EtherCAT Mini-DAQ Overview Document

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1 Introduction

The EtherCAT mini-DAQ is a data acquisition system designed for marine energy tank testing. The mini-DAQ brings signal processing physically onto the test model, allowing for reduced cabling, increased signal integrity and simple integration of both analogue and digital sensors. This document acts as an overview of each section of the mini-DAQ, all software and code can be found at `https://github.com/shaun11740/EtherCAT-Mini-DAQ`. Figure 1 shows the

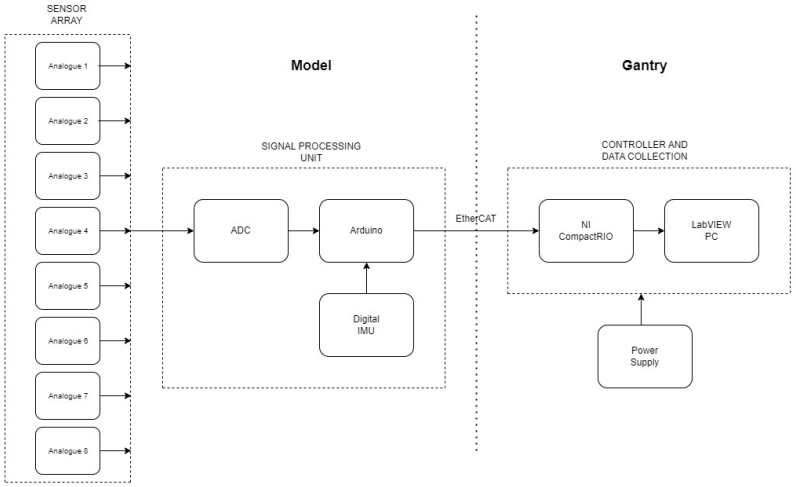

Figure 1: Block Diagram of EtherCAT DAQ System

overall block diagram of the mini-DAQ system in its default setup. The signal processing unit is the main enclosure, 8 analogue sensors may be wired into this unit and a digital IMU is already present within the enclosure. The main sensor and ADC board currently consists of a prototype breadboard, this is to allow for customisation and testing before committing to a permanent PCB.

2 Mini-DAQ Hardware

The mini-DAQ hardware consists of a 220g, 120x100x47mm enclosure. The two main internal parts consist of:

1. Breadboard for sensor inputs and analogue to digital conversion
2. EasyCAT shielded Arduino Uno Microcontroller

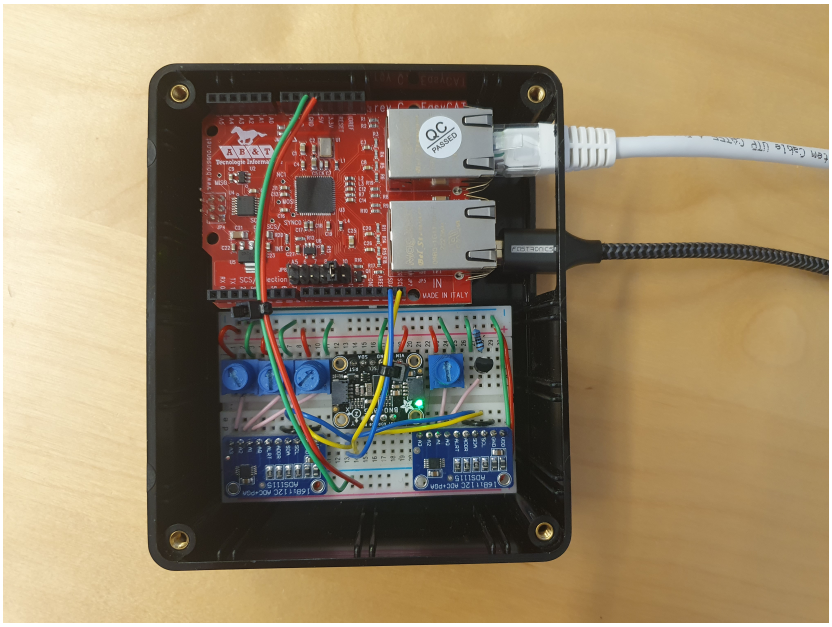

Figure 2: Mini-DAQ main enclosure

2.1 Breadboard

Breadboard components:

1. 16-bit, 4-channel Analogue to Digital Converter (ADS1115) x2
2. Digital Accelerometer Breakout (BNO055) x1
3. Jumper wire for power, ground, signals and data communication

Any 5V sensor may be integrated directly into the DAQ as shown with the potentiometers and temperature sensor present in figure 2, if greater than 5V is required, an external voltage sensor must be used to scale down the voltage before analogue to digital conversion, 5 of which are available with this kit (see figure 3). A full schematic of current connections has also been included to understand wiring of sensors, ADC and accelerometer (see figure 4).

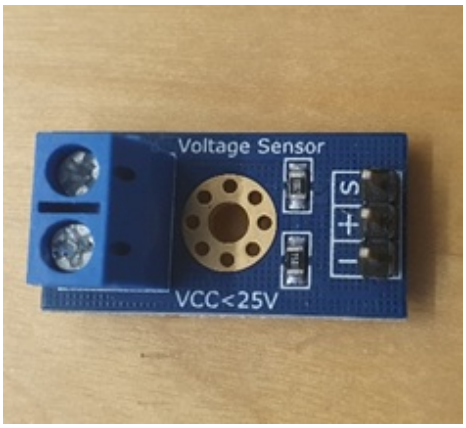

Figure 3: External Voltage Divider

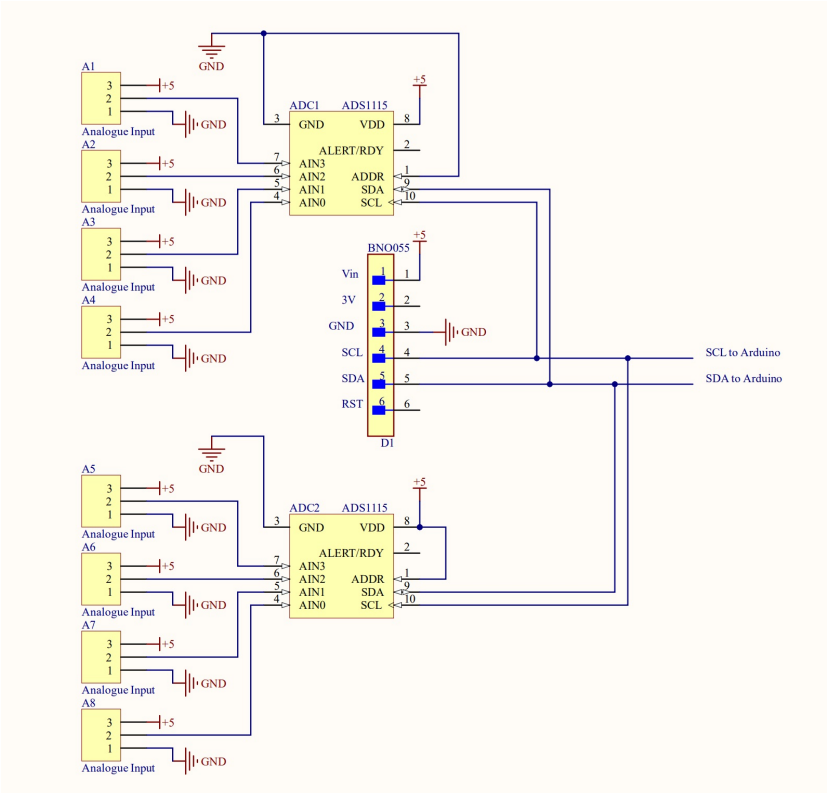

Figure 4: MiniDAQ Breadboard Schematic Diagram

2.2 EasyCAT Arduino

EasyCAT Arduino components:

1. Arduino Uno
2. Bausano EasyCAT Shield

The EasyCAT Arduino board has 4 wires running to breadboard which are assigned as follows:

1. Red - +5V supply
2. Green – GND
3. Yellow – SCL
4. Blue – SDA

Also connected to the EasyCAT Arduino there is an Ethernet cable for data transfer to the master controller and USB for power and re-programming.

3 EtherCAT Network

The mini-DAQ runs on an EtherCAT network system, which requires a real time target machine to act as a master controller. This function is performed by a National Instruments CompactRIO, while the EasyCAT Arduino acts as the peripheral slave of the network. Port 1 of the CRIO should be connected to the network while port 2 should be connected to the output of the EasyCAT Arduino. It is also essential that the CRIO have the NI Industrial Communication for EtherCAT drivers installed and that port 2 is configured to EtherCAT mode in the Measurement and Automation explorer. The CRIO used for this project was the CompactRIO-9082 - S/N 190AFC2.

4 Mini-DAQ Arduino Code

The EasyCAT must be programmed in Arduino IDE, if any custom voltage scaling is required (such as that when voltage division sensor is used) this can be done at this stage. It is essential that both the EasyCAT.h file and the Custom h file must be present in the program folder. If any configuration other than 8 Channel analogue + 3 channel orientation is required it must be reprogrammed at this stage. The code commenting explains each line of the program in greater detail.

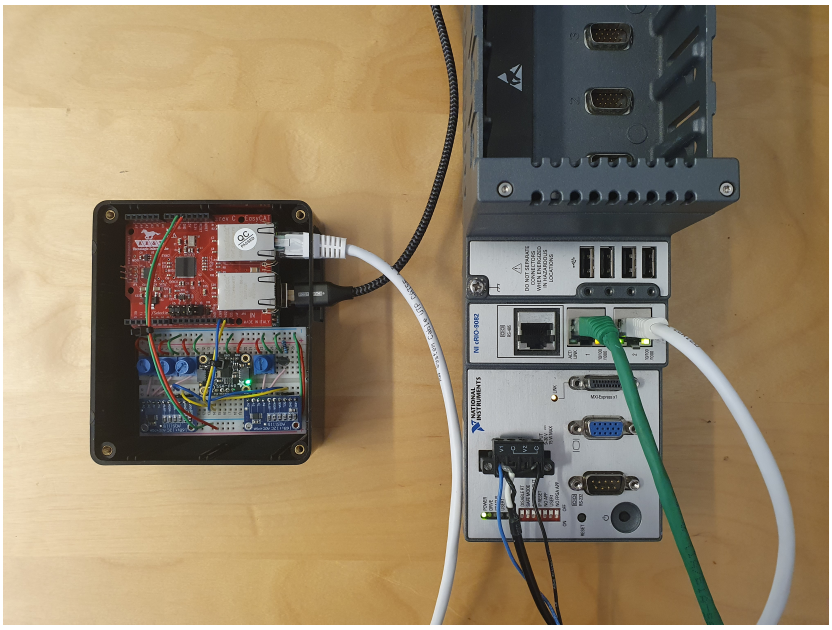

Figure 5: EtherCAT Network Connection

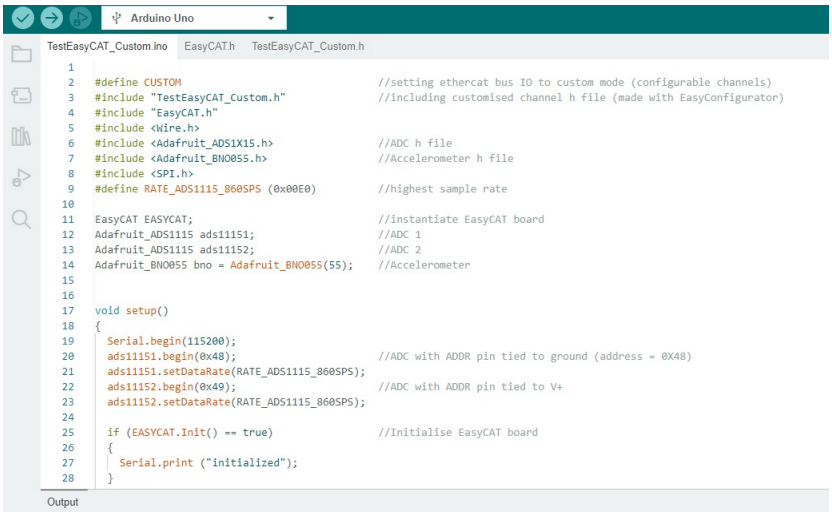

Figure 6: Arduino Code Snippet

5 LabVIEW Project

The LabVIEW project shows an overview of the project. You'll see in figure 7 that if you expand the CompactRIO there is EtherCAT master (ID: 0). Any

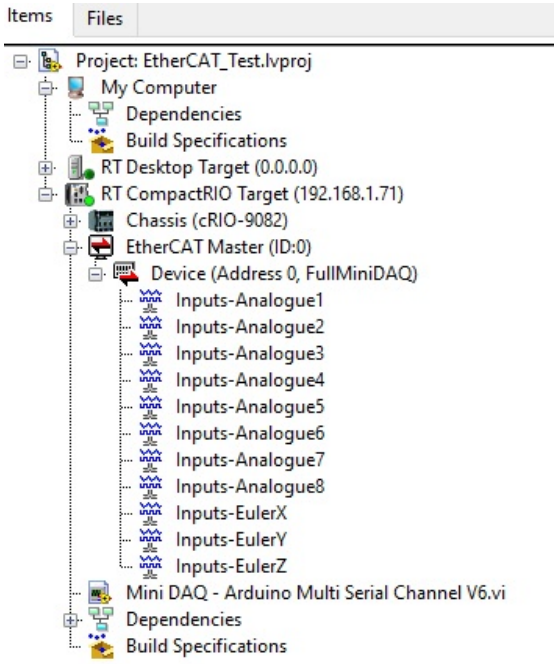

Figure 7: LabVIEW Project Overview

LabVIEW VI must be run within this to receive data over EtherCAT. Beneath the EtherCAT master is the Device, this is essentially the LabVIEW task and expanding this shows all input and output channels. This task is automatically configured in LabVIEW when the XML file (made with EasyConfigurator) is uploaded to the project. A common problem with the EtherCAT mini-DAQ is channels showing up as 0 in the VI. This is normally caused by the arduino losing power or being re-programmed and can be fixed with either one of two methods:

1. Close LabVIEW, turn off CompactRIO, turn off Arduino, Restartin.
2. Right click RT CompactRIO Target in .lvproj, Utilities, Compare Target and System and check for any differences in the target and system inputs, if there are then click Upload, Deploy and then Apply.

5.1 Virtual Instrument

The LabVIEW front panel is the main user interface for the mini-DAQ. Here you can monitor all channels, set file path, set sample rate, start and stop the data acquisition. The LabVIEW back panel shows the inner working of the EtherCAT mini-DAQ. You can see it consists of a loop with each channel being

wired to both a waveform chart for visualisation and a Write to Measurement File Express VI for saving data to CRIO. All data is saved as TDMS or LVM files (configurable by editing the Write to Measurement File Express VI). Note that the timer in the top right corner of the loop defines the sampling rate as it shows how long the EtherCAT master will wait before calling another value from the EtherCAT buffer. The runtime is defined in the bottom right corner of the loop where runtime end or stop button press terminates the loop execution.

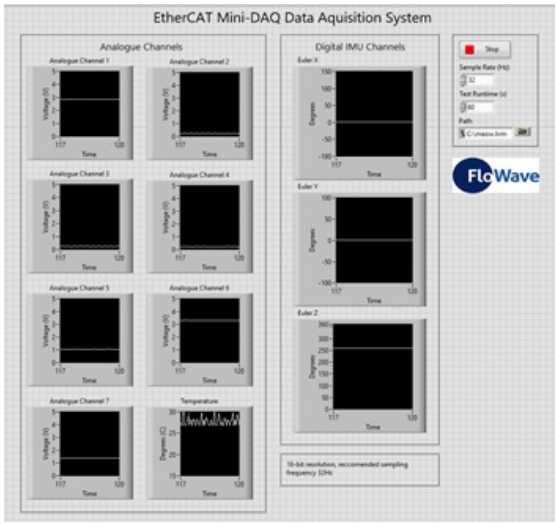

Figure 8: LabVIEW Front Panel

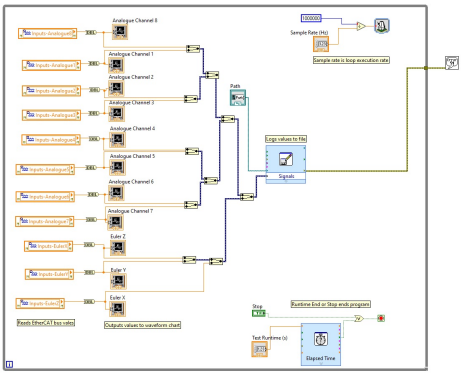

Figure 9: LabVIEW Back Panel