Rail Shunt Connection Test System

ECE SENIOR DESIGN TEAM 9

April 16th Spring 2015

Project Definition

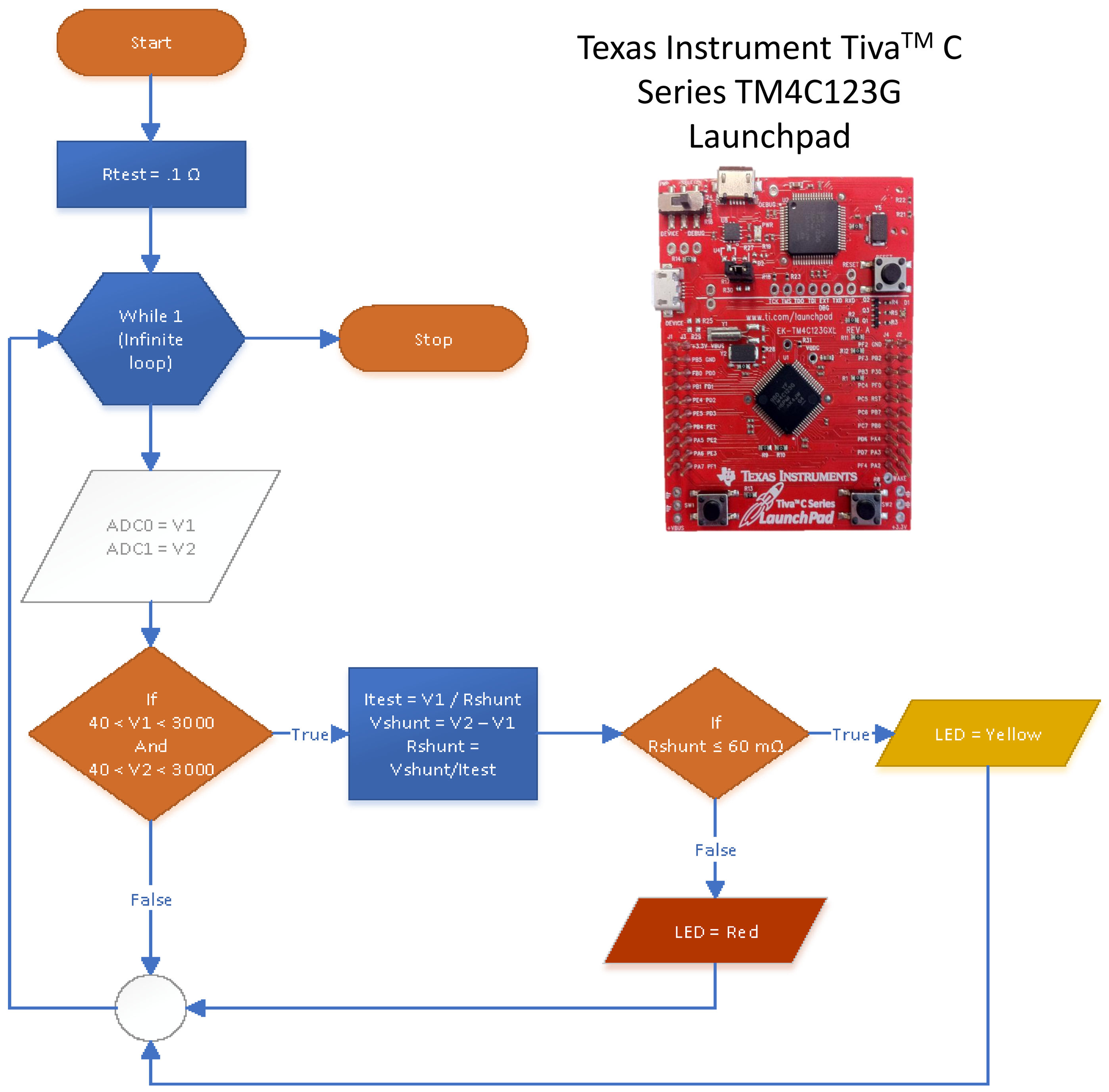
The Rail Shunt Connection Test System is an effort to update current rail industry equipment safety measures. A rail shunt is a device designed to simulate a train axel as it passes down the tracks, primarily used for calibrating crossings and providing safety for rail workers. There is often no way to tell whether a good connection is achieved because it is little more than C-clamps and a low resistance wire. This is potentially dangerous because a train traveling through a maintenance area could result in worker endangerment or even derailment. Team 9 has developed a system which will measure the electrical properties of the shunt and rails in order to determine if a good shunt is achieved. The system consists of new clamps, a measurement device, and housing - all of which can be retrofitted to the existing units in the field.

Retrofit Implementation

After analyzing the routes of implementation in the field, it was determined that a system that could easily be packaged and applied to existing units was preferred. Having retroactive capabilities for a new system saves both time and money in terms of production, implementation, and training. This design is staged such that the measurement system is applied in four steps:

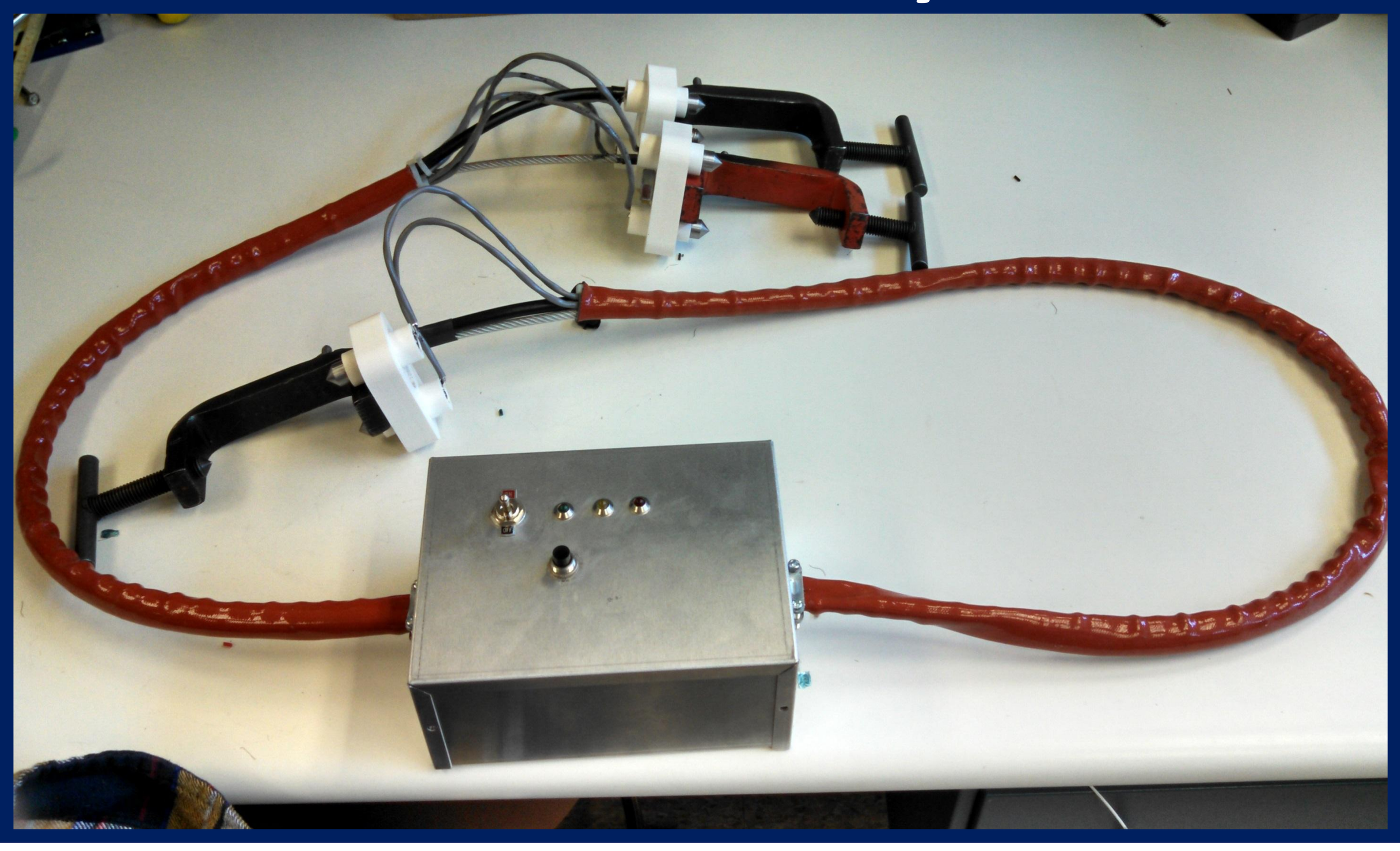
1. Feed two new wires through the existing shunt wire sleeve
2. Feed sleeve through the box
3. Cut the two wires in the sleeve to attach to the box terminals
4. Attach new clamp fittings and wires to the existing clamp

Software Flow Chart



Texas Instrument Tiva™ C Series TM4C123G Launchpad

Finalized Shunt System

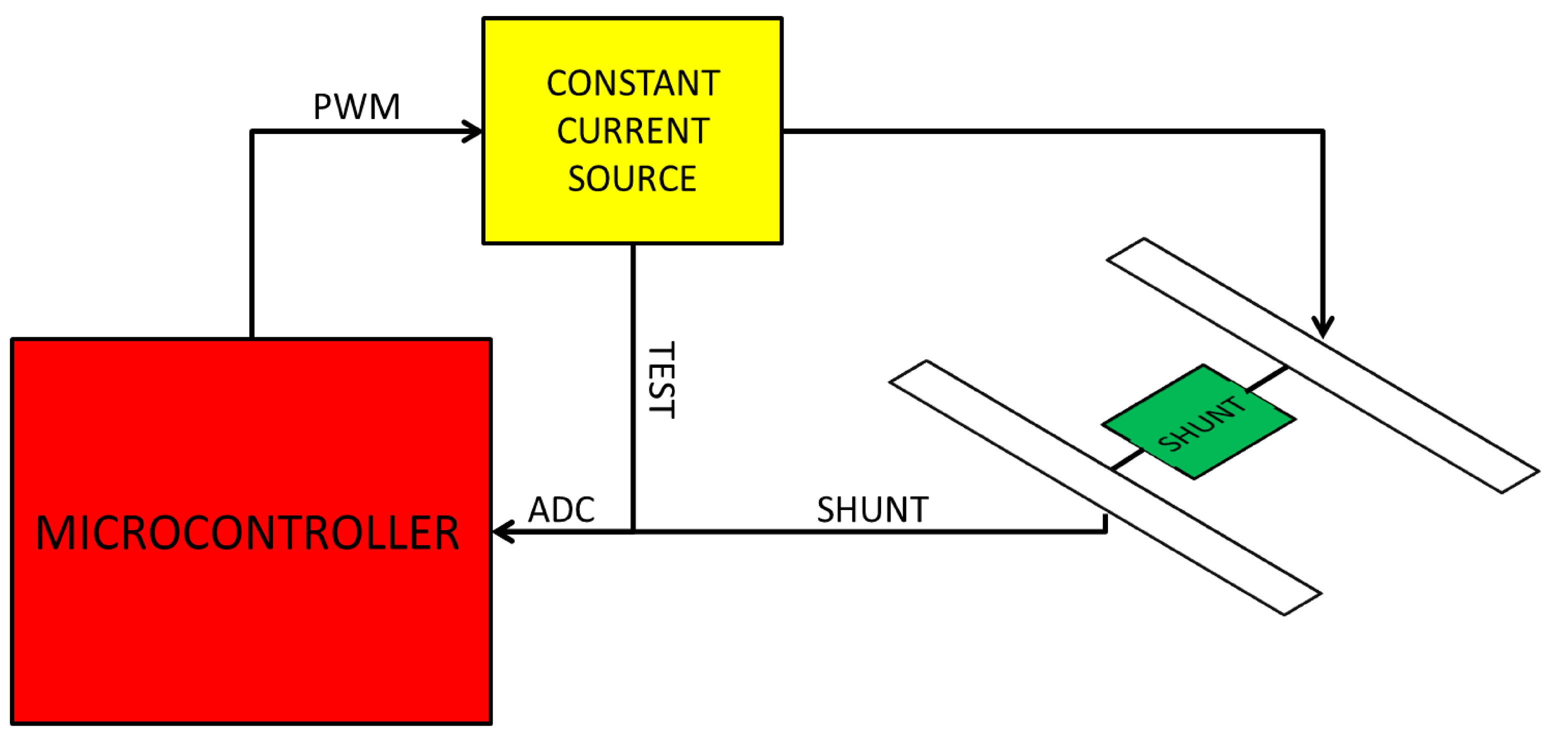


Current Source

In order to achieve optimal results, it is essential that the current source remains constant regardless of the load. This is to provide voltages within the microcontroller's specifications for effective computations. However, the presence of existing AC and DC signals cause noise in the system. An AC current source was determined to be the best option in order to alleviate the signal noise concern. This was achieved using a modified Howland current source.

Even with the constant current, it is important to have redundant accuracy verification processes. A test resistance is used to verify the current because the external and internal component performance variations cause slight discrepancies in the high decimal precision of the microcontroller depending on the environment. Using a moderate current on low resistances, acceptable voltage levels are outputted from the shunt to the microcontroller for accurate measurements.

System Block Diagram



Results

$$\text{Error} = \frac{|Actual - Measured|}{Actual} * 100\%$$

$$\frac{|0.06 - 0.060947|}{0.06} * 100\% = 1.5783\%$$

$$I_{Shunt} = \frac{V_2}{R_{Test}} \text{A}$$

$$R_{Shunt} = \frac{V_1 - V_2}{I_{Shunt}} \Omega$$

V1 = input to ADC0

V2 = input to ADC1

R_{Test} = 100 mΩ

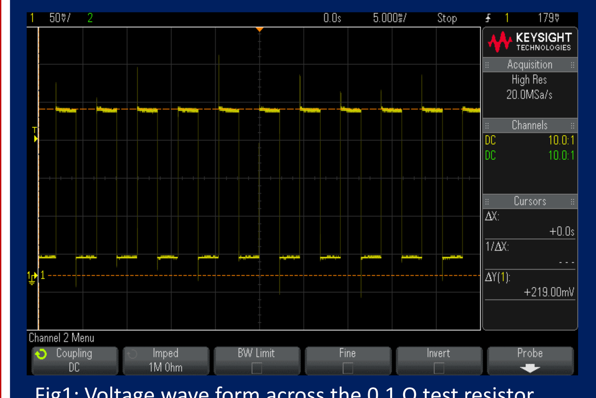


Fig1: Voltage wave form across the 0.1 Ω test resistor

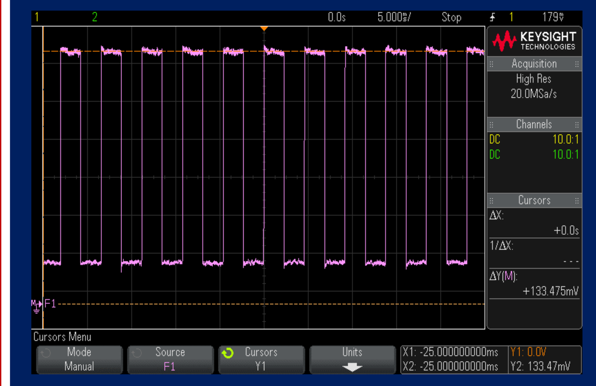


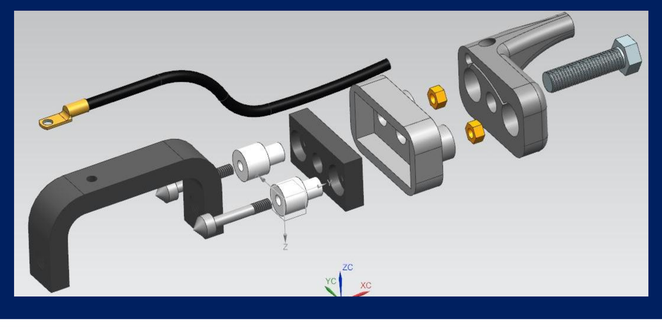
Fig2: Voltage wave form across the 0.06 Ω shunt resistor

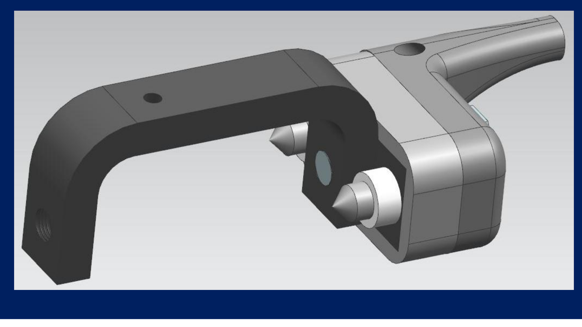
Knowing voltage (shown in Fig1) and resistance, the current can be calculated using Ohm's law as shown above. Because the test resistor and the shunt resistance are in series the current will be the same through both.

The current and the voltage (shown in Fig2) across the shunt resistor can once again be used with Ohm's law to calculate resistance. Calculations show the resistance of the shunt resistor to be 0.060947 Ω. A 0.06 Ω resistor with 1% tolerance was used to simulate a shunt. The tested value is within the standard deviation of the manufacturers specification. The differences are associated with tolerances and accuracy of equipment.

Clamp System

- Three probe system for pushing current and measuring both voltage and current
  - Mounting block
    - Two low resistance steel probes
    - Nonconductive plastic probe supports
  - Rear Clamp Housing
    - Probe mount lock system
    - Rubberized wire and cable support tail





Project Team

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