SENIOR DESIGN PROJECT SUMMARY SLIDE

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INTRODUCTION - DAQ

- DAQ – Data Acquisition System
  - Measure physical signals and convert them into digital signals to view
  - Oscilloscope – DAQ for specifically voltage signals
- Problems with current DAQs
  - Expensive
  - Difficult to maintenance
  - Closed system that is hard to observe

COVID-19 RESPONSE PLAN

- **COVID-19 shifts project from physical implementation to simulation demonstration tested for multiple different cases.**
  - Two or three weeks spent on adjusting project
  - Most purchased physical components purchased became obsolete for the project demonstration

- **Analog section was simulated using TI TINA**
  - All team member are familiar with TI TINA software
  - TINA comes with built in spice models for TI ICs

COVID-19 RESPONSE PLAN

- **Remove objectives for physical implementation and PCB design**
  - PCB designs of implementation complete, but not used
  - Physical component are obsolete, but the restrictions of the components were implemented in simulation
    - System Voltage from power supply
    - Signal conditioning
    - Microcontroller conditioning

COVID-19 RESPONSE PLAN

- **New objectives to convert analog system to circuit simulation**
  1. Develop TINA circuits for all designed circuits
  2. Verify the operation of all TINA circuits through simulation
  3. Link TINA circuits to create simulation flow
     - Export/import to transfer signals between circuits
     - Excel Macro developed to format data for import
     - Establish communication protocol to export data in TINA to be read in LABVIEW
  4. Develop demonstration videos of the DAQ system

COMMUNICATION PROTOCOL

- Developed and agreed upon by the analog section and the digital section to communicate the signal in the analog section to the digital section.

- The signal from the analog section in TINA was exported and read by the digital system as a CSV. The first three lines contained system information about the signal and the remaining lines contained data.

1	0.05	Maximum Time in milliseconds
2	500	Voltage offset in mV
3	100	Scaling factor = 10*(Selected Voltage Division)
4	0.506014	Data
5	0.506014	
6	0.506014	
7	0.506014	
8	0.506014	

ANALOG SPECIFICATIONS

- System Voltage: $\pm 12\mathrm{V}$ based on purchased power supply
- Maximum Frequency: $1\mathrm{MHz}$
- Composed of multiple simple individual TINA circuit files
  - Easier to comprehend each circuit in the system
  - Reduced simulation time
- 4 Analog Input Probes: $\pm 50\mathrm{V}$
  - 3 Voltage Division Options: 1:5, 1:10, 1:20
  - Operates on 2 selected probes: Channel 1 and Channel 2
    - Channel 1 is the primary probe
    - Channel 2 is the auxiliary probe
- 4 Digital Input Probes: $\pm 50\mathrm{V}$
  - Regulates Voltage to logic voltages
    - Logic 1: 3.3V
    - Logic 0: 0V

ANALOG COMPONENTS

- **Linear Power Supply HBB15 – 1.5 - AG**
  - System Voltage $\pm 12V$ DC with small ripple
  - Maximum current: 1.7A
  - Maximum Power : 40W
- **Operational Amplifier: LM318**
  - Used for all operational amplifier circuits
  - Texas Instruments IC included in TINA
  - Bandwidth: 15 MHz
- **Analog Multiplexer: DG408**
  - 8:1 Analog multiplexer used for selecting signals
  - Break before make switching
  - Switch time: <250ns

ANALOG SECTION DESIGN CHANGES

- **Analog Input voltage Changed**
  - Analog Input voltage changed from $\pm 100\text{V}$ to $\pm 50\text{V}$
  - Reduced to match system voltage limits with 1:5 Probe
  - Alternative was to increase system voltage with new power supply
- **FFT Equalizer Operation Removed**
  - The operation was designed to split the signal into multiple frequency bands to observe the different frequency components of a signal. The gain of the different bands could be changed to increase certain frequencies while attenuating other frequencies.
  - The equalizer operation was removed due to time constraints due to the change in the project design and COVID-19.
  - The aspects of the equalizer design were implemented in the differentiation and integration equalizers.

ANALOG SECTION DESIGN CHANGES

- **Single wide band integrator and differentiator replaced with integration and differentiation equalizer**
  - The frequency range from $1\ \mathrm{Hz}$ to $1\ \mathrm{MHz}$ was six decades. Using one low pass filter and one high pass filter will cause extreme attenuation.
  - A system of six low pass and high pass filters that each operated on one decade of the frequency range to limit attenuation.
  - Equalizer design based on removed FFT equalizer operation.

LIMITATIONS OF CIRCUIT SIMULATION DESIGN

- **Limited communication between different analog components**
  - No communication about what voltage division was selected
  - The only communication between files was through imported/exported signals

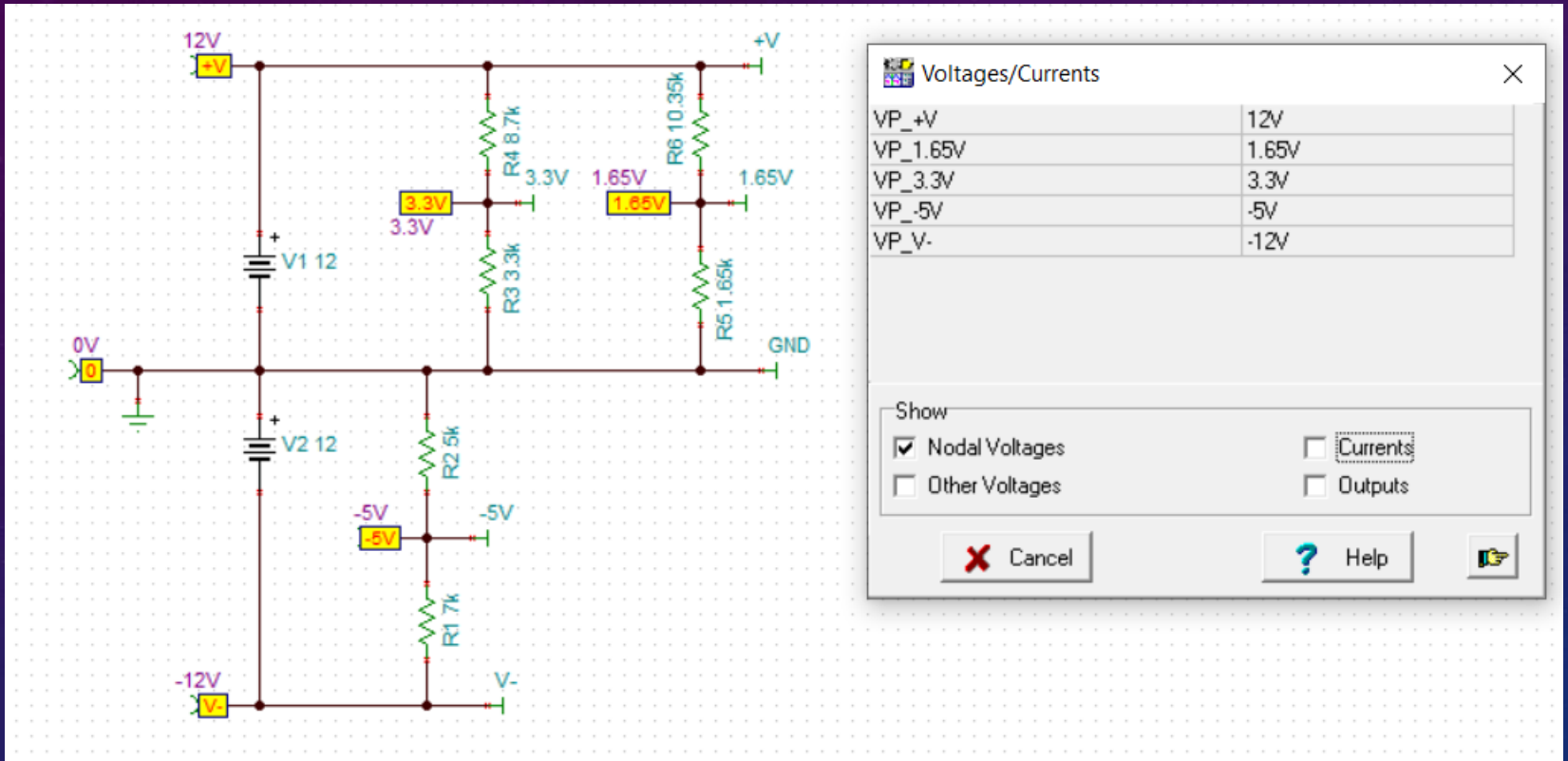
- **Limited communication between analog section and digital section**
  - The digital section could not control the different control switches in the analog section.
  - The only communication between systems was through the CSV file.

LIMITATIONS OF CIRCUIT SIMULATION DESIGN

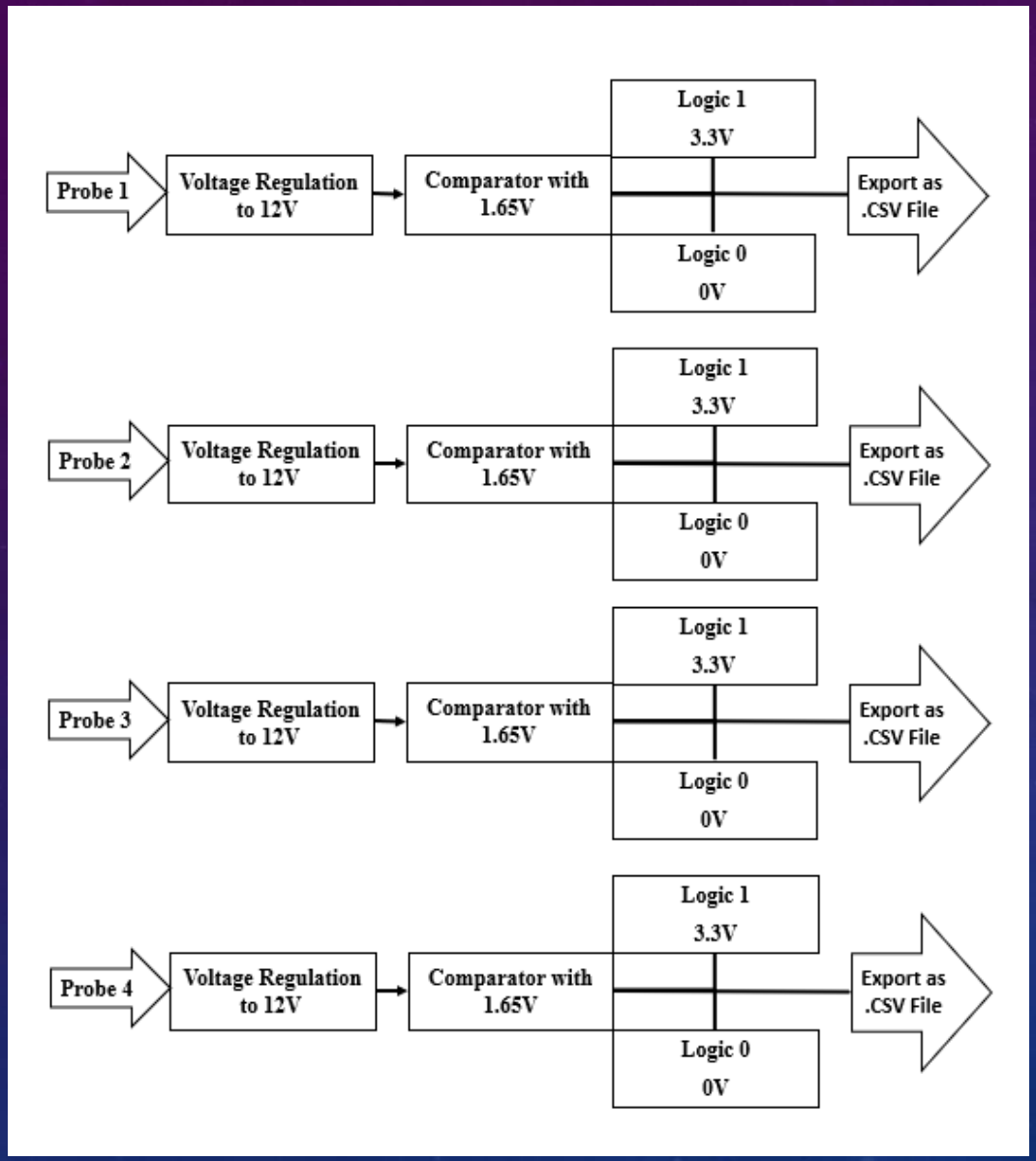
- **Analog sampling was based on TINA simulation**
  - The digital section could not control the sampling of the signal in the analog section.
  - TINA simulations did not generate points using a constant sampling time.
  - The DAQ system assumed a constant sampling time, so the display may appeared stretched or compressed.

1	*Time	Probe 2 1_10
2	0	0.012788
3	1.74E-07	0.260361
4	2.04E-07	0.31072
5	2.47E-07	0.388099
6	3.05E-07	0.495701
7	3.50E-07	0.575874

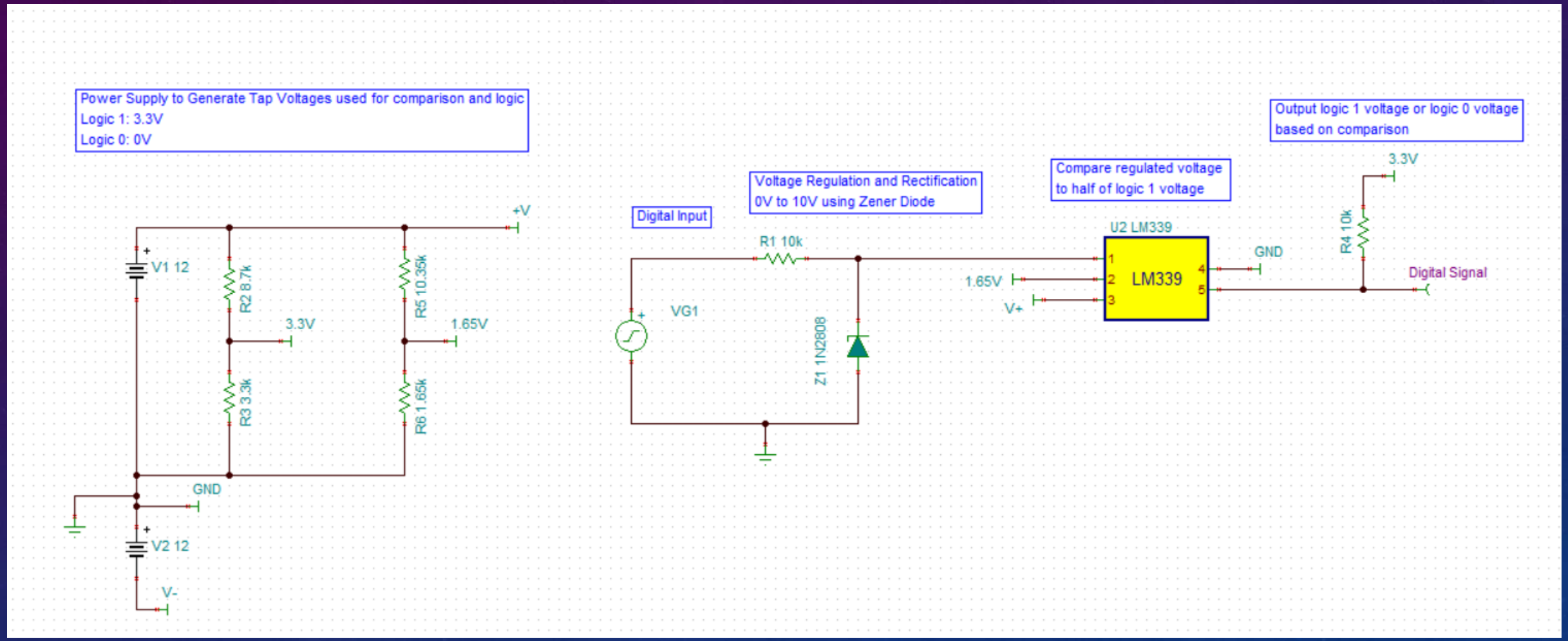
POWER SUPPLY CIRCUIT



BLOCK DIAGRAM DIGITAL INPUTS

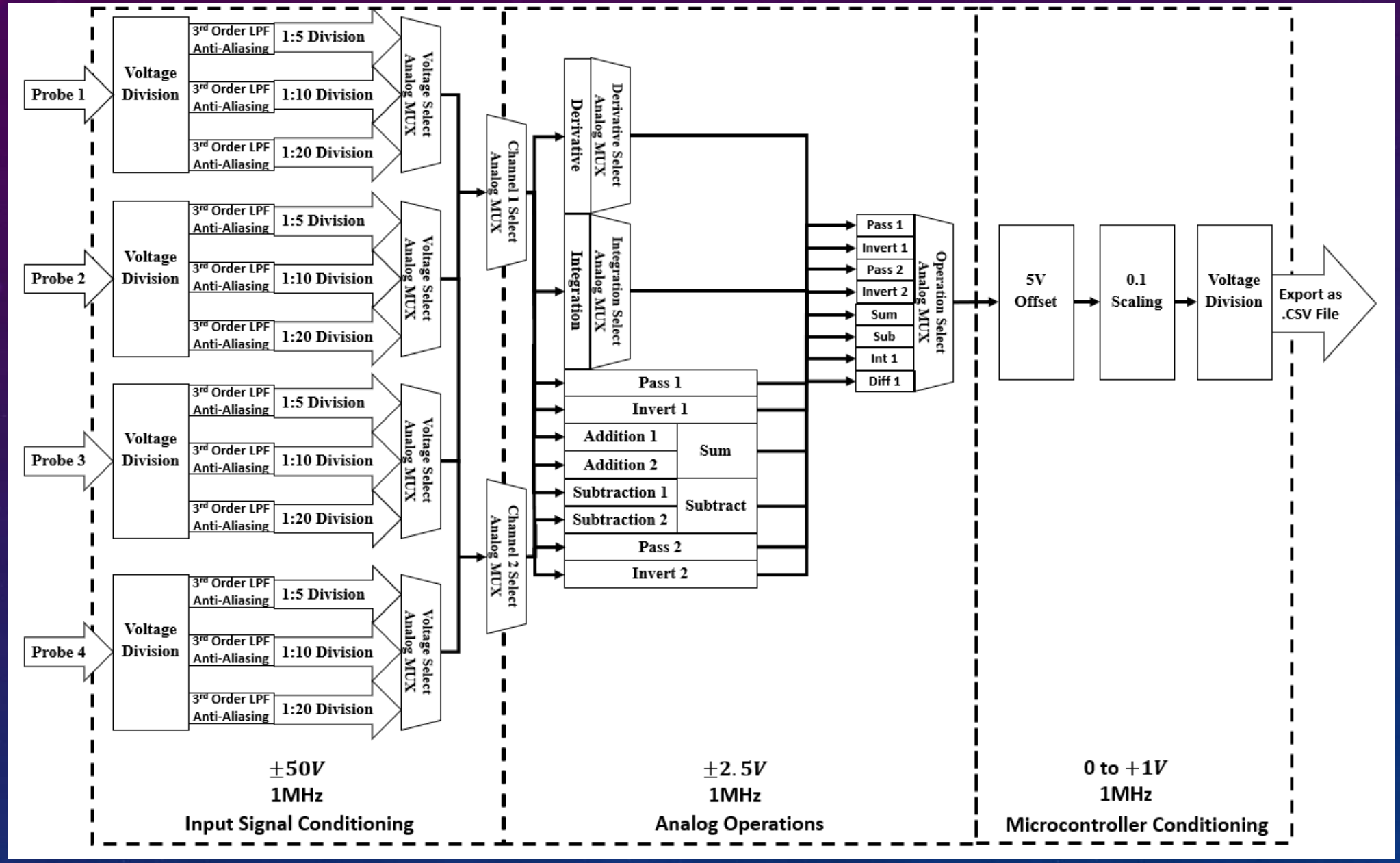


DIGITAL INPUT CIRCUIT



DIGITAL INPUT SIMULATION

BLOCK DIAGRAM – ANALOG INPUTS



Testing Process

- Types of Waves
  - Sine
  - Triangle
- Voltage Levels
  - 10
  - 20
  - 50
- Frequencies
  - 1 kHz
  - 10 kHz
  - 253 kHz
- Operations
  - Pass
  - Invert
  - Addition
  - Subtraction
  - Differentiation
  - Integration
- DC

Requirements

Tina

- Adds data points
- Exports multiple outputs in one file
- Only reads tab delimited

Microcontroller

- Only reads comma delimited .CSV

Solutions

Macros

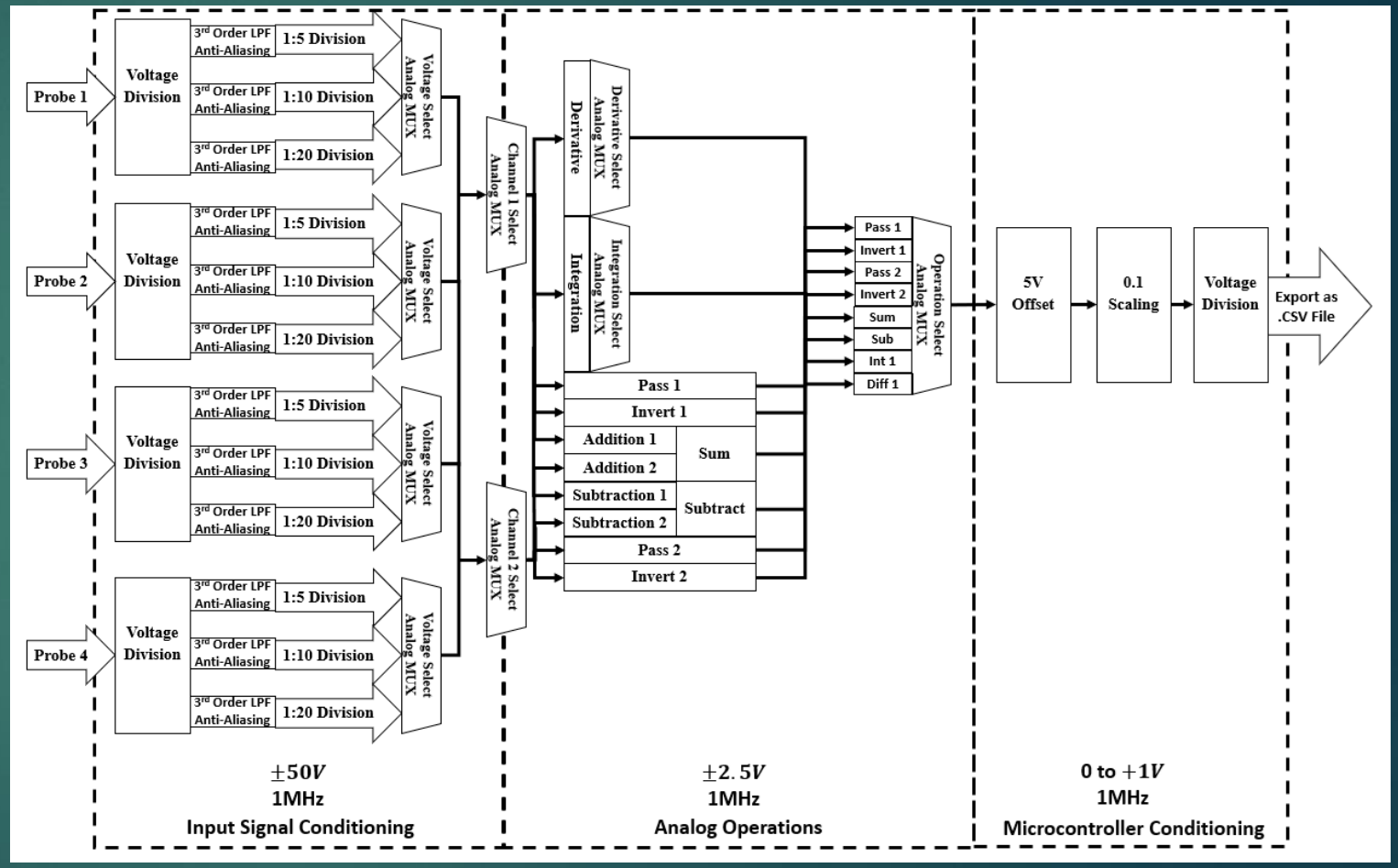
- Separate data points
- Separate data points & reduce by an order of magnitude
- Add & remove necessary information for the microcontroller to use

Manual

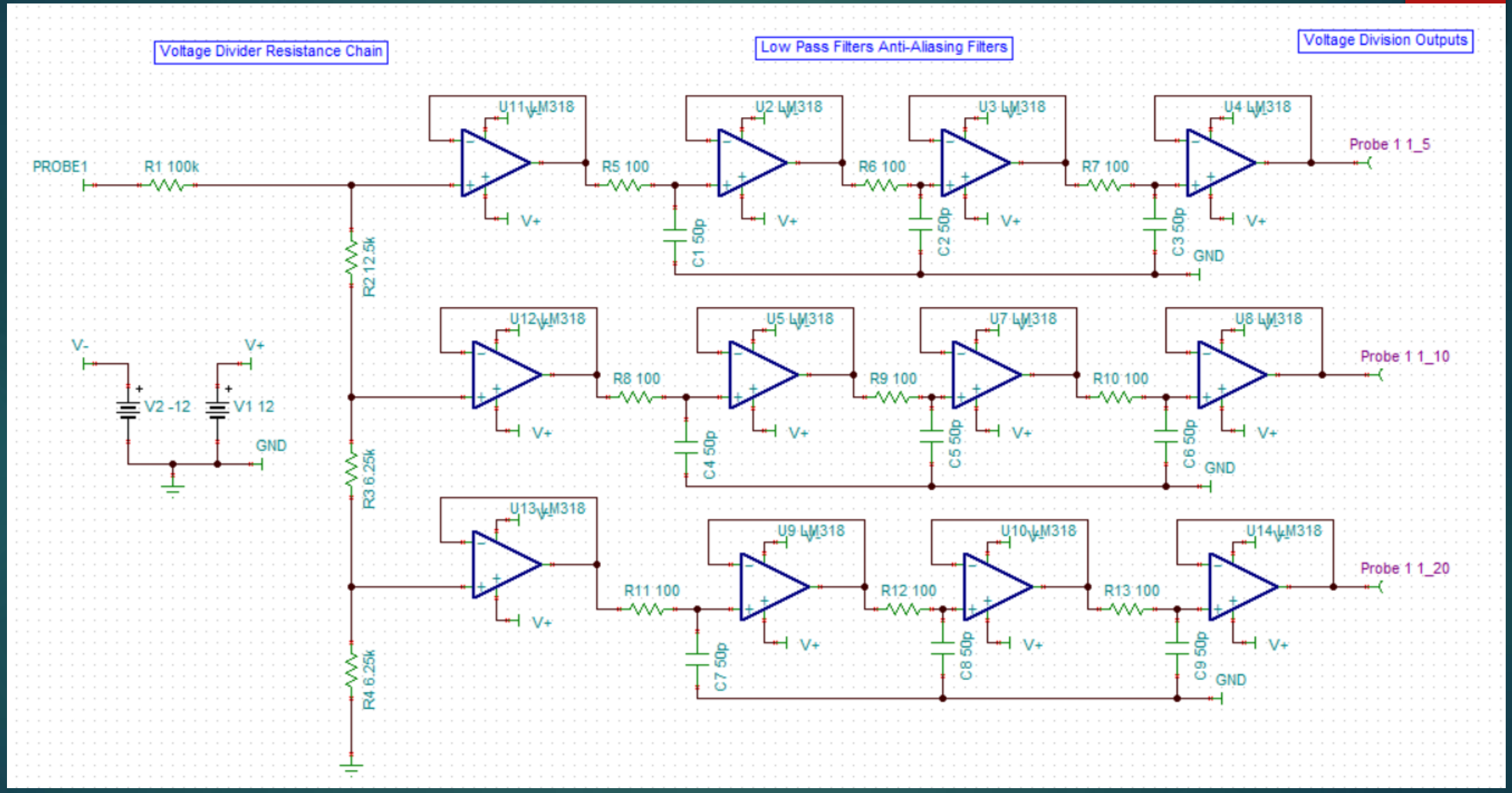
- Save as tab delimited
- Save as comma delimited .CSV
- Importing & Exporting

The Process

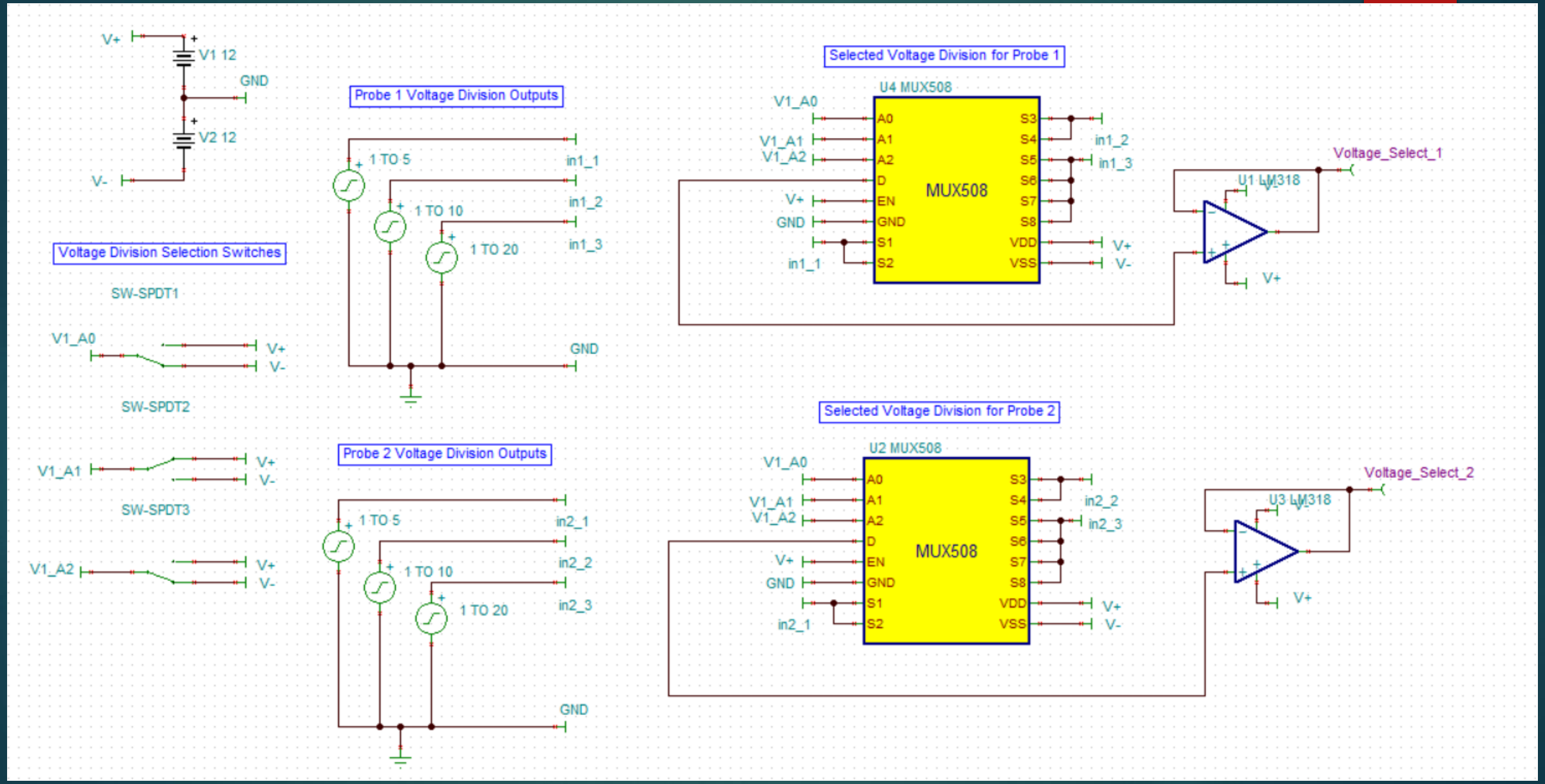
- Create or import signal
- Run the simulation
- Export as text
- Import to Excel
- Run required macro
- Save results as correct file type
- Import to Tina



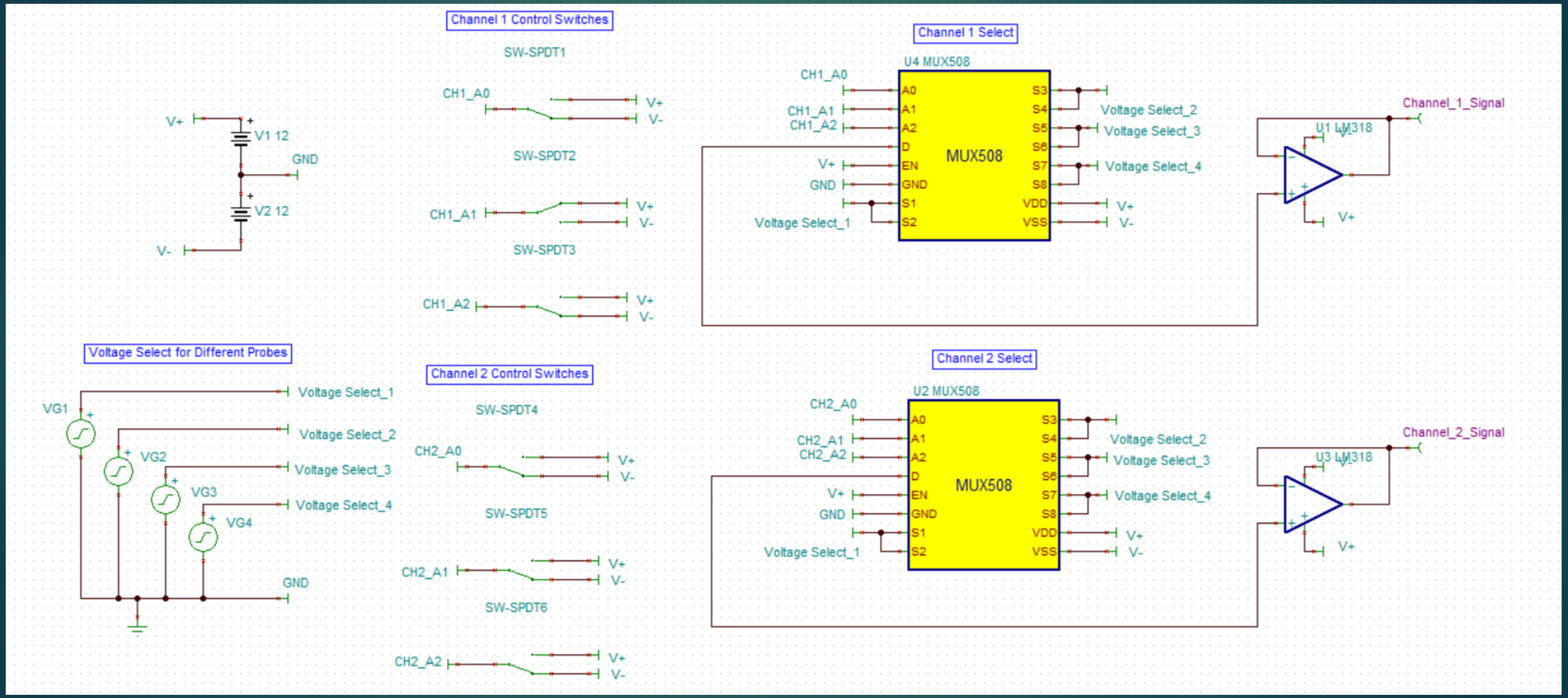
Analog Input Circuit



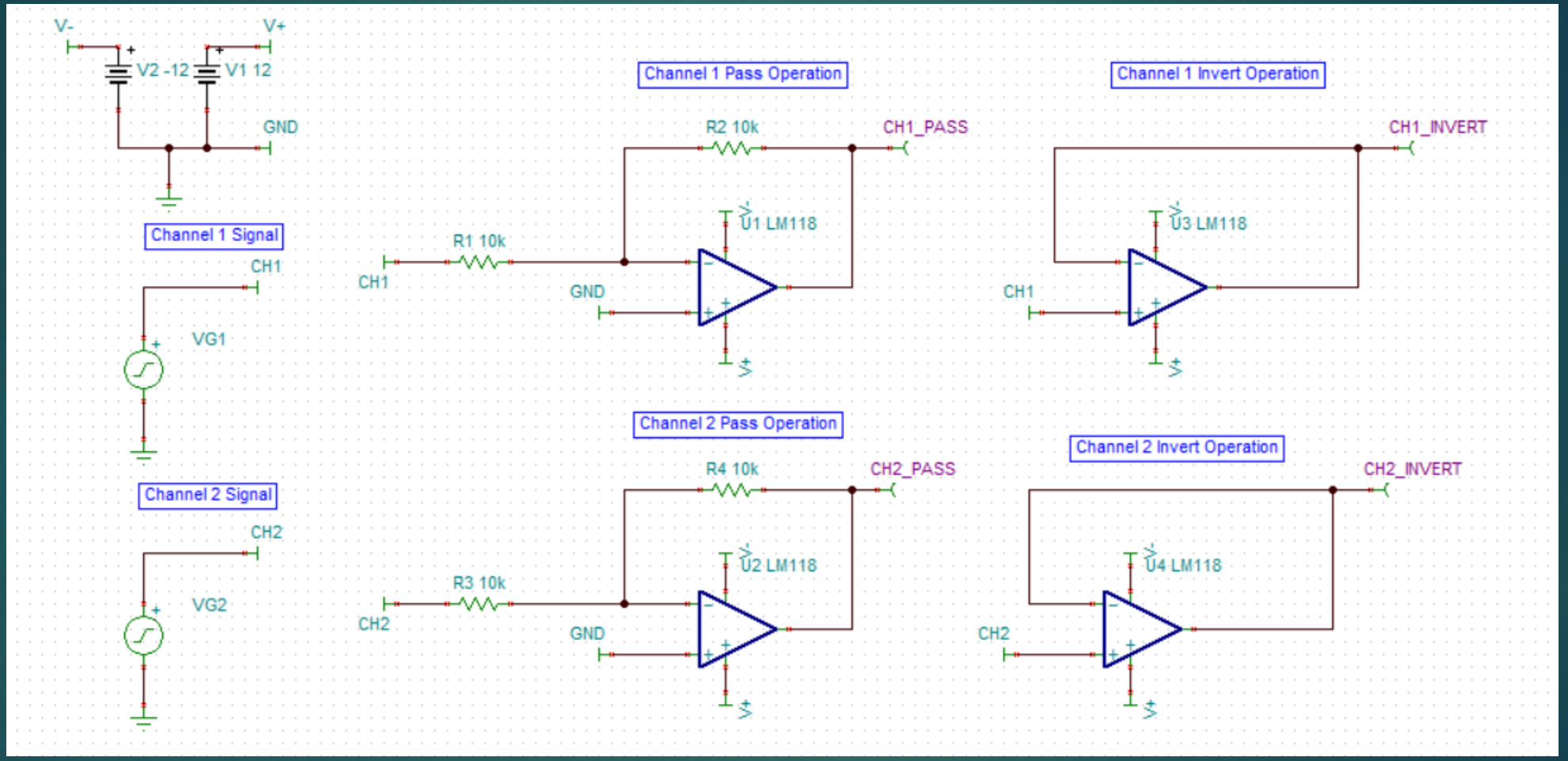
Voltage Select Circuit



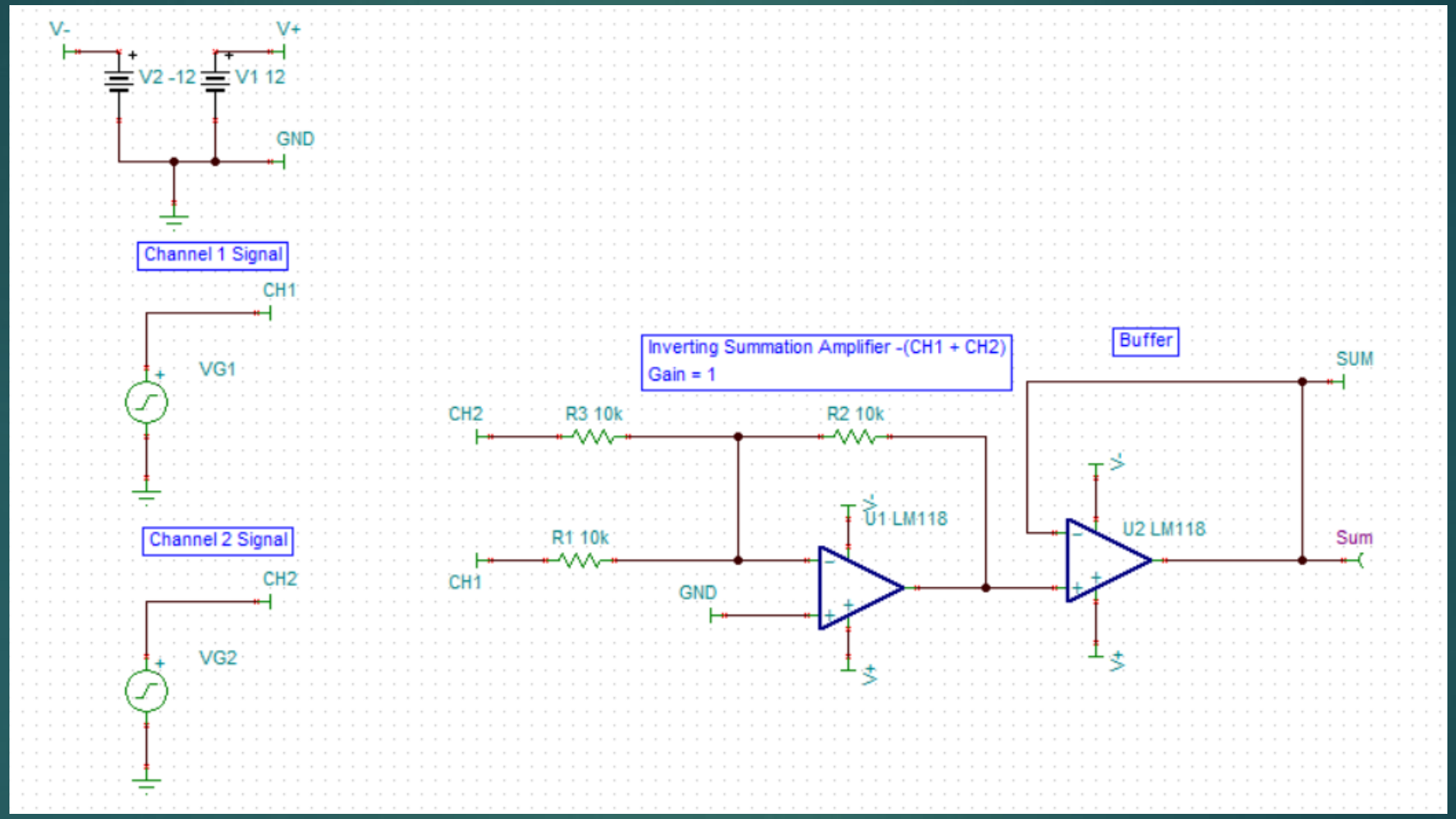
Channel Select Circuit



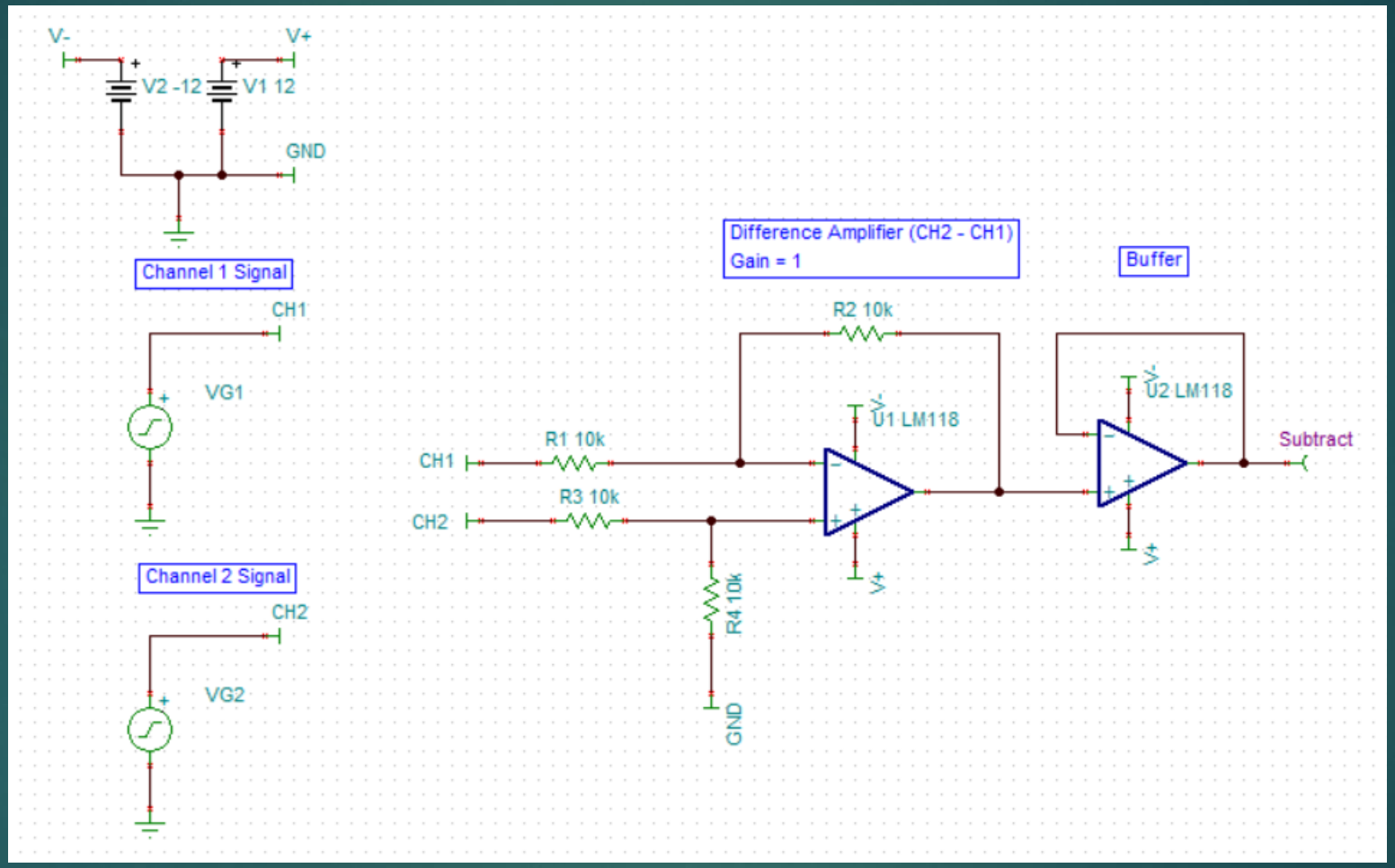
Pass and Invert Operations



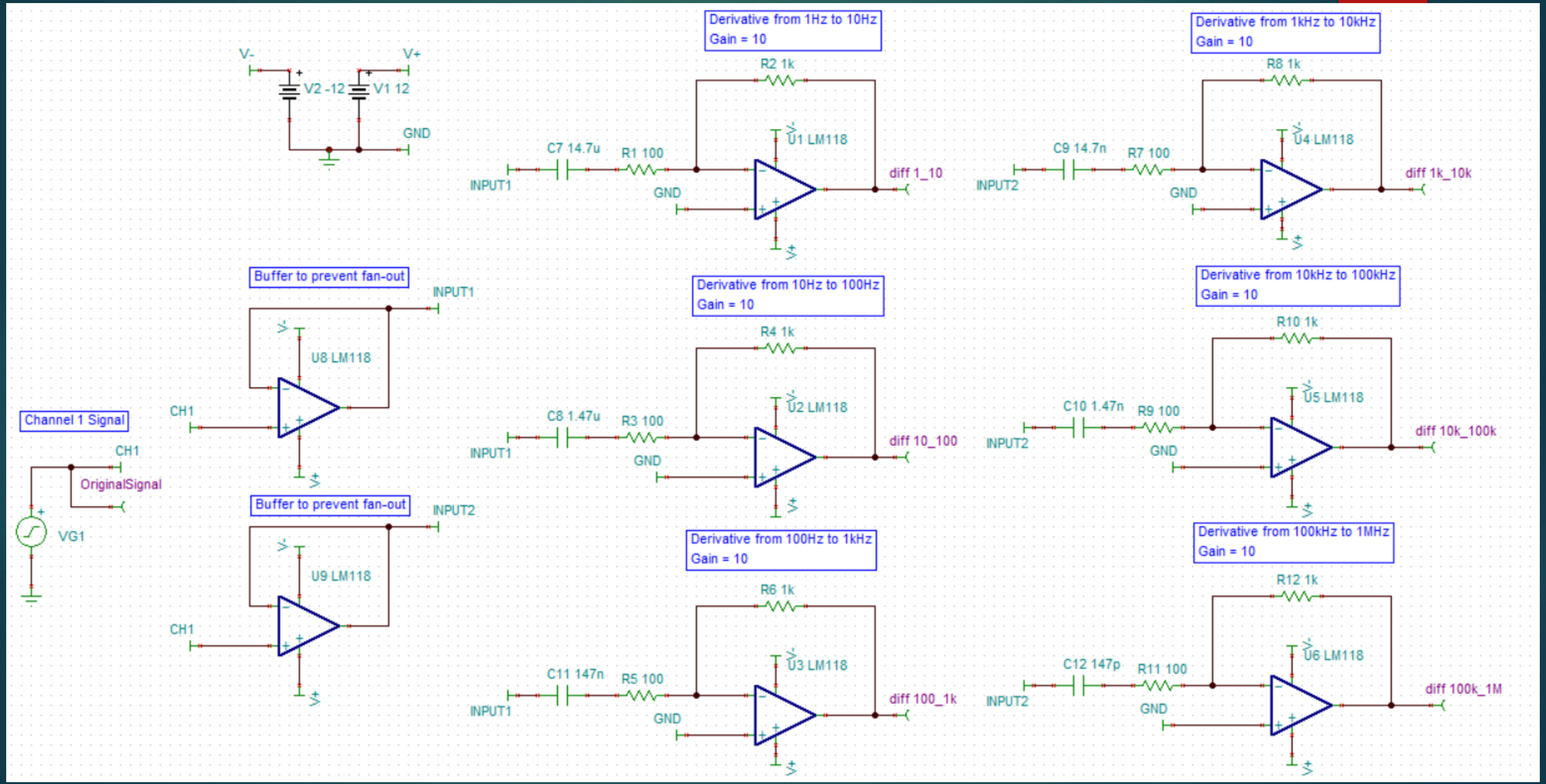
Addition Circuit



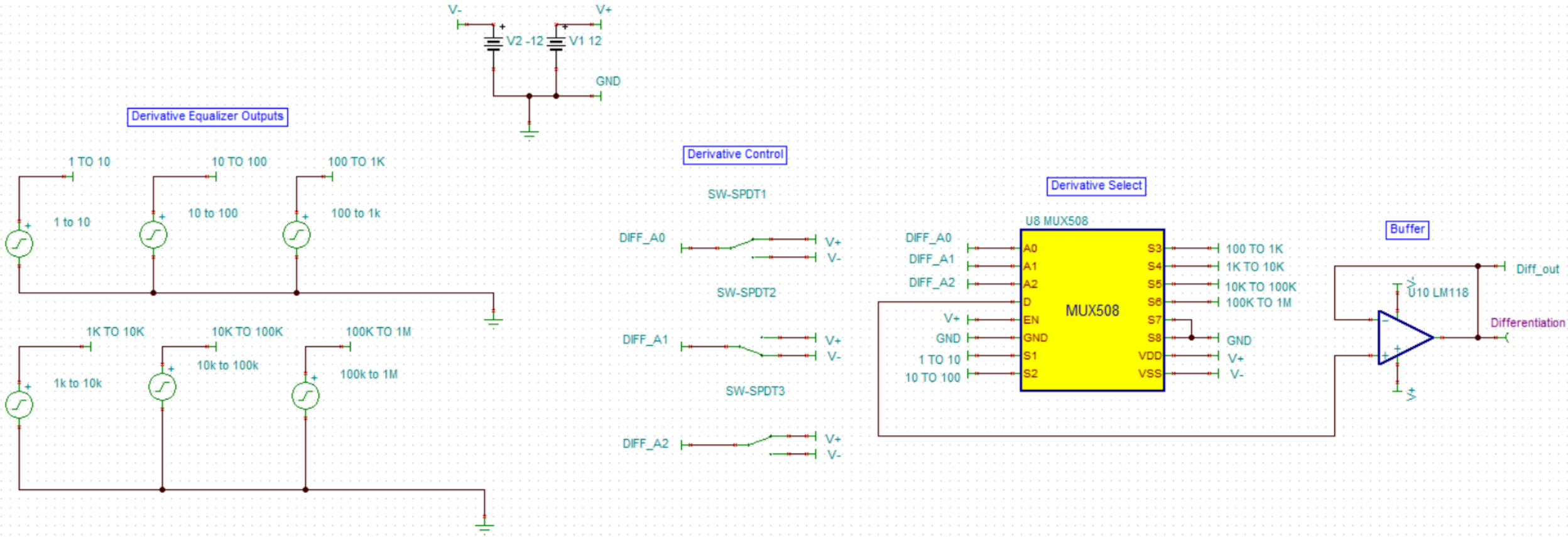
Subtract Circuit



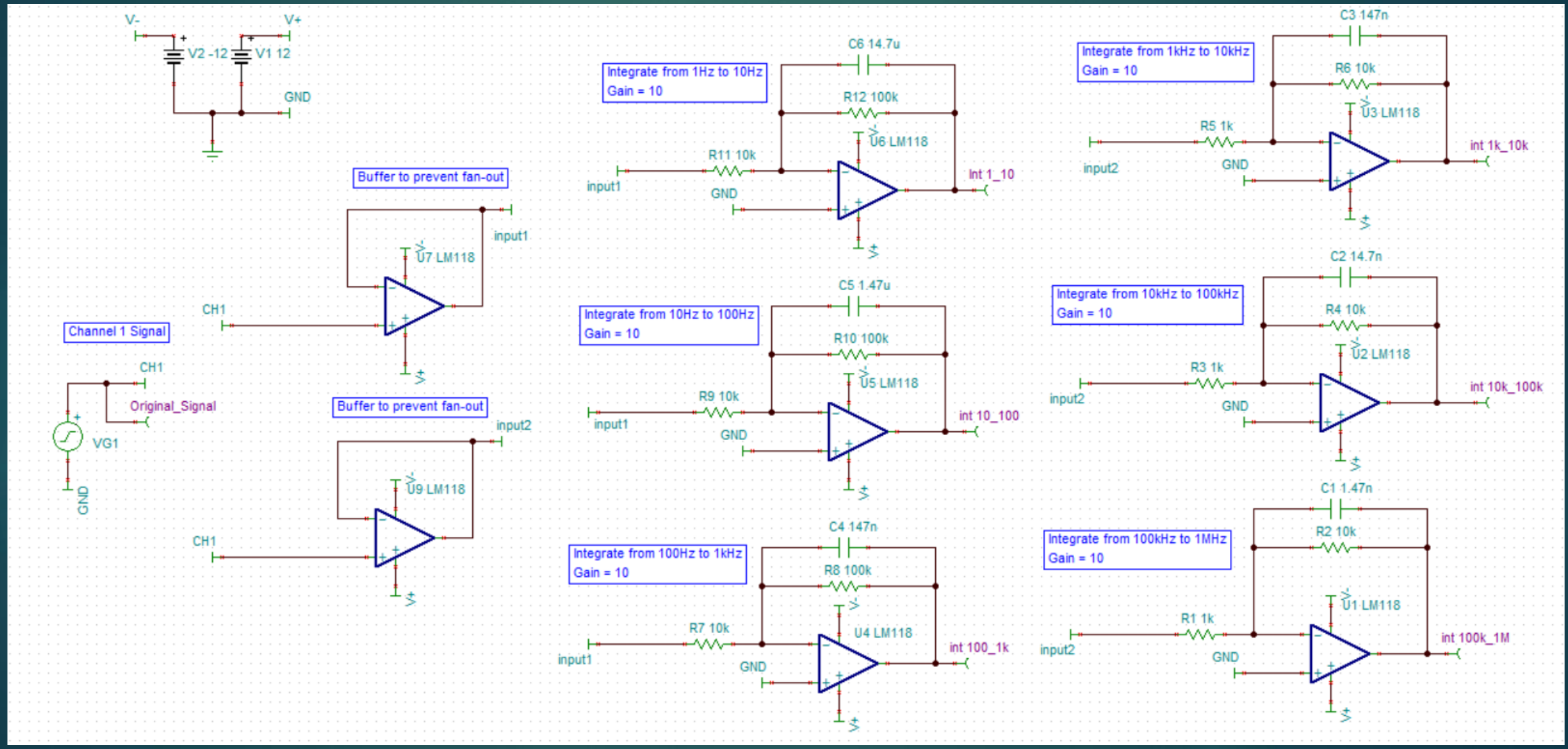
Differentiation Circuit



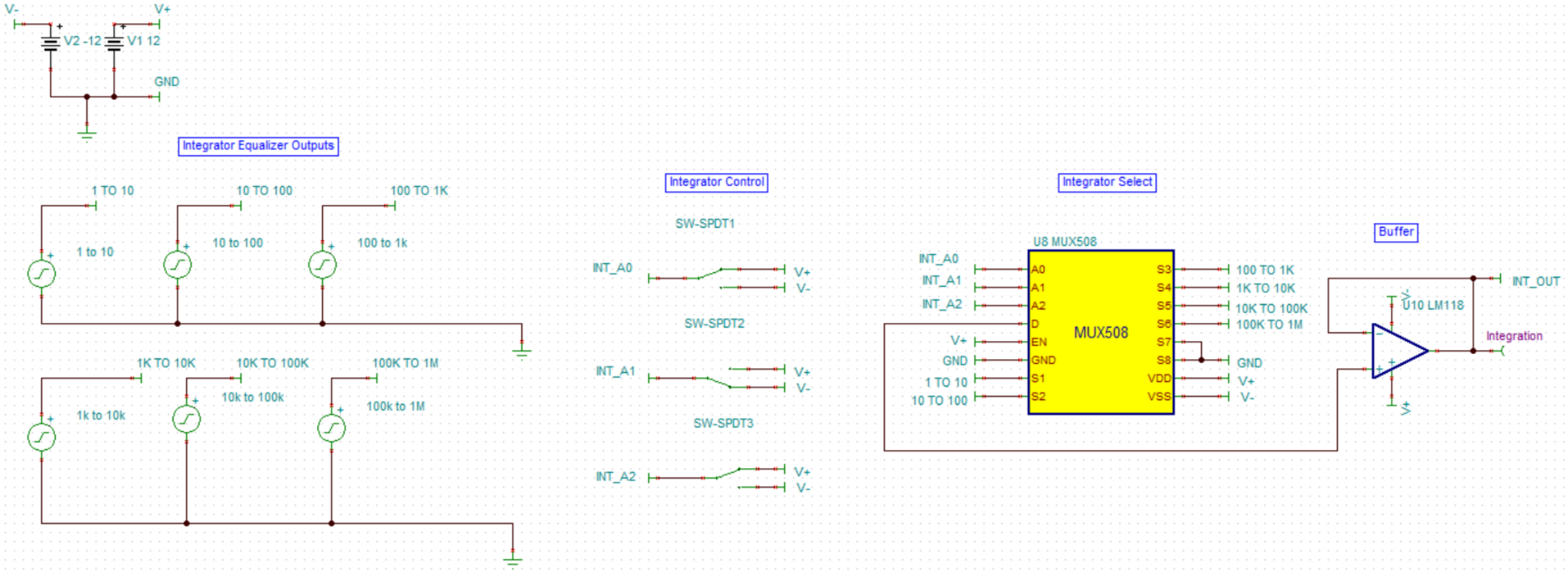
Differentiation Select Circuit



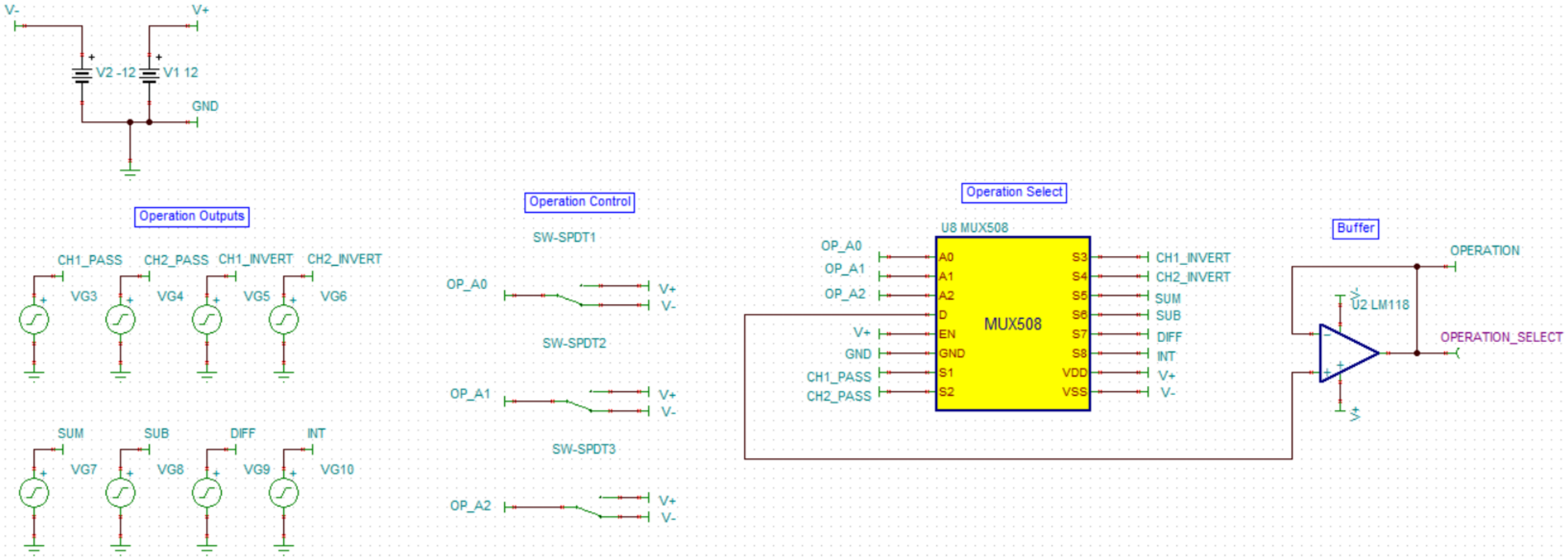
Integration Circuit



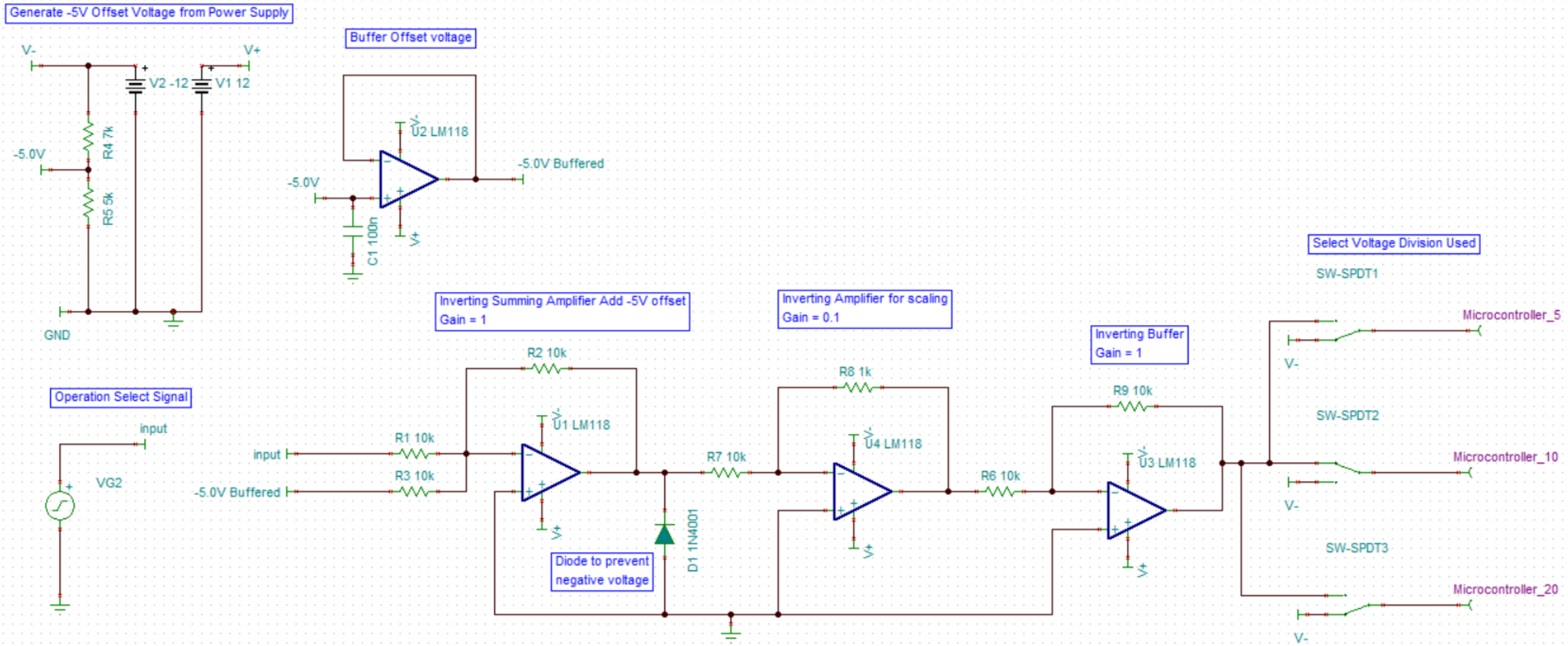
Integration Select Circuit



Operation Select Circuit



Microcontroller Conditioning Circuit



SPECIFICATIONS - DIGITAL OPERATIONS

NI 6501

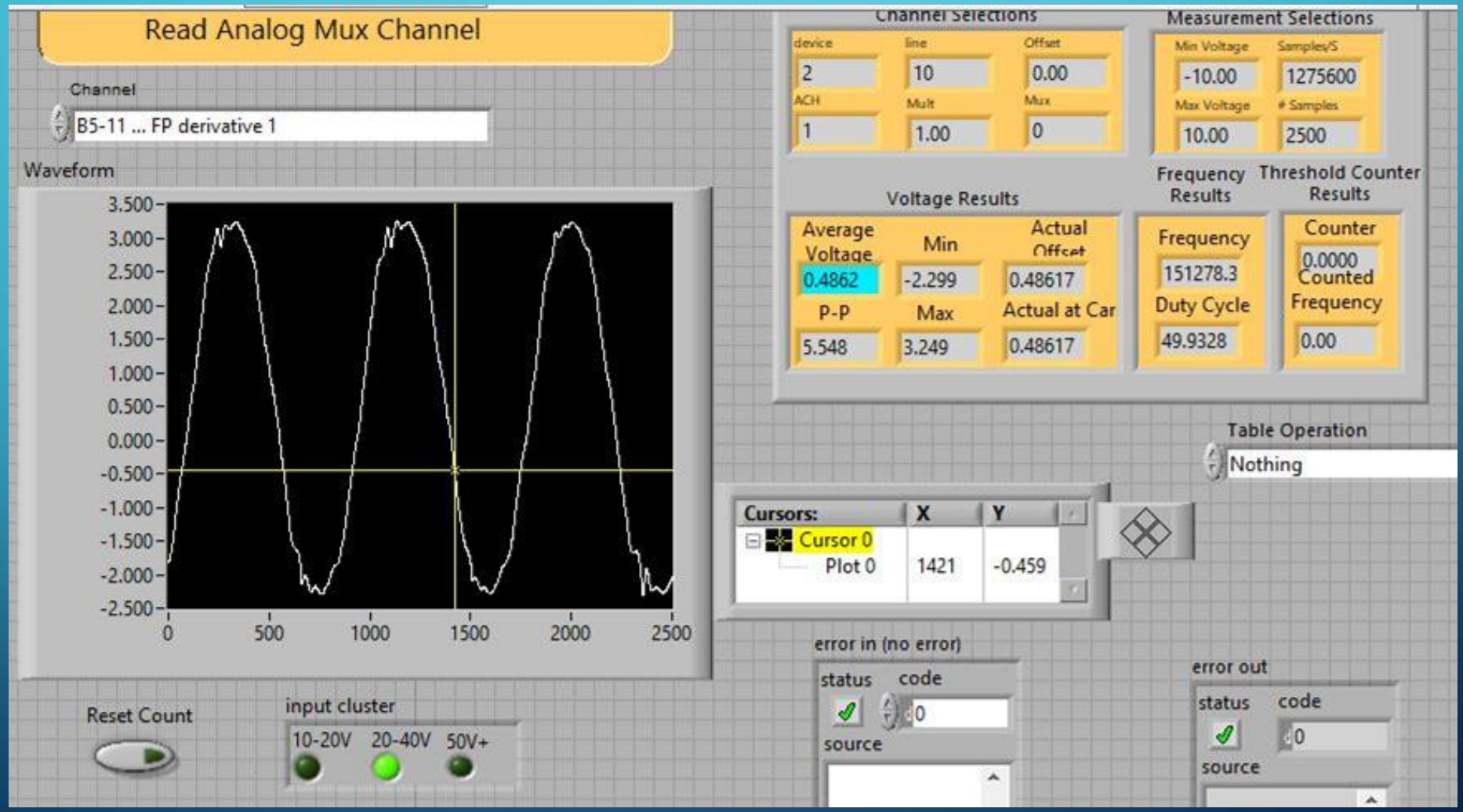
- Uses LabVIEW to do all interactions with microcontroller
- Digital Addition, Subtraction, Integration, Differentiation
- Output Digital Data serially through USB
- Uses NI-6501 due to COVID-19 causing restrictions on parts that are able to be ordered.
- 13 bit ADC at 48K samples per second

SPECIFICATIONS - DIGITAL OPERATIONS

Display Software

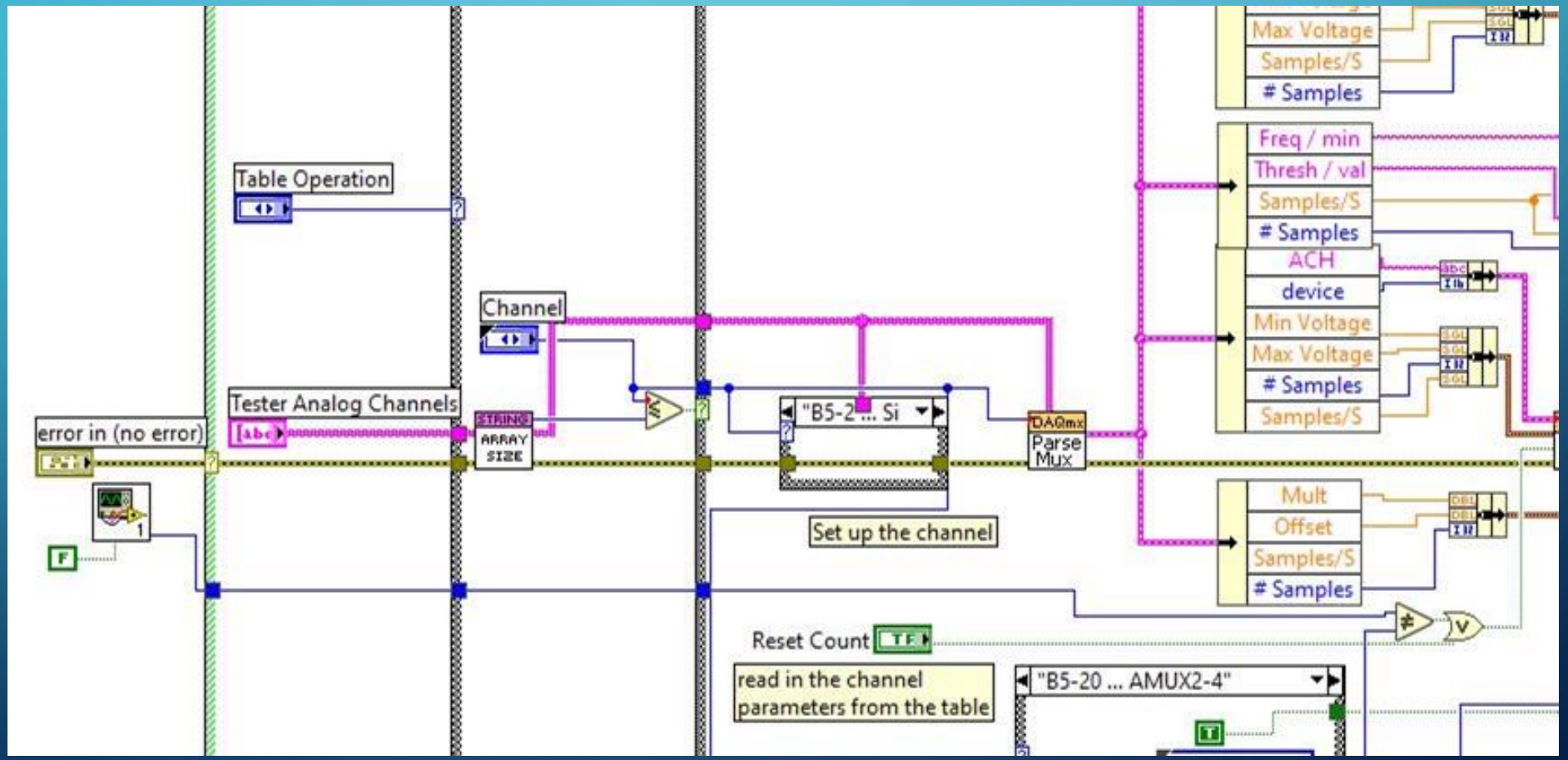
- Use LabVIEW to receive digital data serially as a CSV data stream
- Use LabVIEW to create a front panel to display results

DIGITAL OPERATIONS



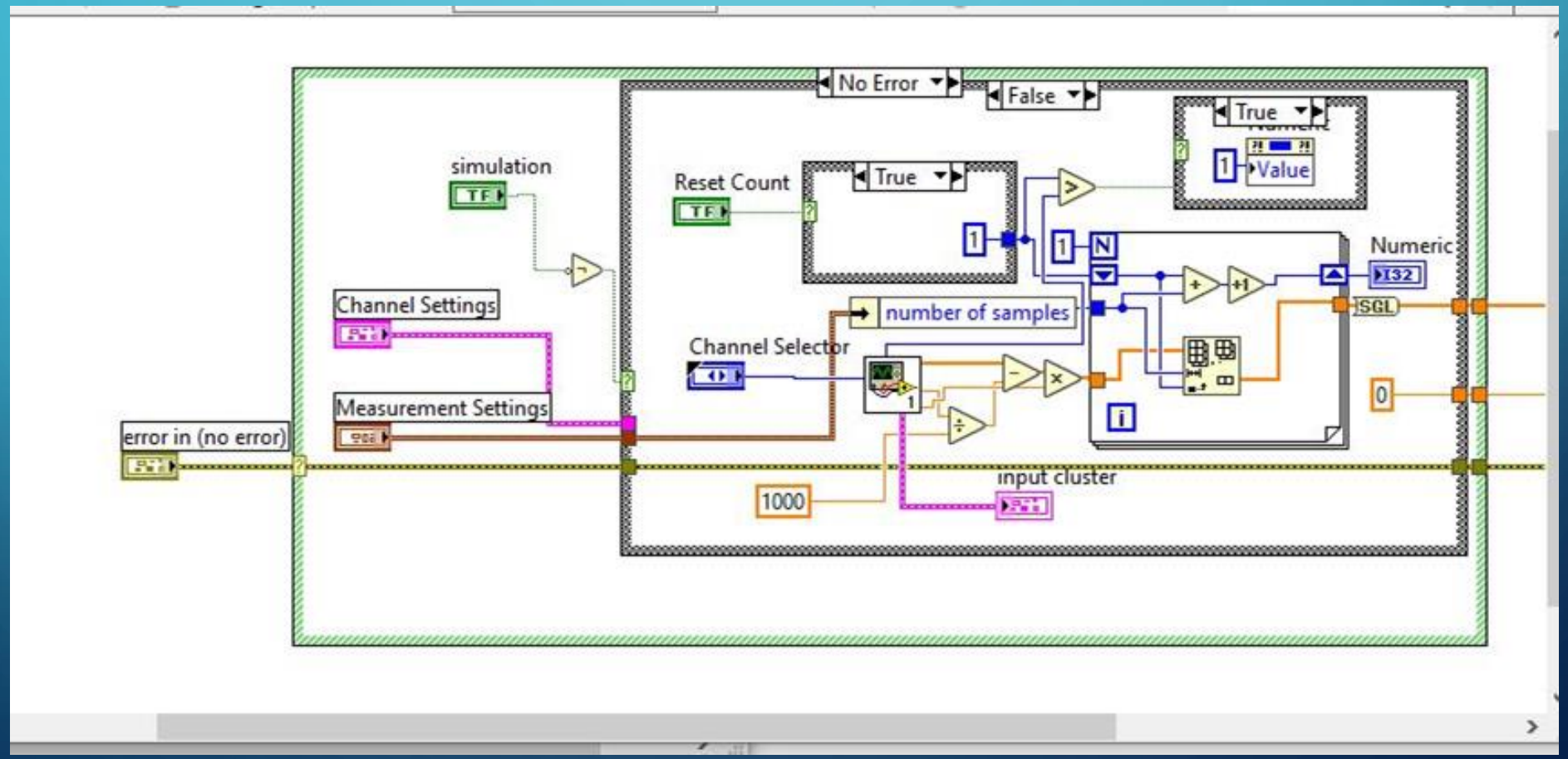
SPECIFICATIONS - DIGITAL OPERATIONS

Display Software Front Panel Code



SPECIFICATIONS - DIGITAL OPERATIONS

Read CSVs and convert to an array for dislpay



Digital Operations: User Interface

- Uses LabView as a basic end user interface
- Installation package to works on any computer Windows 7 or above.
- Ability to scale voltage and time, software performs automatically
- NI-6501 can read up to 24 different channels, some channels have the option to be used as a DAC
- User or calling software can select any channel to take predefined samples of channel

SPECIFICATIONS - DIGITAL OPERATIONS

NI-6501

Max sampling rate

48,000 Samples

per second

SPECIFICATIONS - DIGITAL OPERATIONS

LabView DAQmx - Acquire Waveform