |  |
| Sum BNC on Rear Panel | 0VDC | +/- 10mV |  |  |

**4.4 Transimpedance**

Calculate the transimpedance by using the laboratory Voltage/Current calibrator Model IVC-222HP 11.

Inject 1mA DC into the appropriate anode input of the QPD. Measure the DC Voltage at the differential, and SUM output; calculate the transimpedance of the circuit by:

***Transimpedance = Vout / 1mA***

Table , Differential Output Transimpedance

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| ***Differential DC Measurement Point*** | ***Transimpedance*** | ***Allowable Range*** | ***Calculated Transimpedance*** | |
| **Amplifier 1** | **Amplifier 2** |
| Channel 1 | 1K | +/- 2Ω |  |  |
| Channel 2 | 1K | +/- 2Ω |  |  |
| Channel 3 | 1K | +/- 2Ω |  |  |
| Channel 4 | 1K | +/- 2Ω |  |  |
| SUM BNC on rear panel | 4K | +/- 2Ω |  |  |

## Frequency Response

The transfer function of each channel of the amplifier should be measured using an SR785 dynamic signal analyzer. The input impedance to all channels of this circuit is 10 ohms. Due to this low impedance, a 1kΩ resistor is required to be placed in series with the SR785 source. A simple set of clip leads and a breakout board is sufficient. The SR785 input drive level is 10mV for all swept sine measurements. A jumper (P2) is available in each quadrant’s amplifier chain to permit bypassing the zero-pole whitening stages. A functional test of this feature should be performed to ensure the “un-whitened” position of the jumper performs its intended function.

Measure the magnitude and the phase differentially at the rear panel D-sub output for each channel as required. Record the results the following tables.

Table , Noise Cancellation Amp

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Measurement**  **Frequency** | **Magnitude (dB)** | **Allowable Range** | **Phase (deg)** | **Allowable Range** | **Measured Magnitude** | **Measured Phase** | **Pass/Fail** |
| 10Hz | 34 | +/- 1dB | 73.6 | +/- 5 deg |  |  |  |
| 100Hz | 45 | +/- 1dB | 21.4 | +/- 5 deg |  |  |  |
| 1KHz | 46 | +/- 1dB | 0.9 | +/- 5 deg |  |  |  |
| 10KHz | 46 | +/- 1dB | -12.8 | +/- 5 deg |  |  |  |
| 100KHz | 38 | +/- 1dB | -76.1 | +/- 5 deg |  |  |  |

Table , Frequency Response Amp 1\_Quadrant 1

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Measurement**  **Frequency** | **Magnitude (dB)** | **Allowable Range** | **Phase (deg)** | **Allowable Range** | **Measured Magnitude** | **Measured Phase** | **Pass/Fail** |
| 10Hz | 34 | +/- 1dB | -106 | +/- 5 deg |  |  |  |
| 100Hz | 45 | +/- 1dB | -159 | +/- 5 deg |  |  |  |
| 1KHz | 46 | +/- 1dB | -179 | +/- 5 deg |  |  |  |
| 10KHz | 46 | +/- 1dB | 168 | +/- 5 deg |  |  |  |
| 100KHz | 38 | +/- 1dB | 108 | +/- 5 deg |  |  |  |
| Whitening Bypass (pass/fail check only) | - | Flat Frequency Response to 100kHz | - | - | - | - |  |

Table 7, Frequency Response Amp 1\_Quadrant 2

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Measurement**  **Frequency** | **Magnitude (dB)** | **Allowable Range** | **Phase (deg)** | **Allowable Range** | **Measured Magnitude** | **Measured Phase** | **Pass/Fail** |
| 10Hz | 34 | +/- 1dB | -106 | +/- 5 deg |  |  |  |
| 100Hz | 45 | +/- 1dB | -159 | +/- 5 deg |  |  |  |
| 1KHz | 46 | +/- 1dB | -179 | +/- 5 deg |  |  |  |
| 10KHz | 46 | +/- 1dB | 168 | +/- 5 deg |  |  |  |
| 100KHz | 38 | +/- 1dB | 108 | +/- 5 deg |  |  |  |
| Whitening Bypass (pass/fail check only) | - | Flat Frequency Response to 100kHz | - | - | - | - |  |

Table 8, Frequency Response Amp 1\_Quadrant 3

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Measurement**  **Frequency** | **Magnitude (dB)** | **Allowable Range** | **Phase (deg)** | **Allowable Range** | **Measured Magnitude** | **Measured Phase** | **Pass/Fail** |
| 10Hz | 34 | +/- 1dB | -106 | +/- 5 deg |  |  |  |
| 100Hz | 45 | +/- 1dB | -159 | +/- 5 deg |  |  |  |
| 1KHz | 46 | +/- 1dB | -179 | +/- 5 deg |  |  |  |
| 10KHz | 46 | +/- 1dB | 168 | +/- 5 deg |  |  |  |
| 100KHz | 38 | +/- 1dB | 108 | +/- 5 deg |  |  |  |
| Whitening Bypass (pass/fail check only) | - | Flat Frequency Response to 100kHz | - | - | - | - |  |

Table 9, Frequency Response Amp 1\_Quadrant 4

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Measurement**  **Frequency** | **Magnitude (dB)** | **Allowable Range** | **Phase (deg)** | **Allowable Range** | **Measured Magnitude** | **Measured Phase** | **Pass/Fail** |
| 10Hz | 34 | +/- 1dB | -106 | +/- 5 deg |  |  |  |
| 100Hz | 45 | +/- 1dB | -159 | +/- 5 deg |  |  |  |
| 1KHz | 46 | +/- 1dB | -179 | +/- 5 deg |  |  |  |
| 10KHz | 46 | +/- 1dB | 168 | +/- 5 deg |  |  |  |
| 100KHz | 38 | +/- 1dB | 108 | +/- 5 deg |  |  |  |
| Whitening Bypass (pass/fail check only) | - | Flat Frequency Response to 100kHz | - | - | - | - |  |

Table 10, Frequency Response Amp2\_Quadrant 1

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Measurement**  **Frequency** | **Magnitude (dB)** | **Allowable Range** | **Phase (deg)** | **Allowable Range** | **Measured Magnitude** | **Measured Phase** | **Pass/Fail** |
| 10Hz | 34 | +/- 1dB | -106 | +/- 5 deg |  |  |  |
| 100Hz | 45 | +/- 1dB | -159 | +/- 5 deg |  |  |  |
| 1KHz | 46 | +/- 1dB | -179 | +/- 5 deg |  |  |  |
| 10KHz | 46 | +/- 1dB | 168 | +/- 5 deg |  |  |  |
| 100KHz | 38 | +/- 1dB | 108 | +/- 5 deg |  |  |  |
| Whitening Bypass (pass/fail check only) | - | Flat Frequency Response to 100kHz | - | - | - | - |  |

Table 11, Frequency Response Amp 2\_Quadrant 2

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Measurement**  **Frequency** | **Magnitude (dB)** | **Allowable Range** | **Phase (deg)** | **Allowable Range** | **Measured Magnitude** | **Measured Phase** | **Pass/Fail** |
| 10Hz | 34 | +/- 1dB | -106 | +/- 5 deg |  |  |  |
| 100Hz | 45 | +/- 1dB | -159 | +/- 5 deg |  |  |  |
| 1KHz | 46 | +/- 1dB | -179 | +/- 5 deg |  |  |  |
| 10KHz | 46 | +/- 1dB | 168 | +/- 5 deg |  |  |  |
| 100KHz | 38 | +/- 1dB | 108 | +/- 5 deg |  |  |  |
| Whitening Bypass (pass/fail check only) | - | Flat Frequency Response to 100kHz | - | - | - | - |  |

Table 12, Frequency Response Amp2\_Quadrant 3

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Measurement**  **Frequency** | **Magnitude (dB)** | **Allowable Range** | **Phase (deg)** | **Allowable Range** | **Measured Magnitude** | **Measured Phase** | **Pass/Fail** |
| 10Hz | 34 | +/- 1dB | -106 | +/- 5 deg |  |  |  |
| 100Hz | 45 | +/- 1dB | -159 | +/- 5 deg |  |  |  |
| 1KHz | 46 | +/- 1dB | -179 | +/- 5 deg |  |  |  |
| 10KHz | 46 | +/- 1dB | 168 | +/- 5 deg |  |  |  |
| 100KHz | 38 | +/- 1dB | 108 | +/- 5 deg |  |  |  |
| Whitening Bypass (pass/fail check only) | - | Flat Frequency Response to 100kHz | - | - | - | - |  |

Table 13, Frequency Response Amp 2\_Quadrant 4

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Measurement**  **Frequency** | **Magnitude (dB)** | **Allowable Range** | **Phase (deg)** | **Allowable Range** | **Measured Magnitude** | **Measured Phase** | **Pass/Fail** |
| 10Hz | 34 | +/- 1dB | -106 | +/- 5 deg |  |  |  |
| 100Hz | 45 | +/- 1dB | -159 | +/- 5 deg |  |  |  |
| 1KHz | 46 | +/- 1dB | -179 | +/- 5 deg |  |  |  |
| 10KHz | 46 | +/- 1dB | 168 | +/- 5 deg |  |  |  |
| 100KHz | 38 | +/- 1dB | 108 | +/- 5 deg |  |  |  |
| Whitening Bypass (pass/fail check only) | - | Flat Frequency Response to 100kHz | - | - | - | - |  |

Table 14, Noise Cancellation Amp 2

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Measurement**  **Frequency** | **Magnitude (dB)** | **Allowable Range** | **Phase (deg)** | **Allowable Range** | **Measured Magnitude** | **Measured Phase** | **Pass/Fail** |
| 10Hz | 34 | +/- 1dB | 73.6 | +/- 5 deg |  |  |  |
| 100Hz | 45 | +/- 1dB | 21.4 | +/- 5 deg |  |  |  |
| 1KHz | 46 | +/- 1dB | 0.9 | +/- 5 deg |  |  |  |
| 10KHz | 46 | +/- 1dB | -12.8 | +/- 5 deg |  |  |  |
| 100KHz | 38 | +/- 1dB | -76.1 | +/- 5 deg |  |  |  |

## Output Noise Spectra

The output noise voltage of each channel of the amplifier should be measured using the dynamic signal analyzer SR785. This measurement should be made while the input is open, and the frequency range is set from 1Hz to 100 KHz.

Measure the output referred noise differentially at the rear panel D-sub output for each channel as required. Record the results in Table to

Table

Table 15, Amp 1\_Quadrant 1 Noise

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Measurement Frequency** | **Typical Amplitude dBVrms/√Hz** | **Allowable Range** | **Measured Amplitude dBVrms/√Hz** | **Pass/Fail** |
| 10Hz | -129 | +/- 3dB |  |  |
| 100Hz | -118 | +/- 3dB |  |  |
| 1KHz | -118 | +/- 3dB |  |  |
| 10KHz | -118 | +/- 3dB |  |  |

Table 16, Amp 1\_Quadrant 2 Noise

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Measurement Frequency** | **Typical Amplitude dBVrms/√Hz** | **Allowable Range** | **Measured Amplitude dBVrms/√Hz** | **Pass/Fail** |
| 10Hz | -129 | +/- 3dB |  |  |
| 100Hz | -118 | +/- 3dB |  |  |
| 1KHz | -118 | +/- 3dB |  |  |
| 10KHz | -118 | +/- 3dB |  |  |

Table17, Amp 1\_Quadrant 3 Noise

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Measurement Frequency** | **Typical Amplitude dBVrms/√Hz** | **Allowable Range** | **Measured Amplitude dBVrms/√Hz** | **Pass/Fail** |
| 10Hz | -129 | +/- 3dB |  |  |
| 100Hz | -118 | +/- 3dB |  |  |
| 1KHz | -118 | +/- 3dB |  |  |
| 10KHz | -118 | +/- 3dB |  |  |

Table 18, Amp 1\_Quadrant 4 Noise

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Measurement Frequency** | **Typical Amplitude dBVrms/√Hz** | **Allowable Range** | **Measured Amplitude dBVrms/√Hz** | **Pass/Fail** |
| 10Hz | -129 | +/- 3dB |  |  |
| 100Hz | -118 | +/- 3dB |  |  |
| 1KHz | -118 | +/- 3dB |  |  |
| 10KHz | -118 | +/- 3dB |  |  |

Table 19, Amp 2\_Quadrant 1 Noise

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Measurement Frequency** | **Typical Amplitude dBVrms/√Hz** | **Allowable Range** | **Measured Amplitude dBVrms/√Hz** | **Pass/Fail** |
| 10Hz | -129 | +/- 3dB |  |  |
| 100Hz | -118 | +/- 3dB |  |  |
| 1KHz | -118 | +/- 3dB |  |  |
| 10KHz | -118 | +/- 3dB |  |  |

**Table 20, Amp2\_Quadrant 2 Noise**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Measurement Frequency** | **Typical Amplitude dBVrms/√Hz** | **Allowable Range** | **Measured Amplitude dBVrms/√Hz** | **Pass/Fail** |
| 10Hz | -129 | +/- 3dB |  |  |
| 100Hz | -118 | +/- 3dB |  |  |
| 1KHz | -118 | +/- 3dB |  |  |
| 10KHz | -118 | +/- 3dB |  |  |

Table 21, Amp2\_Quadrant 3 Noise

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Measurement Frequency** | **Typical Amplitude dBVrms/√Hz** | **Allowable Range** | **Measured Amplitude dBVrms/√Hz** | **Pass/Fail** |
| 10Hz | -129 | +/- 3dB |  |  |
| 100Hz | -118 | +/- 3dB |  |  |
| 1KHz | -118 | +/- 3dB |  |  |
| 10KHz | -118 | +/- 3dB |  |  |

Table 22, Amp2\_Quadrant 4 Noise

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Measurement Frequency** | **Typical Amplitude dBVrms/√Hz** | **Allowable Range** | **Measured Amplitude dBVrms/√Hz** | **Pass/Fail** |
| 10Hz | -129 | +/- 3dB |  |  |
| 100Hz | -118 | +/- 3dB |  |  |
| 1KHz | -118 | +/- 3dB |  |  |
| 10KHz | -118 | +/- 3dB |  |  |