University of New Haven

Honeywell

Honeywell Fire-Lite
Reengineered Regulated NAC Tester

University of New Haven Fire Chargers Team

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The Problem & Tasks

- **Problem:**
  - Honeywell wants to replace their legacy Regulated NAC Tester due to age and lack of support. Failure of this legacy tester would mean Honeywell cannot test and ensure quality of their fire panels or NAC devices
- **Tasks:**
  - Create a refreshed Regulated NAC Tester for Honeywell using updated hardware and software
  - The tester will verify that:
    - The fire panel power supply output that handles instantaneous outrush to NACs without voltage drop.
    - Output Voltage remains constant over a minimum of 1 hour.

Project Goals

- **Objective**: Design and construct a modernized Regulated NAC Tester to replace the legacy tester in order to provide a sustainable and usable design
- **Deliverables:**
    - A production-ready modernized Regulated NAC Tester, comprising a PCB, microcontroller, input/output ports, solid state and mechanical relays enclosed in a metal box
    - A program and source code to perform the functional decisions within the microcontroller on the PCB
    - Wiring schematic, enclosure schematic, PCB schematic, functional flow diagram for code
    - System Engineering documentation including a requirements document, statement of work, and various system engineering diagrams

Statement of Work

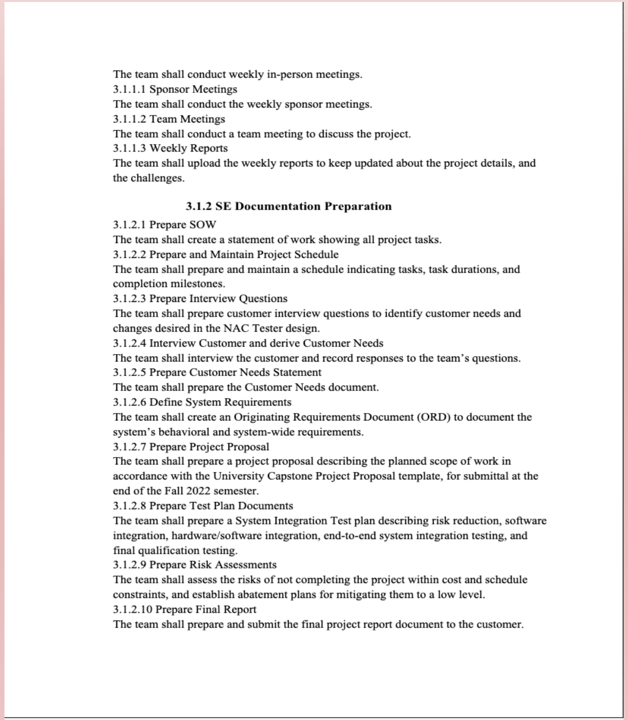
- **3.1.2 SE Documentation Preparation**

    3.1.2.1 Prepare SOW

    The team shall create a statement of work showing all project tasks.

    3.1.2.2 Prepare and Maintain Project Schedule

    The team shall prepare and maintain a schedule indicating tasks, task durations, and completion milestones.



The team shall conduct weekly in-person meetings.
3.1.1.1 Sponsor Meetings
The team shall conduct the weekly sponsor meetings.
3.1.1.2 Team Meetings
The team shall conduct a team meeting to discuss the project.
3.1.1.3 Weekly Reports
The team shall upload the weekly reports to keep updated about the project details, and the challenges.

3.1.2 SE Documentation Preparation

3.1.2.1 Prepare SOW
The team shall create a statement of work showing all project tasks.
3.1.2.2 Prepare and Maintain Project Schedule
The team shall prepare and maintain a schedule indicating tasks, task durations, and completion milestones.
3.1.2.3 Prepare Interview Questions
The team shall prepare customer interview questions to identify customer needs and changes desired in the NAC Tester design.
3.1.2.4 Interview Customer and derive Customer Needs
The team shall interview the customer and record responses to the team's questions.
3.1.2.5 Prepare Customer Needs Statement
The team shall prepare the Customer Needs document.
3.1.2.6 Define System Requirements
The team shall create an Originating Requirements Document (ORD) to document the system's behavioral and system-wide requirements.
3.1.2.7 Prepare Project Proposal
The team shall prepare a project proposal describing the planned scope of work in accordance with the University Capstone Project Proposal template, for submittal at the end of the Fall 2022 semester.
3.1.2.8 Prepare Test Plan Documents
The team shall prepare a System Integration Test plan describing risk reduction, software integration, hardware/software integration, end-to-end system integration testing, and final qualification testing.
3.1.2.9 Prepare Risk Assessments
The team shall assess the risks of not completing the project within cost and schedule constraints, and establish abatement plans for mitigating them to a low level.
3.1.2.10 Prepare Final Report
The team shall prepare and submit the final project report document to the customer.

Originating Requirement Document (ORD)

- **3.1.1 External Input Requirements**

  3.1.1.1 The system shall accept user-defined configuration switch input settings.

- **3.1.2 External Output Requirements**

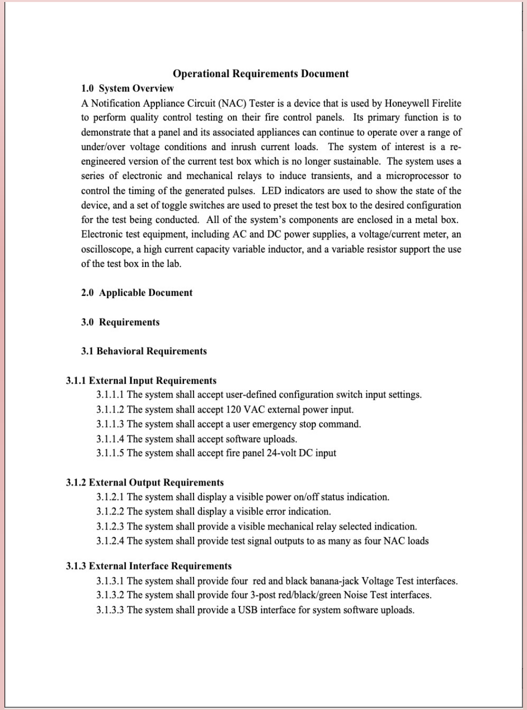
  3.1.2.1 The system shall display a visible power on/off status indication.

- **3.2.2 Physical Requirements**

  3.2.2.1 The system shall fit within a volume of 18 in x 18 in x 8 inches.

- **3.2.4 Cost Requirement**

  3.2.4.1 The system shall cost no more than $3000 to fabricate, including purchased parts costs.



Operational Requirements Document

1.0 System Overview

A Notification Appliance Circuit (NAC) Tester is a device that is used by Honeywell Firelite to perform quality control testing on their fire control panels. Its primary function is to demonstrate that a panel and its associated appliances can continue to operate over a range of under/over voltage conditions and inrush current loads. The system of interest is a re-engineered version of the current test box which is no longer sustainable. The system uses a series of electronic and mechanical relays to induce transients, and a microprocessor to control the timing of the generated pulses. LED indicators are used to show the state of the device, and a set of toggle switches are used to preset the test box to the desired configuration for the test being conducted. All of the system's components are enclosed in a metal box. Electronic test equipment, including AC and DC power supplies, a voltage/current meter, an oscilloscope, a high current capacity variable inductor, and a variable resistor support the use of the test box in the lab.

2.0 Applicable Document

3.0 Requirements

3.1 Behavioral Requirements

3.1.1 External Input Requirements

3.1.1.1 The system shall accept user-defined configuration switch input settings.
3.1.1.2 The system shall accept 120 VAC external power input.
3.1.1.3 The system shall accept a user emergency stop command.
3.1.1.4 The system shall accept software uploads.
3.1.1.5 The system shall accept fire panel 24-volt DC input

3.1.2 External Output Requirements

3.1.2.1 The system shall display a visible power on/off status indication.
3.1.2.2 The system shall display a visible error indication.
3.1.2.3 The system shall provide a visible mechanical relay selected indication.
3.1.2.4 The system shall provide test signal outputs to as many as four NAC loads

3.1.3 External Interface Requirements

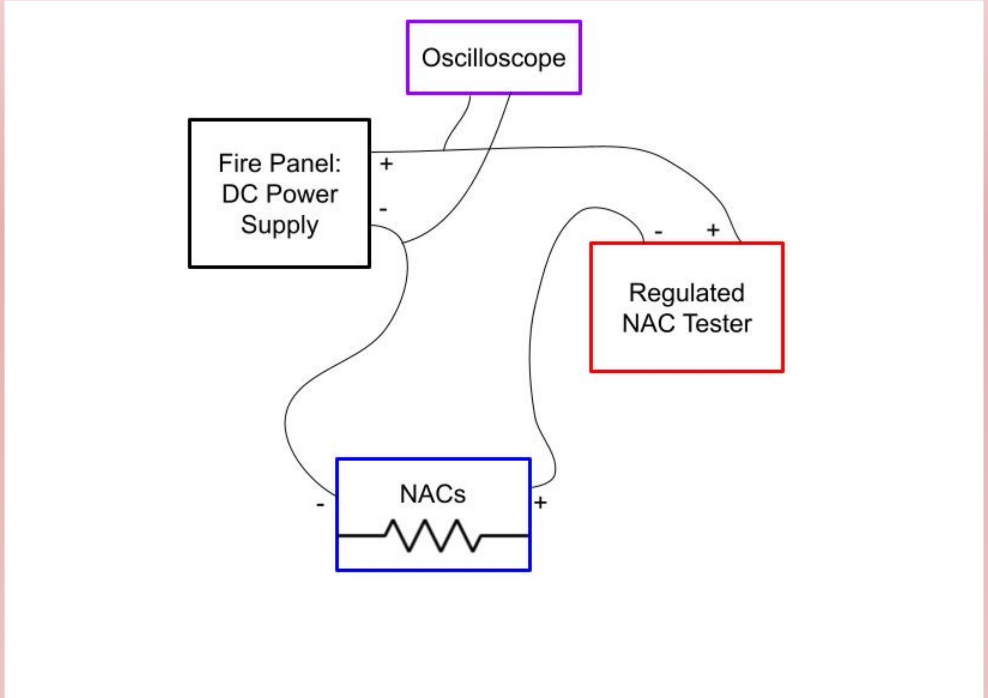
3.1.3.1 The system shall provide four red and black banana-jack Voltage Test interfaces.
3.1.3.2 The system shall provide four 3-post red/black/green Noise Test interfaces.
3.1.3.3 The system shall provide a USB interface for system software uploads.

Gantt Chart

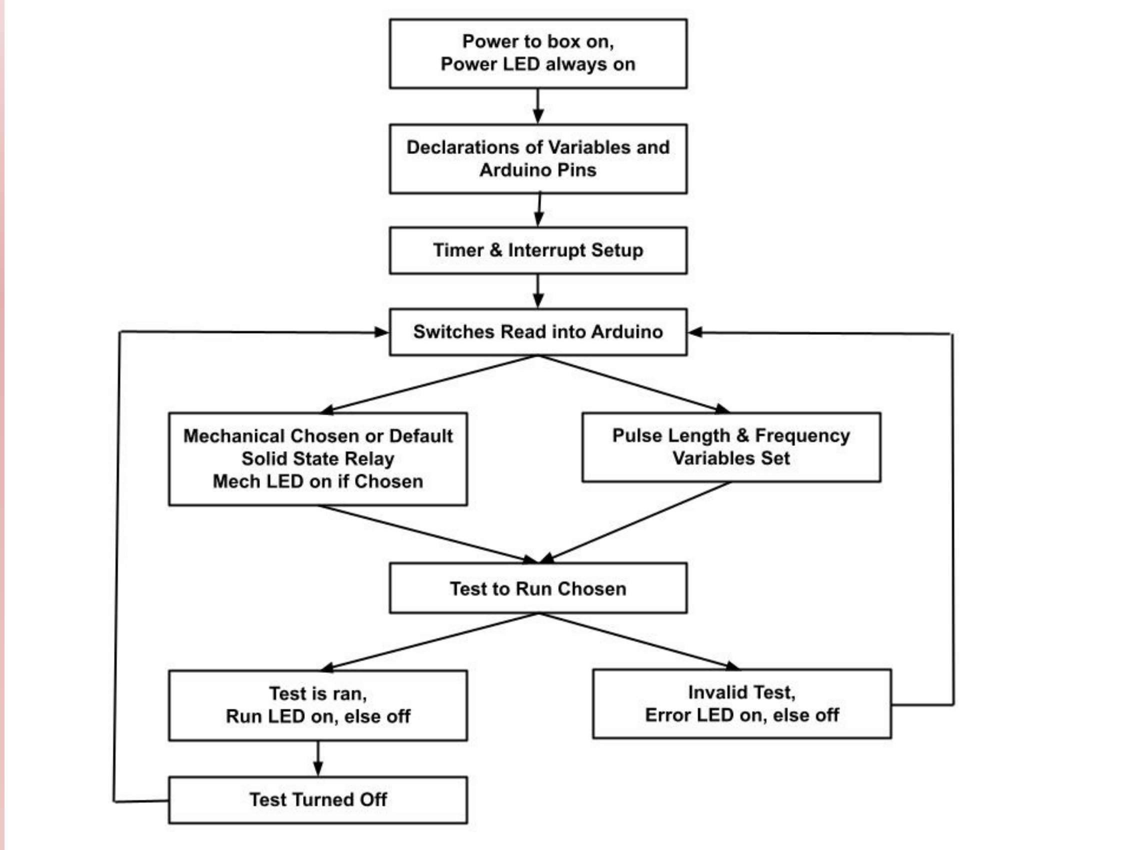
Test Plan Schedule

	A		E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U
1	**System Engineering Design Capstone Project - Semester 2 Honeywell NAC Test Box**	ate	17-Jan	24-Jan	31-Jan	7-Feb	14-Feb	21-Feb	28-Feb	7-Mar	14-Mar	21-Mar	28-Mar	4-Apr	11-Apr	18-Apr	25-Apr	2-May	9-May
2	**Tasks**																		
3	**1. Software Risk Reduction Testing**																		
4	1.1 Write Software Code																		
5	1.2 Verify User Select Switch Logic						2/12/2023												
6	1.3 Verify LED Error Functions						2/12/2023						3/28/2023						
7	1.4 Verify Output Signal to Relays						2/12/2023												
8	1.5 Verify Frequency and Pulse Length Output Parameters								2/28/2023										
9	**2. Breadboard Risk Reduction Testing**																		
10	2.1 Verify Arduino Switch Logic						2/17/2023												
11	2.2 Verify LED Indications						2/17/2023												
12	2.3 Verify Arduino Signal Output Parameters																		
13	**3. PCB Risk Reduction Testing**																		
14	3.1 Procure PCB									7-Mars									
15	3.5 Verify Solder Connection Quality																		
16	3.2 PCB Test Point Voltage (no load) Survey											3/28/2023							
17	3.3 Verify PCB Current/Voltage Parameters With Load											3/28/2023							
18	3.4 Measure Relay Output Voltage Levels												3/28/2023						
19	**4. Integration Testing**																		
20	4.1 Conduct Class 1 Mockup Fit Out								2/24/2023										
21	4.2 NAC Box Installed Component Clearance Check									2/24/2023									
22	4.3 Verify AC/DC Converter Output											3/28/2023							
23	4.4 Measure Integrated PCB Relay Voltage and Timing													4/4/2023					
24	4.5 Measure Output Signal Voltage Stability													4/4/2023					
25	**5. Qualification Testing**																		
26	5.1 Test Long-term Output Timing Stability												3/28/2023						
27	5.2 Verify Functionality of Honeywell Voltage Measuremnt Test												3/38/2023						
28	5.3 Verify Functionality of Honeywell Initial Surge Current Test												3/28/2023						
29	5.4 Verify Functionality of Honeywell Repetitive Surge Current test												3/28/2023						
30	5.5 Verify Functionality of Honeywell Electrical Noise Test															4/18/2023			
31	5.6 Prepare Qual Test Report																4/25/2023		
32	5.7 Honeywell Preliminary Demo													4/4/2023					
33											Spring Break								End of Term 2
34	Note:																		
35	Planned Tasks																		
36	Complete Tasks																		
37	Delayed Tasks																		
38	Re-planning Tasks																		

System Connection



Code Flow

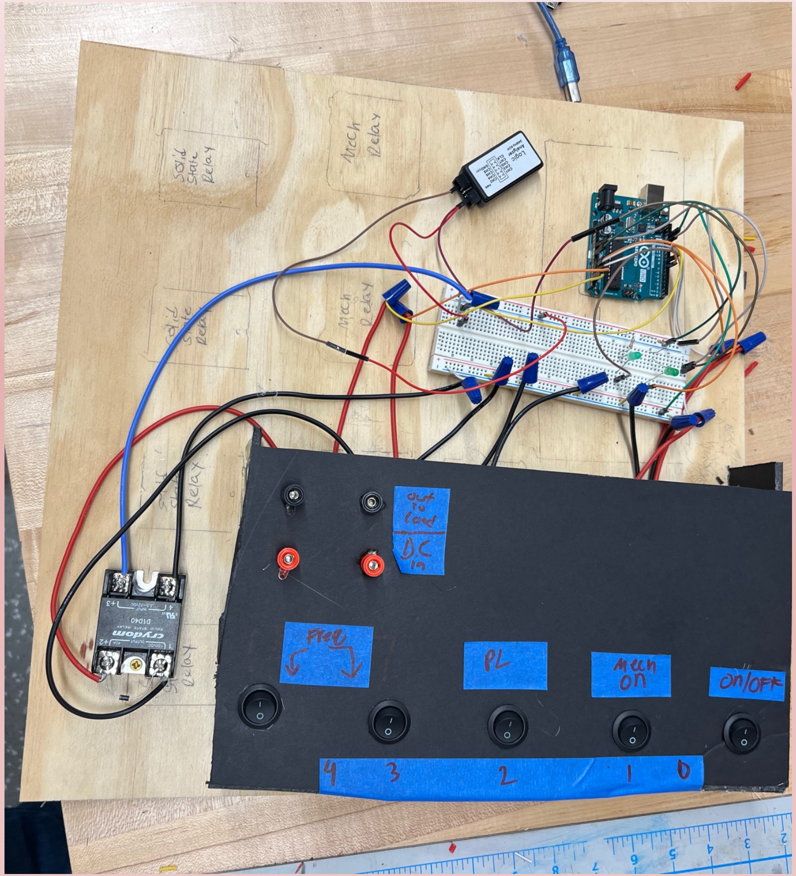

Power to box on,
Power LED always on
Declarations of Variables and
Arduino Pins
Timer & Interrupt Setup
Switches Read into Arduino
Mechanical Chosen or Default
Solid State Relay
Mech LED on if Chosen
Pulse Length & Frequency
Variables Set
Test to Run Chosen
Test is ran,
Run LED on, else off
Invalid Test,
Error LED on, else off
Test Turned Off

Prototype

Breadboard

The prototype allowed the team to quickly verify the test conditions and adjust the microcontroller code as needed.

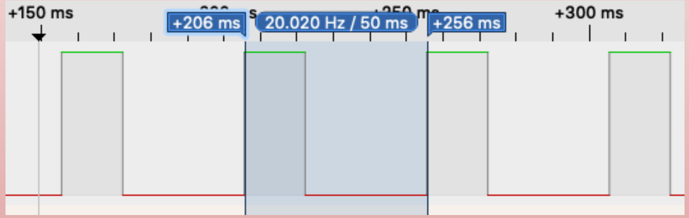
- Verified code functionality.
- Verified component functionality.
- Verified the accuracy of relay timing and test functions.

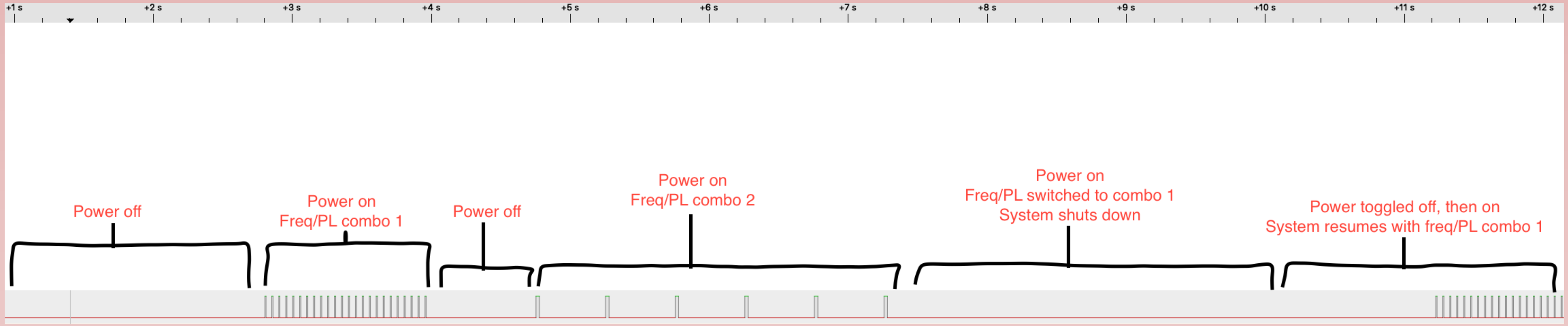


Prototype

Logic Analyzer

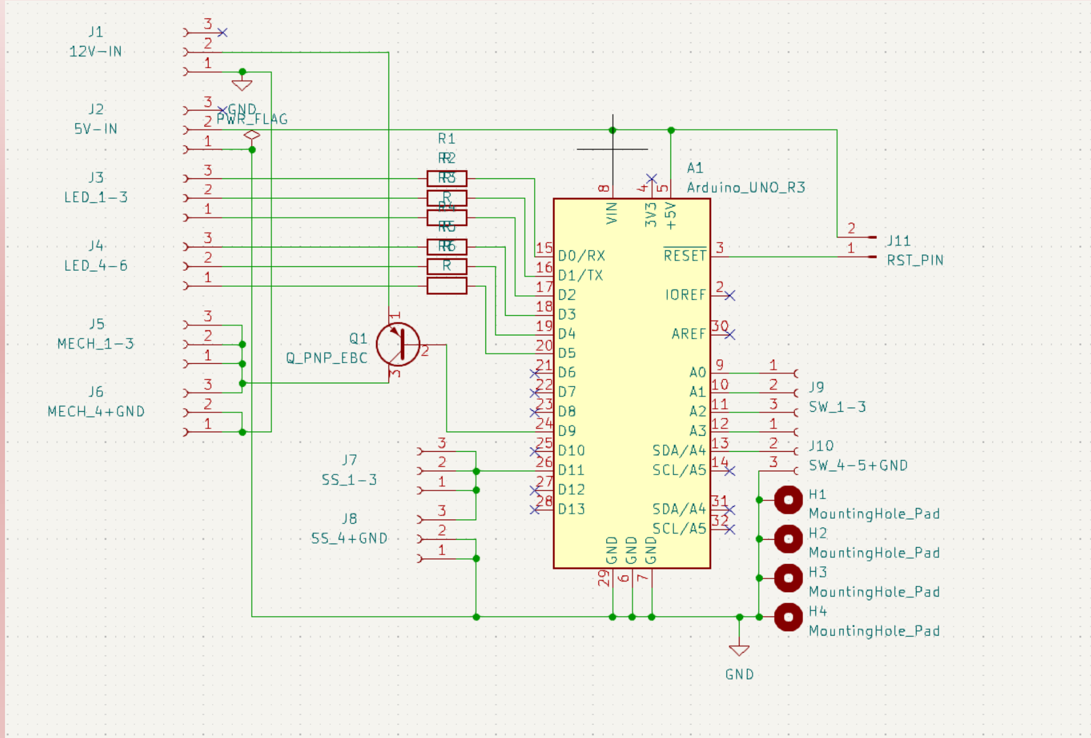
- Test conditions were verified using a Saleae-based USB logic analyzer and the accompanying PulseView software.
- The software assisted in measuring conditions for longer periods of time, verifying continuity.





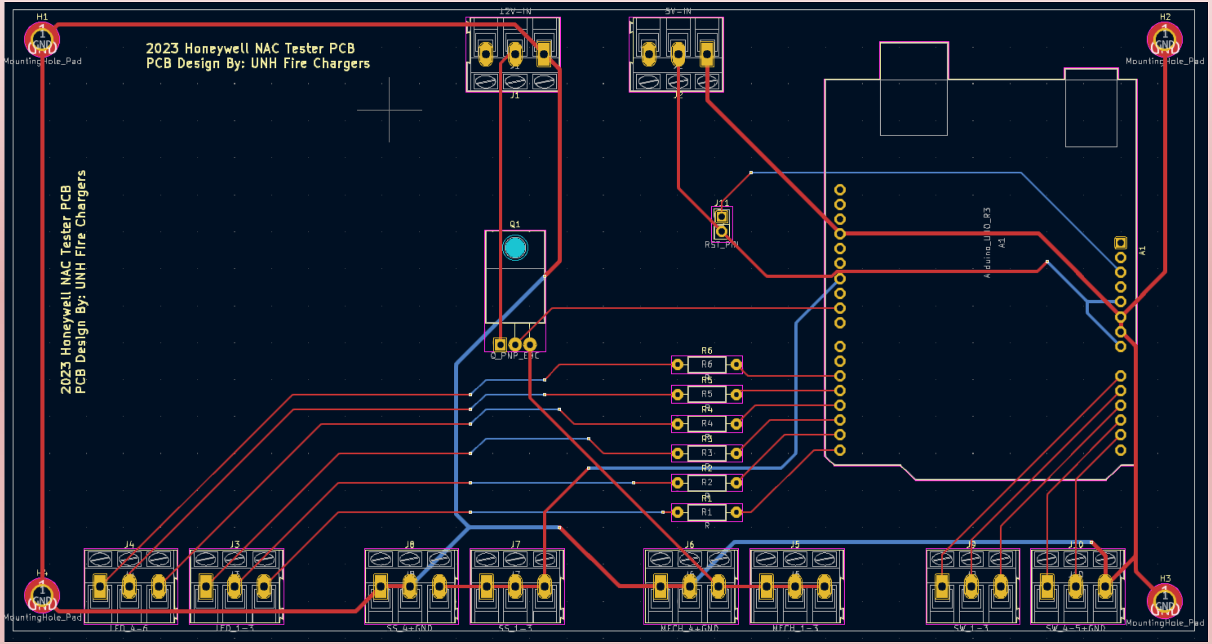
PCB Design

- Arduino microcontroller is used to drive the circuit
- A transistor is used to control mechanical relays due to higher power requirements
- Mounting holes are grounded to ensure safe and secure grounding to enclosure
- Common components are utilized to minimize risk of a component becoming EOL

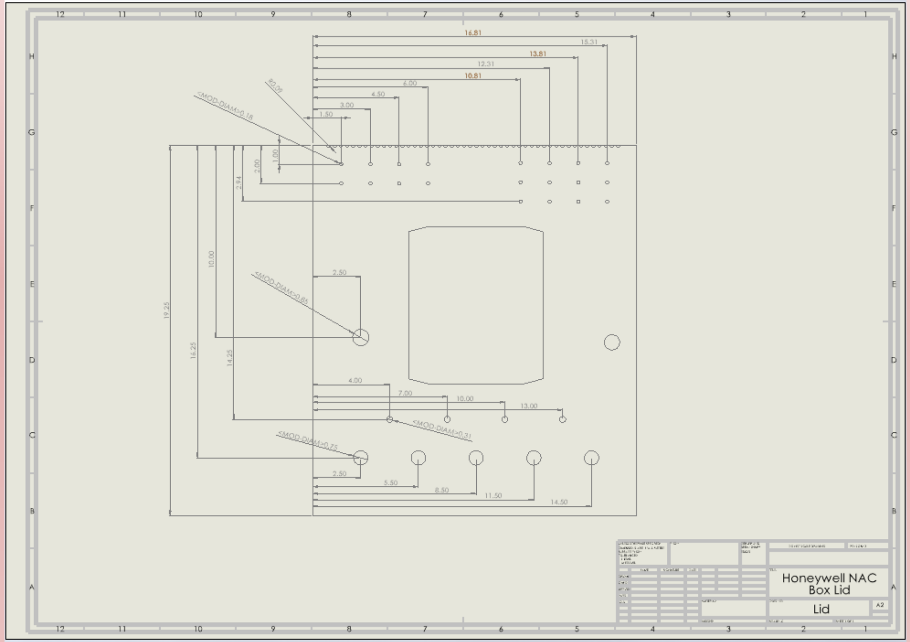


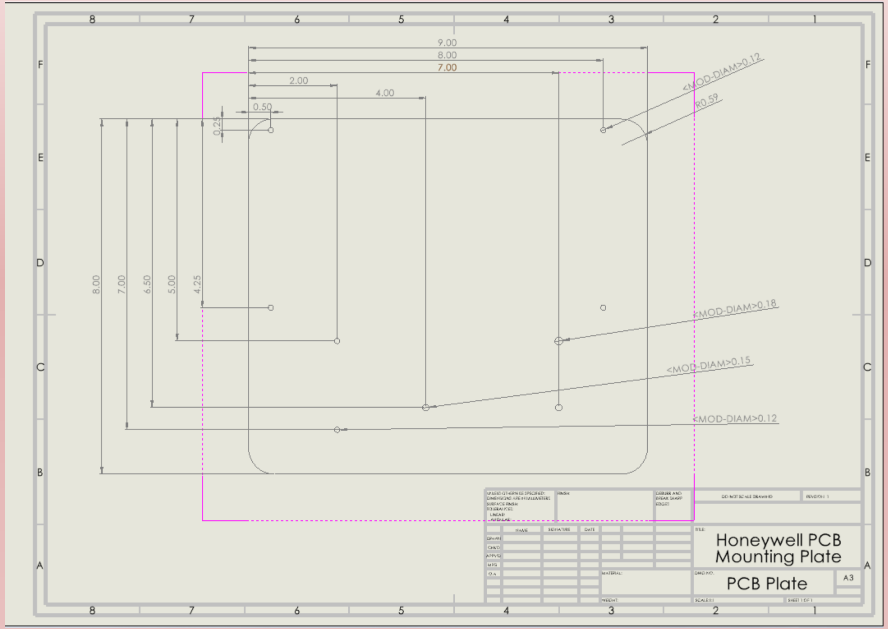
PCB Design

- All board connections are secured by screw terminals
- Arduino is removable for ease of replacement in the case of a failure
- Reset switch is available in the case of a software malfunction
- Redundant power sources for Arduino to improve reliability

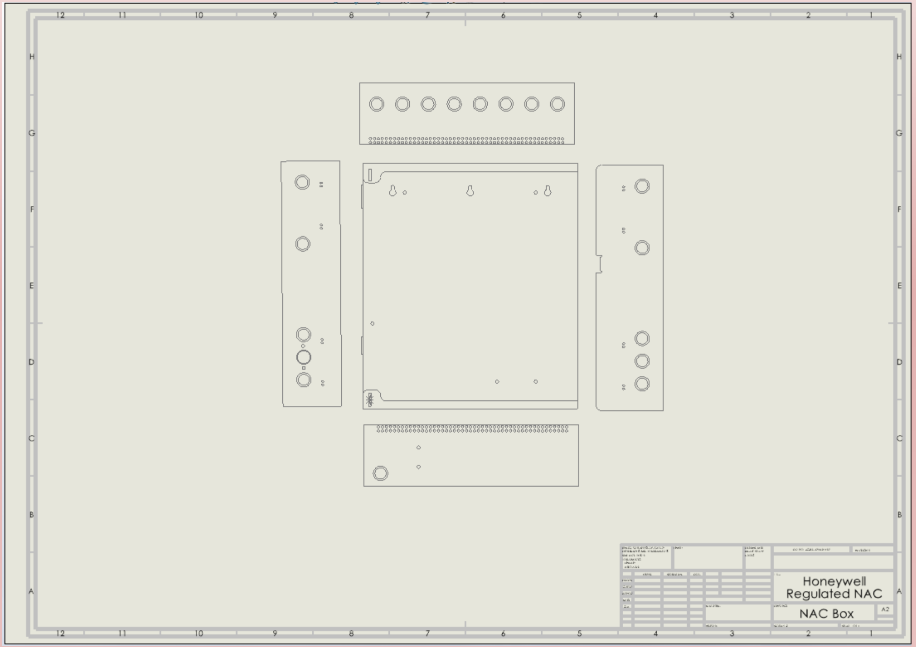


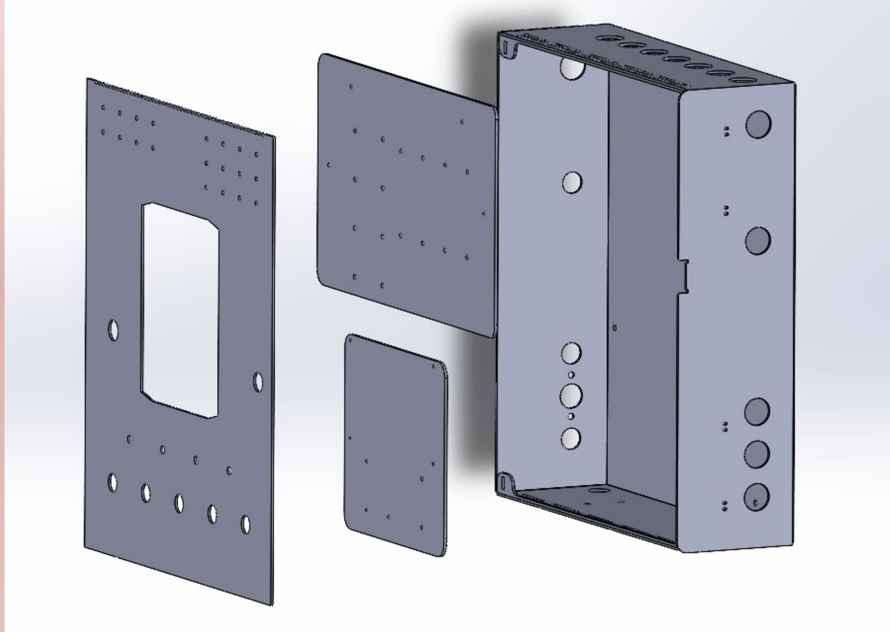
Enclosure Design





Enclosure Design

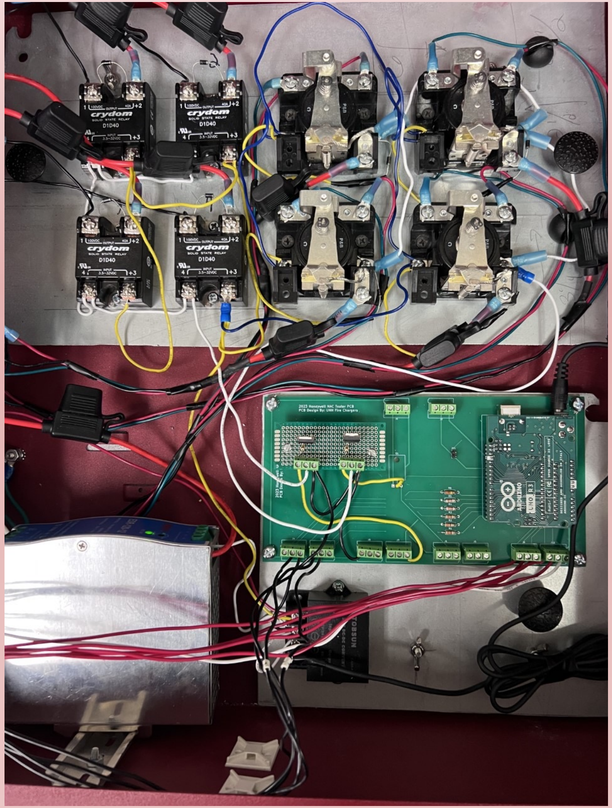




New Test Box Features

- Arduino microcontroller on PCB for quick code uploads and future updates
- Removable mounting plates and wires for easy maintenance for components
- New rocker switches for a more ergonomic design
- Emergency stop button added to cut off 120V power to the box
- Added fuses for internal circuit protection

NAC Test Box Design



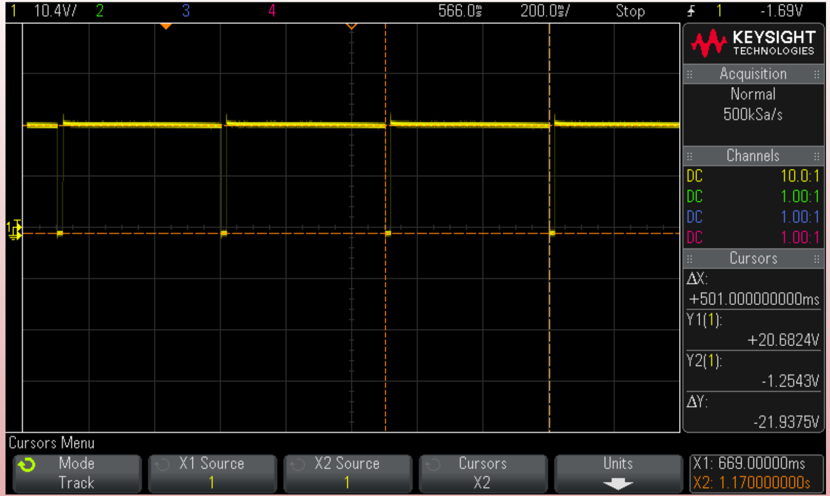
Cost

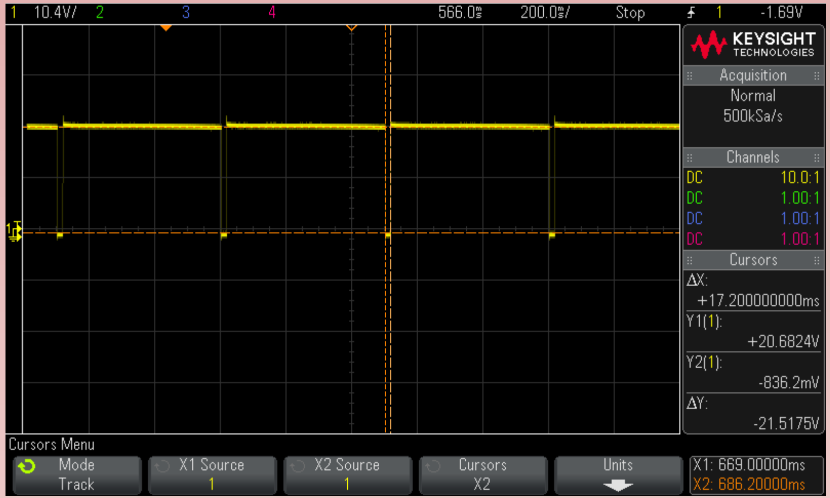
- Final Cost: $1,100
  - Included in cost: wires, hardware, relays, wires, LEDS, switches, and electrical components

Item #	Manufacturer	Part ID #	Part Overview	Cost Per Unit	Item Quantity	Final Cost
1	TE Connectivity	PRD-74AY0-120	Mechanical Relay	$ 52.62	4	$ 210.48
2	Crydom	D1D40	Solid-State Relay	107.45	4	$ 429.80
3	Arduino	A000066	Uno Rev3	28.5	1	$ 28.50
4	Mxuteuk	39122216	E-Stop	14.88	1	$ 14.88
5	DaierTek	KCD1-101	Rocker Switch	0.8	10	$ 8.00
6	TuoFeng	AUB085QD9DWP	Wires	15.99	2	$ 31.98
7	Nilight	NI-FH01	Fuse Holders	9.55	1	$ 9.55
8	CrocSee	B0895PV8S2	Fuses	13.99	1	$ 13.99
9	Texas Instruments	CD4051BE	IC	0.74	3	$ 2.22
10	Tegg	STB-3PIN-5MM-20	Terminal Block	0.4	20	$ 8.00
11	Eboot	LN0628	LED	0.08	4	$ 0.32
12	Tobsun	B09WZ9DC9W	12v to 5V convertor	10.97	1	$ 10.97
13	Nikou	B07YKYP8MN	Banana Jack	0.43	20	$ 8.60
14	Wirefy	RSSV2-5S-130	Fork Connectors	0.15	130	$ 19.50
15	Baomain	B01N5APVEE	Insulated Spade Connectors	0.07	100	$ 7.00
16	MCIGICM	B07Z7LTNR5	Spade Connectors	0.05	200	$ 10.00
17	Hoffman	39121301	Mounting Plate	110.47	1	$ 110.47
18	NVVV	B0932WDCYW	120V-12V Power Supply	27.99	1	$ 27.99
19	Bridgold	B07LFZ34C3	PNP Transistor	0.4	20	$ 8.00
20	STMicroelectronics	B06ZY654XN	TIP120 NPN Transistor	0.63	2	$ 1.26
21	SINGARE	B079DN31SW	PCB Prototype Board	0.28	2	$ 0.56
22	JLCPCB	FirecChargers1	PCB Board	1	40	$ 40.00
23	Bridgold	B07R49F39B	NPN	0.4	20	$ 8.00
24	Everbilt	803761	#8-32 x 3/4 machine screw	0.17	8	$ 1.36
25	Everbilt	803751	#8-32 x 1/2 machine screw	0.17	8	$ 1.36
26	Everbilt	803681	#6-32 x 1/2 machine screw	0.17	8	$ 1.36
27	Everbilt	800181	#8-32 Wing Nut	1.38	4	$ 5.52
28	Everbilt	803111	#8-32 x 1 machine screw	0.17	8	$ 1.36
29	Everbilt	803331	#10-32 x 3/4 machine screw	0.17	8	$ 1.36
30	Everbilt	803181	#10-24 x 1/2 machine screw	0.17	8	$ 1.36
31	Liberty	P94500H-BL-C	Mounting Plate Knon	0.93	4	$ 3.72

Test Method I

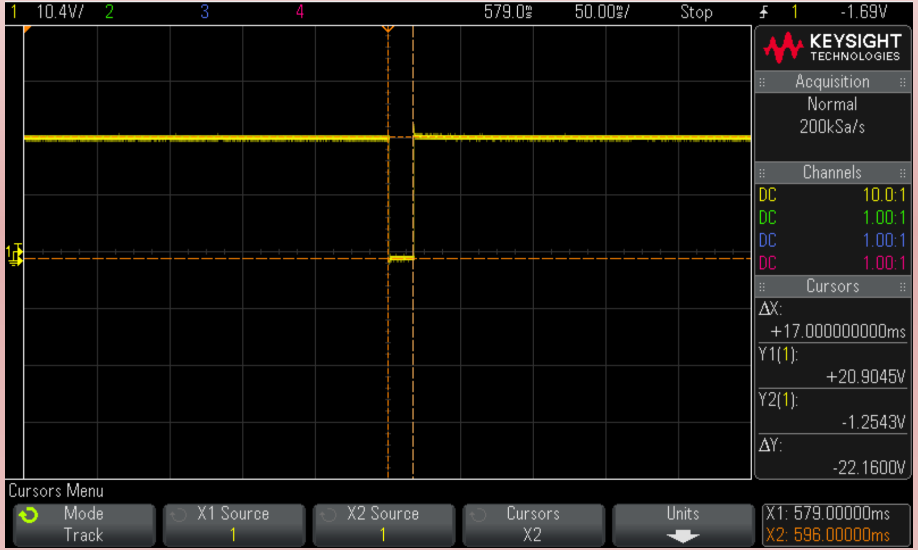
- This test simulates a low voltage. This ensures that the test panel can continue to output within the voltage range in the case of a drop in voltage.
- The test conditions were as follows:
    - Minimum 16.7ms pulse length
    - Minimum 2 Hz (0.5s) frequency
    - 30-minute ideal runtime
- The tester box performs as follows:
    - 17.2ms pulse length
    - 1.996 Hz (0.501s) frequency





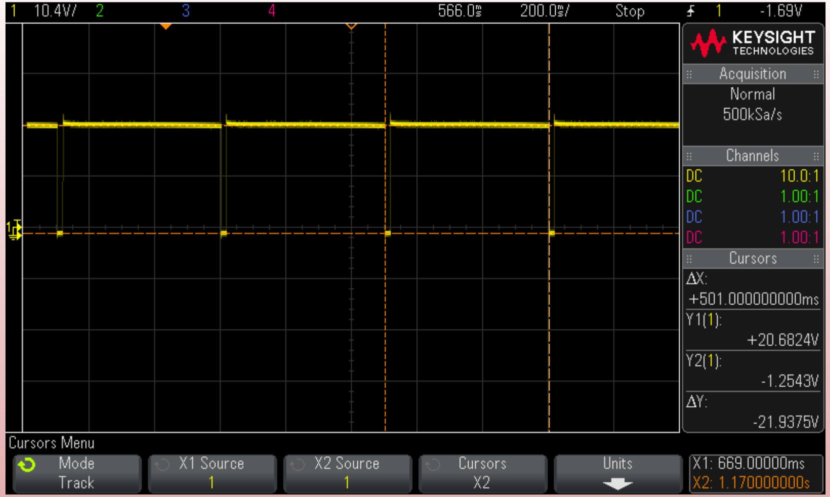
Test Method II–A

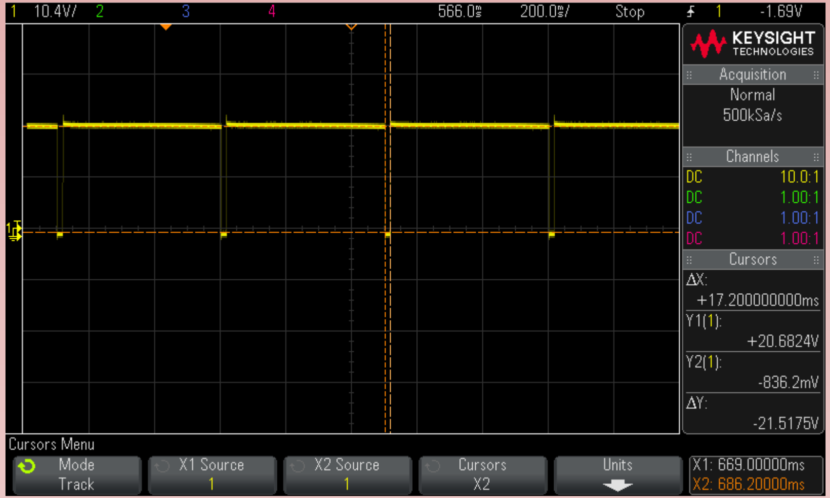
- This test simulates an initial surge current. This ensures that a test panel does not misfire, reset, or fail in the case of initial inrush current.
- The test conditions were as follows:
    - Minimum 16.7ms pulse length
    - Minimum 16.7 mHz (60s) frequency
    - 50-minute ideal runtime
- The tester box performs as follows:
    - 17.0ms pulse length
    - 16.7 mHz (60s) frequency



Test Method II–B

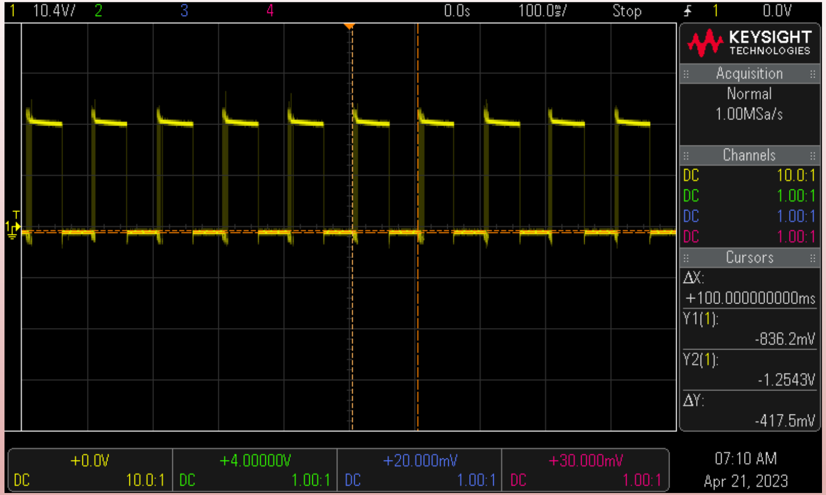
- This test simulates a repetitive surge current. This ensures that a test panel can handle the repetitive surges of current while an alarm is active.
- The test conditions were as follows:
  - Minimum 16.7ms pulse length
  - Minimum 2 Hz (0.5s) frequency
  - 15-minute ideal runtime
- The tester box performs as follows:
  - 17.2ms pulse length
  - 1.996 Hz (0.501s) frequency

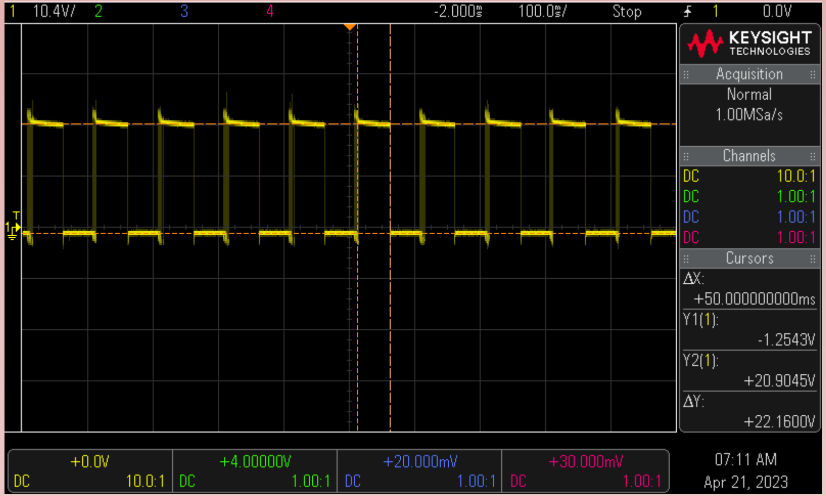




Test Method II–C

- This test simulates electrical noise. This ensures that a test panel is not affected by the electrical noise of mechanical components, such as the chatter of a school bell.
- The test conditions were as follows:
  - Minimum 50ms pulse length
  - Minimum 10 Hz (0.1s) frequency
  - 15-minute ideal runtime
  - Use of mechanical relays instead of solid-state relays
- The tester box performs as follows:
  - 50ms pulse length
  - 10 Hz (0.1s) frequency





Thank You!

Questions?