Tekdaqc

MANUAL

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Index

System Overview

The **Tekdaqc Data Acquisition** and **Control** system is a high-performance, high-resolution, low-noise measurement instrument. It was designed for laboratory and industrial applications where extremely precise measurements of many sensors are necessary, but its robust feature set makes it suitable for a wide range of uses. It features an **STM32 ARM Cortex M4 processor**, a **24-bit analog-to-digital converter**, **32 analog input channels**, **24 digital input channels**, and **16 digital output channels**. The Tekdaqc communicates with your computer over **Ethernet**, and interfaces with several software packages, including our provided **Tekdaqc Manager software**, **LabVIEW** data acquisition software, or **Java** platforms.

KEY DETAILS

- **32 isolated** analog input channels, with **0 - 5V** or **0 - 400V** input ranges.
- Sample rates from **2.5 - 30,000 Hz** and programmable gain amplification from **1 - 64**.
- **24 isolated** digital input channels, with **5 - 240 VAC** or **VDC** input ranges.
- **16 high-current** digital outputs.
- **168 MHz 32-bit** ARM Cortex M4 processor.
- Supports many industry-standard communication protocols, including **Ethernet**, **CAN**, **I2C**, and **SPI**.
- Bundled with cross-platform software for easy data acquisition.
- Built-in support for **LabVIEW** and **Java** platforms.

Quick Start Guide

Included with Tekdaqc:

- **1 Tekdaqc.**
- **1 Ethernet cable.**
- **1 power cable.**

If you’re ready to start taking measurements now, follow the setup steps below and you’ll be up and running in no time.

EQUIPMENT SETUP

The first step to setting up your **Tekdaqc** is choosing your location. Though the Tekdaqc will work with sensors at great distances, the Tekdaqc will perform best (*high precision and low noise*) when placed **close to the sensors you want to read**. It should also be used in a stable environment; temperature or humidity fluctuations can affect measurement readings. Also, minimize the amount of digital electronics plugged in near your **Tekdaqc**. Digital electronics like computers are electrically noisy - while the Tekdaqc is specifically designed to filter the high frequency noise created by **digital electronics** and **50** or **60Hz AC line voltage**, less noise equals better measurements. Once you've picked your location, setting up the Tekdaqc is quick and easy.

1. **Plug in** the power cable to the Tekdaqc and the wall outlet.

2. **Connect an ethernet cable** from the Tekdaqc's ethernet port to your router, and from the router to the ethernet port or WiFi on your computer.

3. **Open the Tekdaqc** enclosure. When the enclosure is open, the circuit board is accessible and available for sensor connection.

4. If any of your sensors have a **ground wire** or **shielded cable**, connect the ground wire to a ground connection point on the Tekdaqc enclosure. The easiest connection method is attaching a ring terminal to the ground wire, then threading the ring around one of the ground posts and tightening the wingtip.

* ***A note about connecting sensors to the Tekdaqc:*** *you may be unfamiliar with screw terminals. Screw terminals allow for a wide variety of connections and are used for all connections (**digital or analog**) on the Tekdaqc. A screw terminal has* **two terminal blocks** *- one attached to the board and a removable block that mates with the board-mounted block. The removable block has a series of slots and screws. To connect with screw terminals, push a wire into a slot and tighten the associated screw to create an electrical connection, then connect the removable block to the onboard terminal block.*

5. **Connect analog inputs**. Analog inputs are used for sensors with continuous range and varying voltage output, such as **thermocouples**, **pressure sensors**, or **accelerometers** (*learn more about analog measurements on page 10)*. Make sure you connect the wires from the sensors in pairs – the Tekdaqc measures voltage differentially, like a multimeter, so it needs a pair of wires from the sensor to compare voltages. Usually this is the common and voltage output wires of the sensor. There is no common or ground terminal on the analog or digital inputs on the Tekdaqc, every input is completely isolated from every other input. Thus, every input needs 2 terminals to make a complete circuit. If you have difficulty connecting your sensor, consult your sensor's user manual and use the instructions given for measurements with a digital multimeter.

6. **Connect digital inputs**. Digital inputs are used for sensors and other devices that have discrete binary states. These can measure switch closures, logic outputs from microprocessors and other digital devices, or power state (*when you only need to know it is on or off but don't need to know the actual voltage*). All **24 digital inputs** are individually isolated to **1500 Volts** and are polarity insensitive (*you can connect either the positive or negative voltage to either input terminal*). Any voltage from **3.3** to **24 Volts AC** or **DC** will register as an active input.

7. Connect digital outputs. The factory default for the output voltage is **5 VDC** but can be changed to **12 VDC** by moving **jumper 2**. The outputs are divided into banks of **8 per driver chip**. All outputs can provide **240 ma** continuously (*up to the limit of the Tekdaqc power supply*) but any one output per bank can output **1 Amp** continuously. **Every output is short and overcurrent protected**. In addition, the outputs will report a short / overcurrent / open circuit condition. The outputs use an **N-Channel MOSFET** to pull the negative terminal low when active. The positive lead of all channels is always connected to the +5 volt power supply (*or +12V supply if jumper 2 is set to 12V*). The negative lead is pulled low when a channel is activated. **The outputs are not isolated so care should be taken to ensure that these outputs are never connected to voltages above or below the supply rails of the Tekdaqc.**

8. Ensure that the wires are properly slotted into the channels in the silicon gasket. Use the **small channels** for individual wires, or the **rounded cutout** for larger bundled wires. Proper wire seating helps reduce exposure to outside conditions and improve thermal stability and noise reduction.

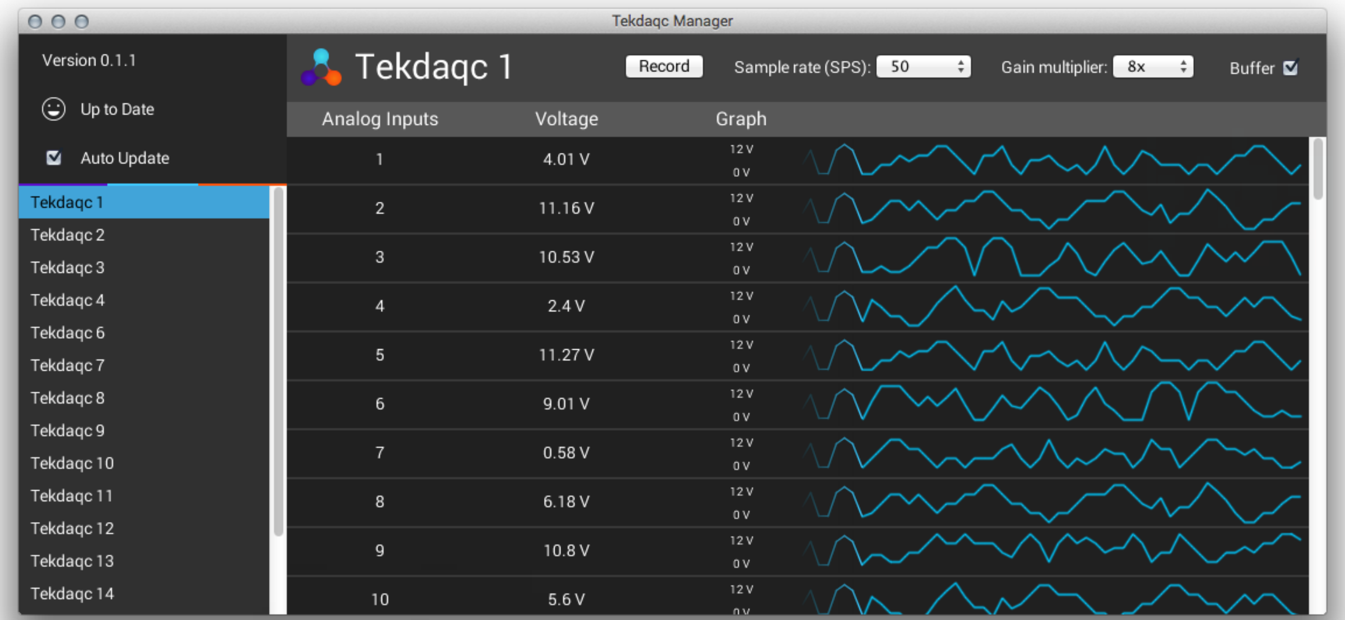
9. Press the lid firmly back down, locking it onto the lower half of the enclosure.

10. Power up your Tekdaqc and leave it on for 2 hours before you begin taking precision measurements. Precision measurement instruments like the Tekdaqc are affected by temperature, and need time to thermally stabilize to give extremely accurate readings. If your measurements don't need microvolt accuracy, you can begin sampling at any time. Also, when not using the Tekdaqc, it should be left powered on to maintain thermal stability.

SOFTWARE SETUP

Your next step is setting up the measurement software used to control and communicate with the Tekdaqc. Visit tenkiv.com to download the software. We provide Tekdaqc management software for **Linux**, **OSX**, and **Windows**, as well as drivers for **LabView**. You can also communicate with the Tekdaqc via Terminal and command line utilities or our custom Java API. Regardless of how you plan on gathering data, all users should download our **Tekdaqc Manager** software to get firmware updates.

The **Tekdaqc Manager** is a controller software designed to give intuitive access to the basic functions of the Tekdaqc, and allow for simple data monitoring and recording. Once you've downloaded the Tekdaqc Manager, follow the prompts to install it. After you open the application, the main window will appear as below.



The column on the left shows a list of connected Tekdaqc's, as well as various details about the version of the selected Tekdaqc, firmware update availability status, and a toggle button to control the Tekdaqc's auto update feature (*we recommend most users leave this activated*). Most users will see only one Tekdaqc, but the Tekdaqc Manager can control as many Tekdaqcs as you can connect.

The remainder of the window highlights the data collected by the selected Tekdaqc. It provides voltage data and a real-time scrolling graph of the signal being sampled on each input channel. The top bar allows you to adjust the data collection settings.

Sample Rate: this setting controls how fast the Tekdaqc samples (*reads data from*) the attached sensor. Sample rate essentially controls the precision of measurements – lower sample rates have higher precision. It can be set at a variety of speeds, from sampling a few times a second (*2.5 Hz*) to 30,000 times a second (*30 kHz*).

Gain: this setting controls how much the Tekdaqc amplifies the sensor signal. Proper gain is determined by the output voltage range of the sampled sensor. For sensors with large voltage ranges (*several volts or more*), gain can be left at one, but you may need to increase the gain if your sensor has a small voltage range (*thermocouples have a range of 0 – 30 mV, for example*).

Buffer: this setting controls if the Tekdaqc uses an electrical buffer (*80 MΩ*) between the sensor and the sampling electronics. Generally, you will always sample with the buffer on.

Record: This button allows you to record all data collected until the stop button is pressed. You will then be prompted to save the collected data as a **CSV file**, allowing for convenient analysis with other programs.

MAINTENANCE

Because the Tekdaqc is such a complex device, most repairs will be beyond the capabilities of the average user. For example, a common adjustment that measurement systems undergo is recalibration. Over time, instrument accuracy drifts – that is, their measured values no longer match the real world values as closely as they could. During **recalibration**, a series of extremely stable voltages are applied to the board and the board is adjusted so that its output values mirror the applied voltages. Since users rarely have access to a nanovolt-stable voltage source, it's easier to send your board to a professional.

Here are some tips that will help your Tekdaqc run better longer, so you hopefully won't need that trip to the repair shop.

PREVENTATIVE MAINTENANCE TIPS

- Don't open the Tekdaqc enclosure unless absolutely necessary.
- Operate the Tekdaqc in a thermally stable environment. Temperature variations will drastically affect measurement accuracy.
- Operate the Tekdaqc in normal ambient conditions (*room temperature, normal humidity, etc.*). Prolonged exposure to temperatures above 50°C may reduce your Tekdaqc's accuracy.

TROUBLESHOOTING PROBLEMS

In case you run into a problem with your Tekdaqc, follow the steps below to diagnose and remedy the problem.

ADC Failure

- Check that inputs are connected and sensors are functional.

- Check that position of high/low voltage is appropriate for sensor.

- Are you able to communicate with the Tekdaqc? If not, then check further.

Carrier Board Failure

- Check for power light on carrier board.

Power Supply Failure

- Check for power lights on main board. If they are on, then the power supply is working, if not:

- Check that the Tekdaqc is connected to line power, then check the fuse on the power supply, then check the integrity of all cables.

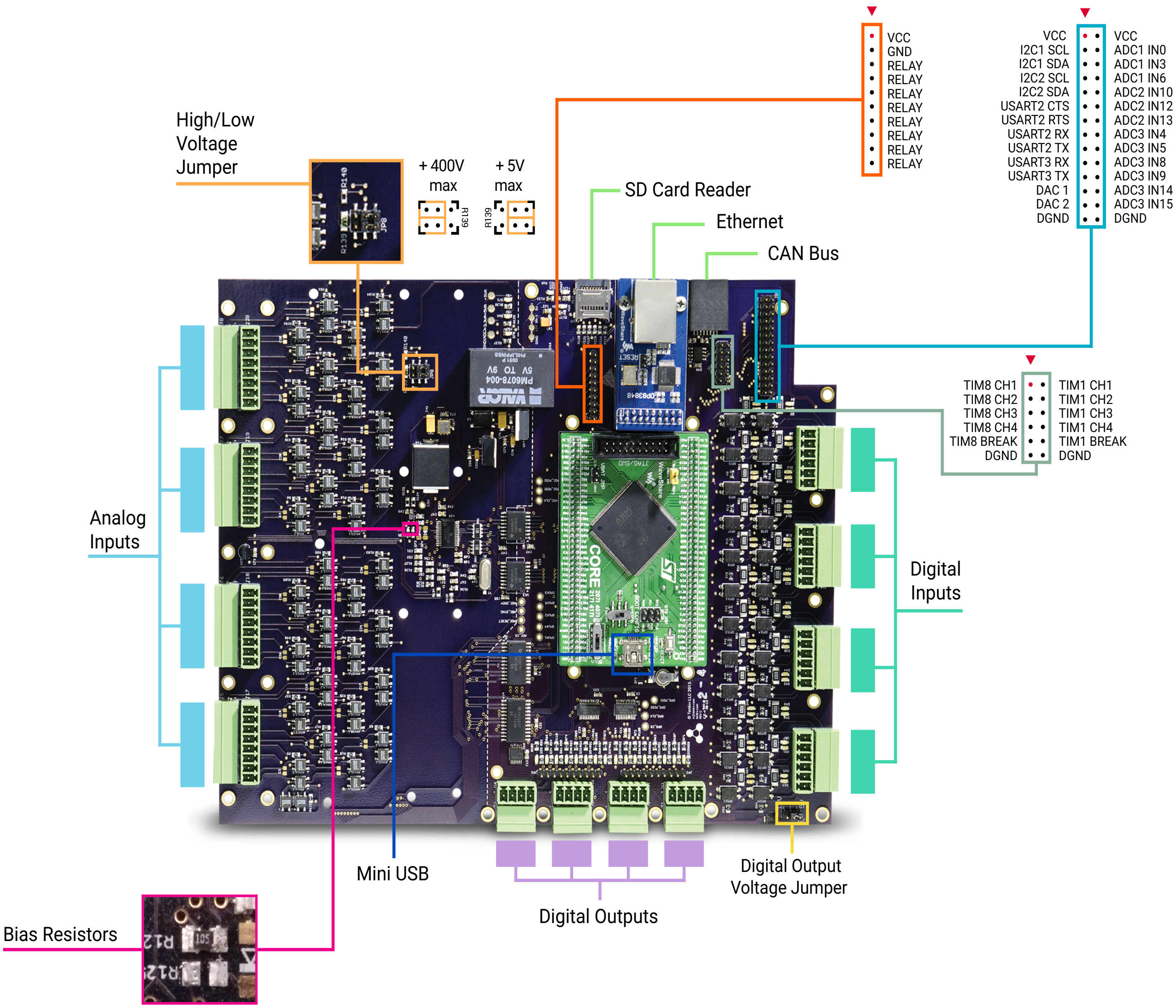
Communication Failure

- Check all Ethernet connections, cables, switches, and routers.

- Reset routers and switches.

- Reset Tekdaqc (*remove power for 10 seconds*).

- Restart computer.

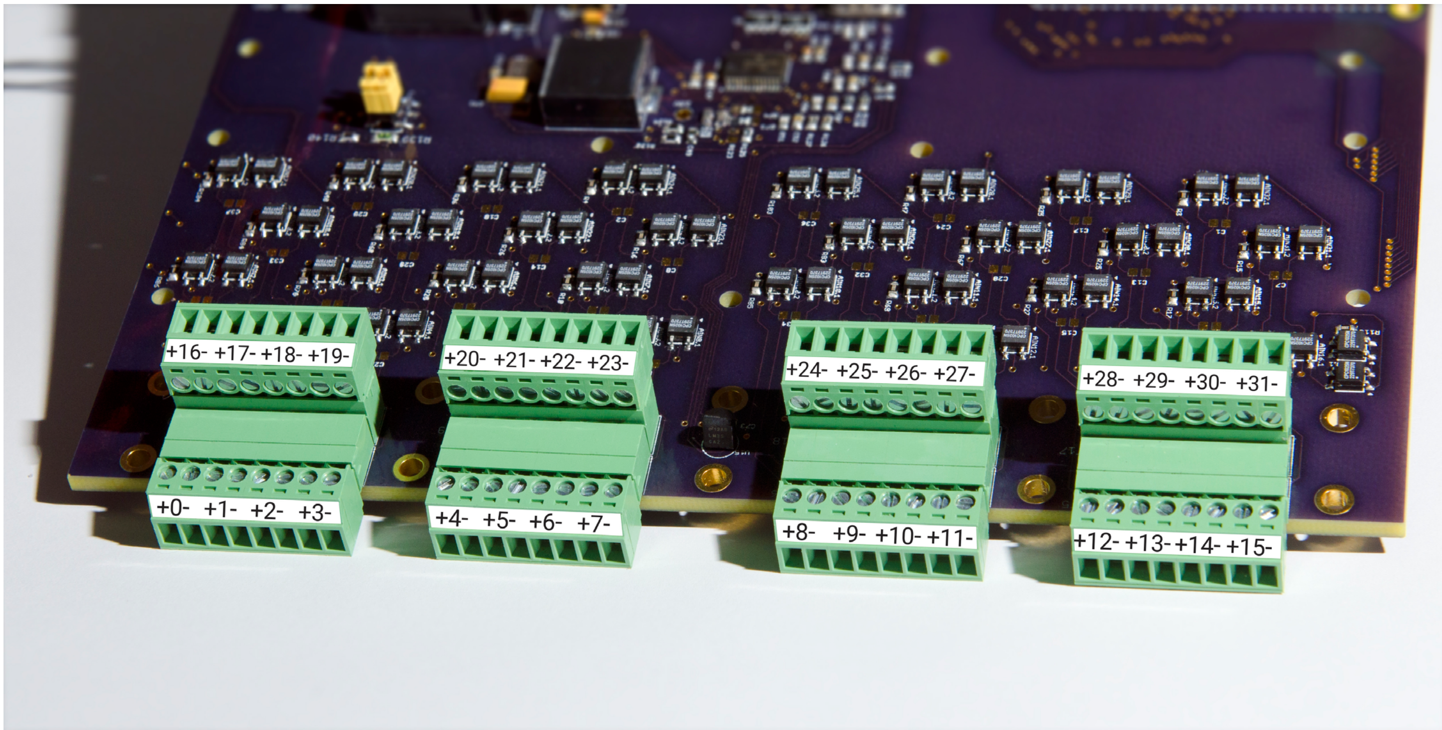


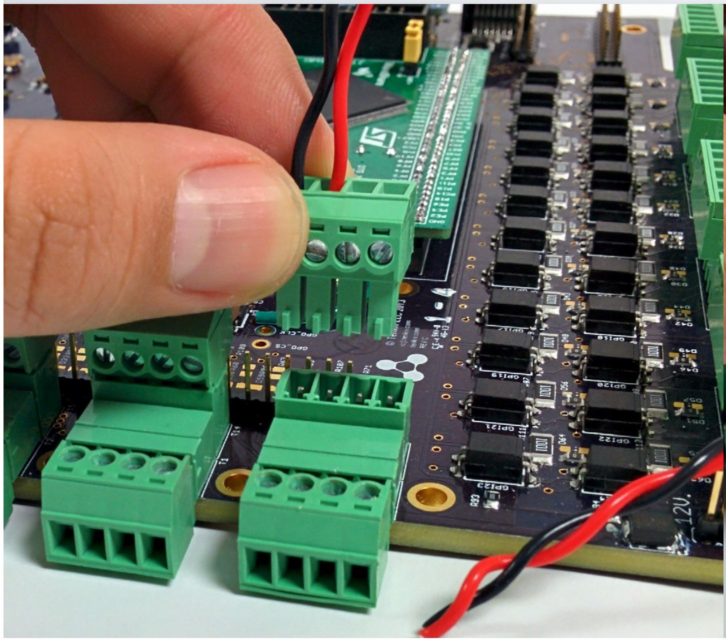
Tekdaqc Description

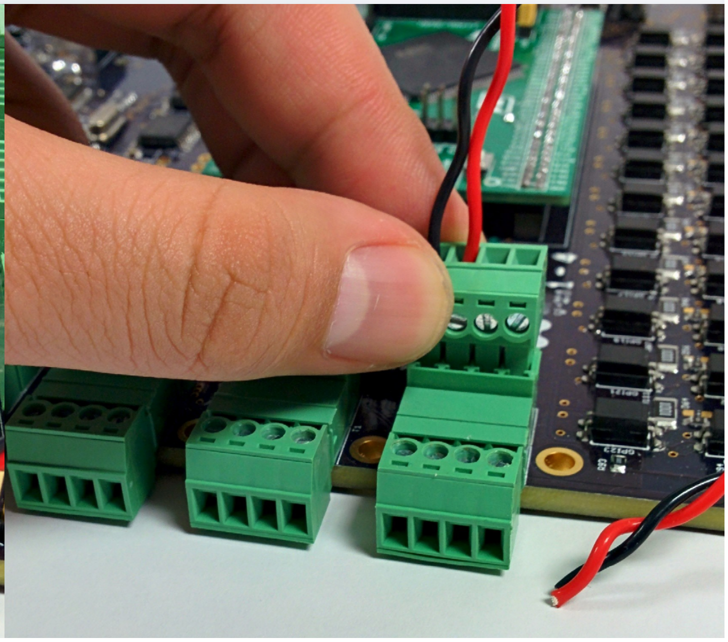
ETHERNET PORT

Used to connect the Tekdaqc to your local ethernet network. The Tekdaqc can be connected directly to the router or through a switch to the router. It is possible to connect the Tekdaqc directly to the ethernet port of a computer (*without going through a router*) but this will require a crossover cable. We caution against this approach, as the provided Tekdaqc Manager software has not been tested in this setup and we cannot guarentee proper functionality.

ANALOG INPUTS







The Tekdaqc has 32 optically isolated analog input channels. Isolation is above **400V** peak (*280 AC RMS*) channel to channel and over **1000V** from the analog section to the rest of the Tekdaqc. The signal path of the Tekdaqc runs from the input terminals, through a pair of FET isolators (http://ixapps.ixys.com/DataSheet/CPC1025N.pdf), then though a low pass filter, and into the ADC (*ADS 1256*). The **ADS 1256** (http://www.ti.com.cn/cn/lit/ds/symlink/ads1256.pdf) is a precision very low noise 24 bit ADC with a 1-64x programmable gain amplifier. The reference for the ADC is a **LTC6655** (http://cds.linear.com/docs/en/datasheet/6655fd.pdf) in a ceramic package, which provides a voltage drift of less than **2 PPM** and a long term drift of **20ppm/√kHr**. Because the references are burned in on the Tekdaqc for several weeks prior to shipping the drift is typically reduced to less than **10ppm/√kHr**.

Unlike typical DAQC systems that lack analog channel to channel isolation, the Tekdaqc is essentially insensitive to ground loop and biasing issues. You simply connect two wires from each sensor to one pair of analog input terminals on the Tekdaqc. There is no need for bias resistors and no potential for ground loops that can cause excessive errors on typical DAQC systems. All channels are true differential and common mode noise rejection is essentially **100%** due to the isolation and excellent common mode performance of the ADC.

The analog section is carefully calibrated to a known PPM-accurate reference before shipping to ensure that the readings will meet the specified limits. Like all extreme precision instruments, the Tecdaqc will require recalibration in order to maintain specified accuracy. If you are using the Tekdaqc for measurements that require the extreme precision it is capable of then you will need to send it in for recalibration at intervals commensurate with the accuracy you need (*refer to Table 2*). Typically the time drift of the Tekdaqc will decrease with use, so if the Tekdaqc is left operating for several years, and you see that it is showing little error when sent in for calibration, you can decrease the calibration interval. If the Tekdaqc is being used for less demanding tasks (*like measuring the voltage of a power supply, or with sensors that are not accurate to better than 0.1%*), it is unnecessary to recalibrate unless the Tekdaqc is exposed to excessive stress (*extreme temperature above 85 °C, condensing environment or water, physical damage, etc.*).

The accuracy of the Tekdaqc is likely to be better than any other instruments you have – be careful to not assume that a disagreement in readings between the Tekdaqc and your other meters and DAQC systems is indicative of an error in the Tekdaqc.

The channel to channel leakage is extremely low, typically on the order of a **few nA** at **400V**, and a few pA when the inputs are connected to low voltage sensors such as thermocouples.

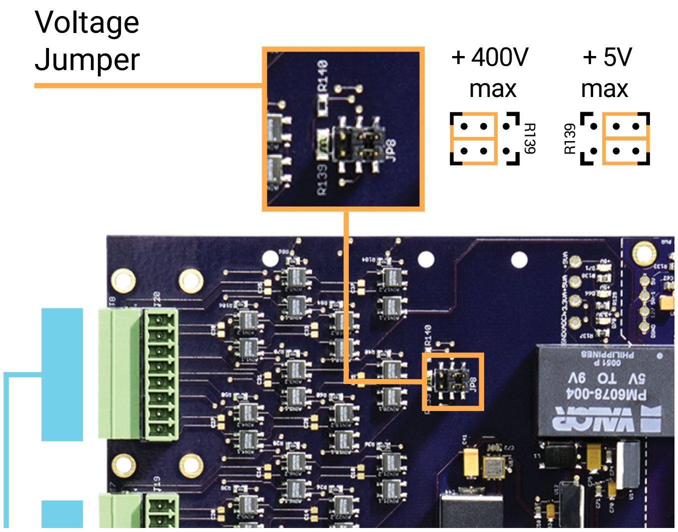
Tips for Connecting the Analog Inputs

The analog inputs are divided into 8 sets of 4 differential input channels. Each connector has 8 screw terminals – one pair for each input. Though no damage will occur if the inputs are connected with reversed polarity, the reading will be reversed (*read negative when it was positive, or vice versa*).

Since the intrinsic noise of the analog section of the Tekdaqc is very low, it is a near certainty that the primary noise sources in any measurement will be external to the Tekdaqc. Ensure that the wiring from the sensors to the Tekdaqc introduces the least possible noise if the specified performance is going to be achieved. To best limit introducing noise to your signal, connect sensors using **individual twisted pair, shielded cables** with the shield connected to ground **only** at the Tekdaqc, and minimize the distance between the sensor and the Tekdaqc. While the Tekdaqc can be located at any distance from the sensors connected to its analog inputs, limiting this distance will result in higher quality measurements, as a general rule.

The Tekdaqc is particularly good at attenuating high frequency and common mode noise. However, it is still best practice to try to avoid these noise sources in the first place. **Sensor cables** should be routed as far as possible from electrical and thermal noise sources (*computer power cables, hot plates, etc.)*. If your sensor leads must pass near sources of electrical noise try to limit the distance where they pass to a minimum. If you must pass a sensor cable near an AC line, try to have the sensor cable cross the AC line cable at a right angle. Most importantly, avoid long runs of sensor cable parallel to a noise source. If you must run sensor cables in electrically noisy environments then use the lowest sample rate possible. Since the largest source of electrical noise in most cases is the line frequency noise from power lines, it is always best to sample at a rate that will alias that frequency. So in countries where **60Hz** power is used (*USA, Canada, Mexico and others*) use a sample rate of **60Hz, 30Hz, 15Hz, 10Hz, 5Hz or 2.5Hz**. In countries where **50Hz** power is used (*EU, Russia, China and others*) use a sample rate of **50Hz, 25Hz, 10Hz, 5Hz or 2.5Hz**. For more information on noise reduction and optimizing sensors, see Appendix A.

High / Low Voltage Jumper:



The position of this jumper will determine the maximum input voltage into the analog input ports. In the default HIGH position the Tekdaqc analog inputs can measure a maximum of approximately **300V**. It is safe to apply up to **400V** to any analog input with the jumper in the high position, but measurements won't be accurate above **300V**.

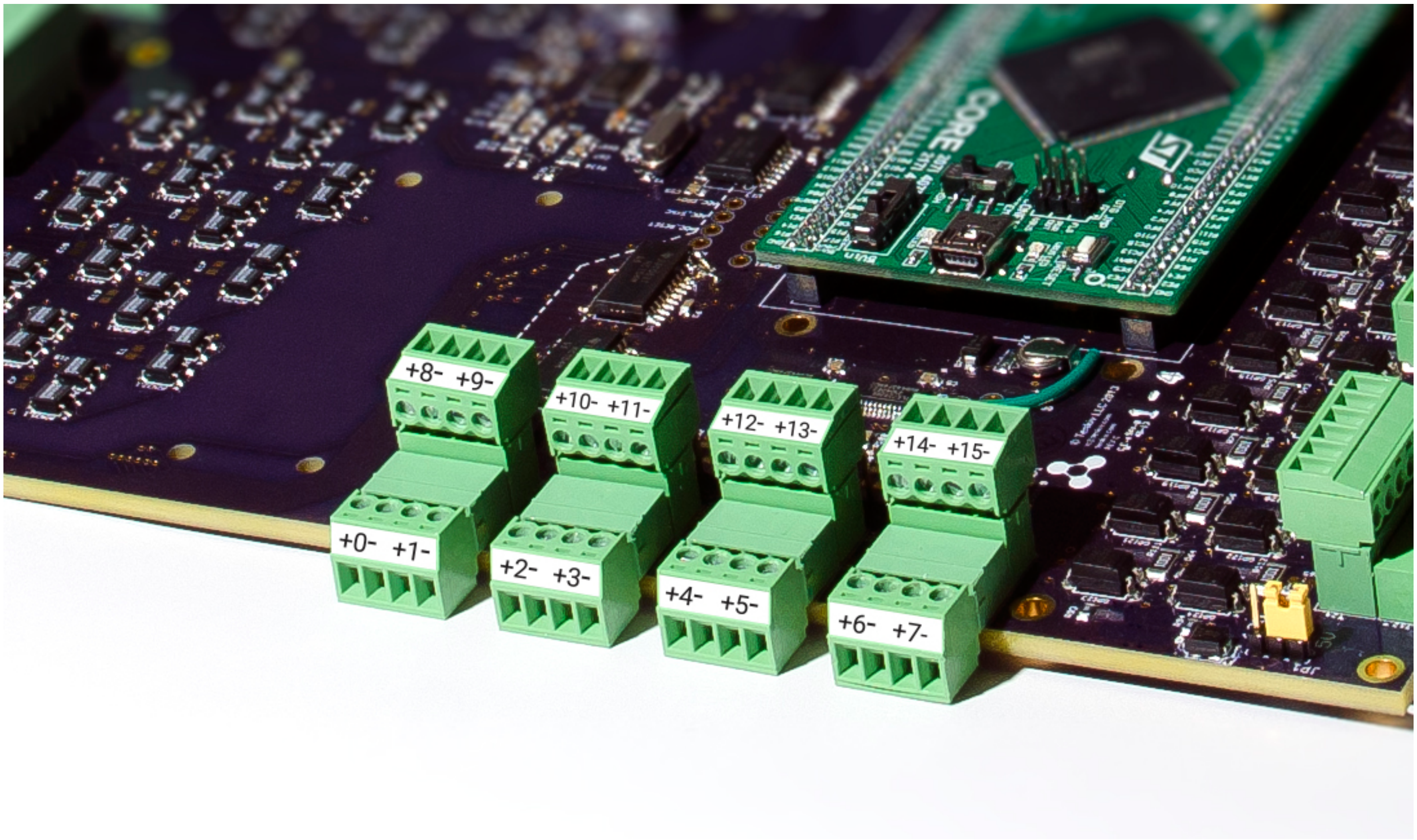
If extremely precise measurements of voltages of **2.5V** or less are desired then move the jumper to the LOW position. In the low voltage setting it is safe to apply up to **5V** to any analog input. Low impedance sensors outputting more than **5V** can damage the Tekdaqc ADC when the jumper is set to low voltage, so exercise caution when using the low voltage setting. Remember to return the jumper to HIGH when you finish with any low voltage measurements to protect the Tekdaqc analog circuitry from voltage spikes.

Notes on Input Range

The Tekdaqc's analog inputs are biased to the **2.5V DC** reference voltage. This prevents the linearity errors that normally occur when attempting to read negative voltages on a ground-biased system. Unfortunately, this biasing does limit the analog input range to **± 2.5V** with a LOW voltage jumper setting, and **± 200V** with a HIGH voltage jumper setting. When sampling with the ADC's **80 MΩ** buffer on, the effective range will be approximately **1V** in the LOW setting and **80V** in the HIGH setting (*signals will experience a voltage clipping error, where the sampled measurement is lower than the actual voltage, thus limiting the range*). As the low voltage setting is designed for extremely precise measurements of sub-volt magnitude signals (*for example, the milivolt signal produced by thermocouples*) and **80V** is well above most analog sensor's output ranges, these range limitations shouldn't affect most measurements you will make with the Tekdaqc. However, if you must have a full scale range of **5V** in the LOW setting (*3.6V with buffer on*) or **400V** in the HIGH setting, you can move the bias resistor to bias to ground instead of **2.5V**. Take care when un-soldering and resoldering this component; **if you are careless, you can do irreparable damage to the Tekdaqc**. We do not reccomend this option for most individuals. There are two safer ways to deal with input range issues:

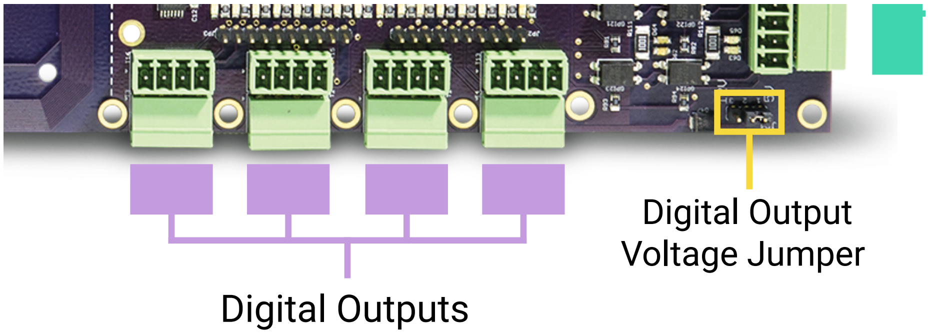
1. If your signal is low impedance (*high power*), you can turn the buffer off, this avoiding the voltage clipping errors.
2. If you need a buffered signal, set the voltage jumper to **HIGH** and the **PGA to 4 or higher**. Any time the PGA is set at 4 or higher, you will reach a full scale reading prior to reaching any biasing or clipping limits, so biasing and buffer settings won't affect the accuracy of the measurement.

DIGITAL OUTPUTS



The Tekdaqc has **16 high-current digital output channels.** The channels are **current limited** and **short circuit protected**. The output chips are also **over temperature protected**. The Tekdaqc will send error codes for short to ground, overcurrent, open load (*nothing connected to output*) and over-temperature. These outputs are reverse polarity protected with a **40 VDC** blocking diode; however, there is no isolation between outputs or other Tekdaqc circuitry, so it is important to ensure that excessive voltages are not applied to them.

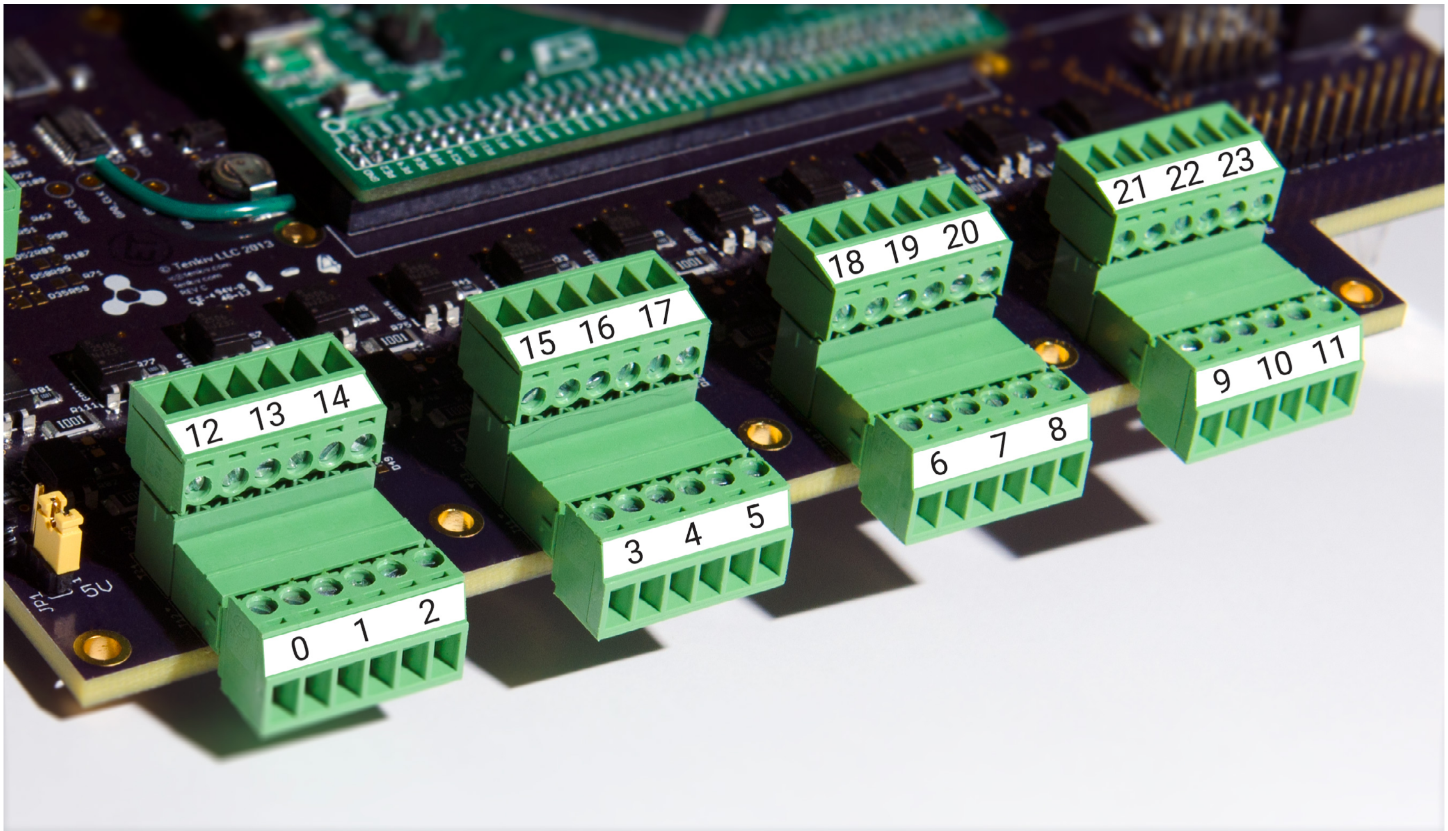
Digital Output Voltage Jumper:



This jumper determines the voltage of the high current digital outputs ports. The factory default setting is **12 VDC**. When set to **12V**, the Tekdaqc supplies **1000 mA** total to the digital outputs. Setting the jumper to the **5V** position will connect the outputs to the **5 VDC** digital supply and provide **1700 mA**. If more power or a higher voltage is required for the outputs, contact Tenkiv about an upgraded power supply. Replacing or altering the power circuitry of the Tekdaqc will void any warranty/calibration guarantees and may result in irreparable damage to your Tekdaqc.

Warning: all other jumpers and switches (*beside those described separately above*) on the Tekdaqc are for factory use only. Operating the Tekdaqc with these jumpers or switches set to any other than the factory default position could damage your system.

DIGITAL INPUTS



The Tekdaqc has **24 optically isolated digital inputs**. These inputs are designed to detect a voltage of **3.3-120V** AC or DC. The inputs are bipolar (*polarity insensitive; will trigger either way*). These inputs offer **over 1000 volts** of isolation. The activation current required by the input will vary with input voltage. The necessary input current at **3.3V** is approximately **0.1 mA**, while at **120V** requires **6 mA**.

The digital input circuit consists of a bipolar optical isolator with **Darlington output**. The output of this isolator is in series with a **1 watt 20 KΩ** resistor so the current will vary linearly with input voltage. This resistor was selected to allow a wide range of input voltages; unfortunately, this causes the optical isolator speed to vary with input voltage. At **3.3V** the input can take up to a few tenths of a second to register a change in input voltage. However, higher voltages result in much higher activation speeds – at **120V** the input only takes a few microseconds to register a change of state.

Note that AC voltage polarity shifts may register as a change of state of the input. You may need to add external filtering to the digital inputs to reject high frequency state changes in AC signals if you are only monitoring switch closures and similar slow state changes.

Other I/O

The following features are for use by those wishing to create their own firmware and/or software. We do not provide any technical support for these features other than a description and schematic diagram. We do, however, encourage anyone attempting firmware modifications to discuss and share their projects on our **DAQC community** (https://plus.google.com/communities/109351353187504550254) with other users.

Warning: Though these ports are no more fragile than those on many other DAQC or processor boards (*ie Arduino, non-isolated analog inputs on products from National Instruments, etc.*) they do not have the extensive protection built into the other ports on the Tekdaqc. Use of these ports requires a much greater understanding of electronics and the Tekdaqc hardware, and is undertaken at the user's own risk.

CAN Bus Port:

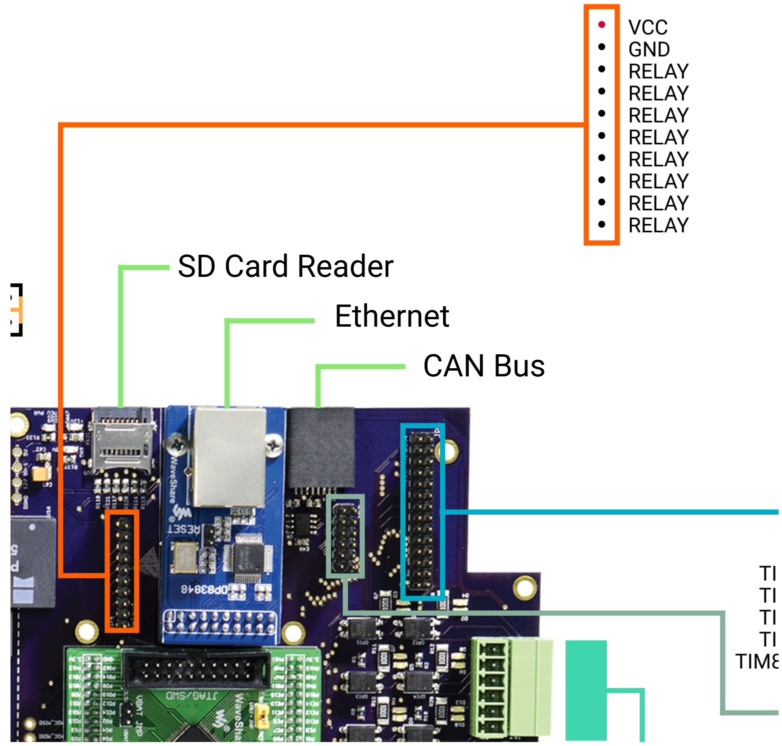
This is the connector for CAN bus. The drivers currently included with the Tekdaqc (*firmware and control libraries*) do not currently include any CAN bus support. This feature is on our road map – check our GitHub pages and DAQC community for more details as they become available.

Micro SD Card Socket:

Standard Micro SD card can be installed here. The drivers currently included with the Tekdaqc (*firmware and control libraries*) do not provide any SD card support. This feature is on our road map – check our GitHub pages and DAQC community for more details as they become available.

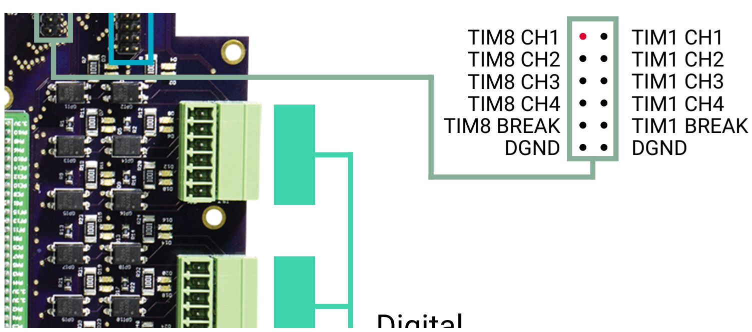
Relay Driver Header:

The Tekdaqc includes a **10-pin single row header** that connects directly to **8 GPIO pins** on the ARM processor. This header was designed to drive a **buffered 8 relay board** (*not included with Tekdaqc*). Use of this output will require user-created firmware and/or software, though our fvirmware libraries provide functions for these pins. Consult the schematic for details.



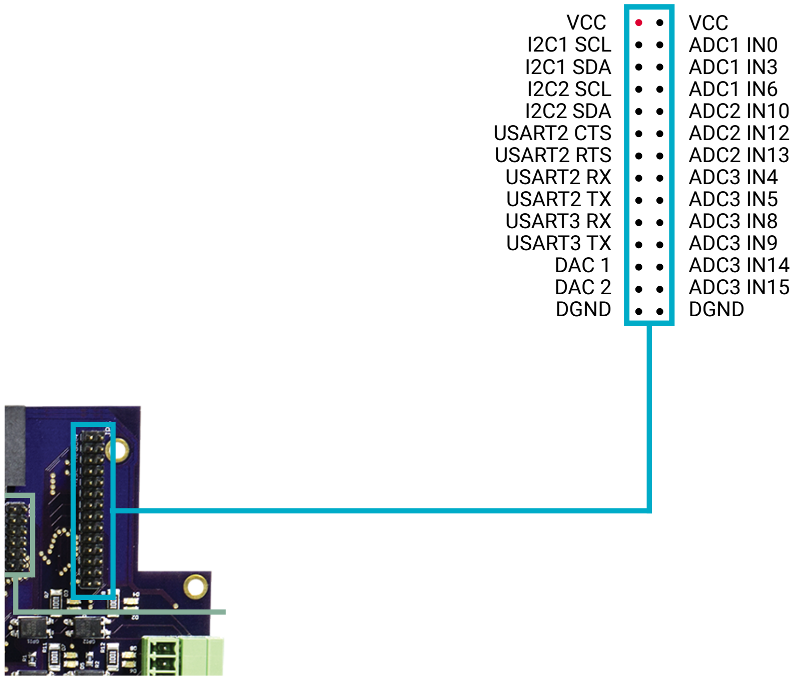
PWM Output Header:

The Tekdaqc includes a **12-pin dual row header** that connects directly to the PWM outputs of the ARM processor. Use of this port will require user-created firmware and/or software, though our firmware libraries do provide functions for these pins. Consult the schematic for details.



Miscellaneous I/O Port Header:

The Tekdaqc includes a **28-pin dual row header** that connects directly to some of the special purpose I/O on the ARM processor. These include **11 inputs** to the **3 twelve bit 2.4MHz A/D converters**, **2 D/A converters** and some **GPIO pins**. Use of this port will require user-created firmware and/or software, though our firmware libraries do provide functions for these pins. Consult the schematic for details.



JTAG Connector:

For users wishing to develop their own firmware for the Tekdaqc, this is the connector for your JTAG programming interface. We use the **JTAG programmer from ST Microelectronics** (*the manufacturer of the ARM processor used on the Tekdaqc*) **ST-LINK V2** (*not included*).

Specifications

GENERAL

Input Voltage	110 - 240 50 - 60 Hz 25 Watts max (< 2 Watts typical) auto-switching
Environmental	0 - 75° Celsius non-condensing atmosphere
	Specified accuracy at 23° Celsius ± 2, 0 - 85% humidity
	Enclosure is rated as spill proof (do not operate submerged)
Dimensions	Width 250mm, length 250mm, height 60mm
Weight	3.9 Kg

Analog Inputs:

- **32** differential channel to channel Isolated Analog inputs (*400 Volts isolation per channel*)
- **24 Bit, 30 KSPS** very low noise analog to digital converter (*TI ADS1256*)
- Up to **23 bits** of noise free resolution (*less than 1 part per 8,000,000*)
- Input noise as low as **0.03 uV** (*depending on sample rate and gain setting*)
- Input impedance: **80 MΩ** with voltage jumper in LOW setting, **1MΩ** with voltage jumper in high setting.
- **1- 64** gain programmable gain amplifier (*independent setting for each channel*)
- Input range **5V** at gain of **1** (*up to 400 Volts with voltage jumper in HIGH setting*)
- **ADC** settles in a single conversion.
- Maximum sample rate: **30,000 samples per second** single channel.
- Maximum sample rate: **1000 samples per second** multi channel.
- Open sensor detection.
- Auto calibration.
- Pluggable screw terminals built in.

Refer to Table 1 for noise performance.
Refer to Table 2 for full scale accuracy.
Total error = full scale error + reading error.

Digital Inputs:

- **24** optically isolated **3.3-120 VAC** or **VDC** inputs.
- Pluggable screw terminals built in.

Digital Outputs:

- **16** high current outputs (*2 banks of 8 outputs*).
- **2A** max per bank, **240 mA** max per output with all outputs on (*up to the total power supply rating or 1A on 12V or 2A on 5V*).
- **12 VDC** default setting, **5V** configurable by jumper setting (*with included power supply*).
- **3.3 - 28 VDC** with user supplied power supply.
- Outputs current limited (*short circuit protected*)
- Output circuits **over temperature protected**.
- Each channel reports faults for open circuit, overcurrent, short to ground, over temperature.
- Pluggable screw terminals built in.

ARM Processor:

- **STM32F407IG** 168MHz ARM Cortex M4.
- DSP with FPU.
- **1MB** Flash.
- **192KB** RAM.
- Industry standard **10 pin JTAG interface** (*used for programming, debugging and FLASH read/write*), also SWD compatible.

Additional Inputs Available on ARM Processor:

(*Not supported with included software but user programmable*)

ADC:

- **ADC 1:** 5 channels.
- **ADC 2:** 5 channels shared with **ADC 1.**

- **ADC 3:** 11 channels, 5 shared with **ADC 1** and **ADC 2.**
- **11 channels** utilizing 3 separate **2.4 MSPS 12 bit A/D converters** (*total 7.2 MSPS*)
- Up to **26 PWM** outputs (*usage is at the expense of other additional functions*)
- **2 DAC** outputs.
- **2 PWM** inputs (*32 bit*)

Connectivity:

- **10/100 Ethernet**. Future support for fiber connection planned by swapping out the transceiver module.
- **USB OTG** 2.0 FS
- **USART** with **CTS/RTS** flow control.
- **USART** with no flow control.
- **SPI / I2S**.
- **I2C**.

Firmware:

- Comes pre-programmed ready to run with **LabVIEW** and **Java JAR** library drivers.
- Source code included.
- User can create custom firmware for stand alone operation with our provided firmware driver libraries.

Software:

- Comes with **LabVIEW** drivers.
- Comes with **Java JAR** library drivers.
- Comes with the **Tekdacq Manager** software compatible with **Android**, **Linux**, **OSX**, and **Windows** for testing and basic data acquisition

Detailed Specifications

Table 1 - Analog Noise Performance

RMS Noise vs Sample Rate or Period and Gain

			Noise	Noise	Noise	Noise	Noise	Noise	Noise
Rate 1/P	Period 1/R	Multi Ch	uV RMS	uV RMS	uV RMS	uV RMS	uV RMS	uV RMS	uV RMS
Sample/Sec	Sec/Sample	Sec/Ch	Gain: 1	Gain: 2	Gain: 4	Gain: 8	Gain: 16	Gain: 32	Gain: 64
2.5	0.40000	0.400	0.3	0.2	0.15	0.1	0.06	0.05	0.05
5	0.20000	0.200	0.4	0.3	0.15	0.1	0.08	0.06	0.06
10	0.10000	0.100	0.4	0.3	0.2	0.15	0.1	0.07	0.07
15	0.06667	0.067	0.5	0.3	0.2	0.15	0.13	0.1	0.09
25	0.04000	0.040	0.6	0.4	0.25	0.2	0.16	0.14	0.1
30	0.03333	0.033	0.6	0.4	0.3	0.2	0.016	0.014	0.12
50	0.02000	0.020	0.7	0.5	0.3	0.25	0.2	0.15	0.14
60	0.01667	0.017	0.8	0.5	0.4	0.3	0.2	0.16	0.15
100	0.01000	0.010	1	0.7	0.5	0.4	0.25	0.2	0.19
500	0.00200	0.002	2	1.5	0.7	0.7	0.6	0.5	0.4
1,000	0.00100	0.001	3	2	1.5	1.3	0.8	0.6	0.5
2,000	0.0050	n/a	4.5	3	2	2	1	0.8	0.7
3,750	0.0027	n/a	6	4	3	2	1.5	1	1
7,500	0.0013	n/a	8	5	4	3	2	1.5	1.3
15,000	0.00007	n/a	10	7	5	4	3	2	2
30,000	0.00003	n/a	12	8	5	4	3	2	2

** For peak to peak noise multiply by 3.*

Table 2 - TekDAQC Accuracy in Parts Per Million Error

Accuracy = ± PPM reading + (± PPM of range)

		24 Hour	90 Day	1 Year	Temp
Range	Gain	Tcal ± 1C	Tcal ± 5C	Tcal ±5C	Coefficient
Low Range					
3.6 V	1	3 + (3)	3 + (28)	3 + (38)	3
2.5 V	2	4 + (3)	4 + (28)	4 + (38)	3
1.25 V	4	2 + (3)	2 + (28)	2 + (38)	3
0.625 V	8	2 + (3)	2 + (28)	2 + (38)	3
0.3125 V	16	3 + (3)	3 + (28)	3 + (38)	3
0.156 V	32	5 + (3)	5 + (28)	5 + (38)	3
78 mV	64	6 + (3)	6 + (28)	6 + (38)	3
High Range					
400 V	1	3 + (28)	3 + (128)	3 + (138)	28
200 V	2	4 + (28)	4 + (128)	4 + (138)	28
100 V	4	2 + (28)	2 + (128)	2 + (138)	28
50 V	8	2 + (28)	2 + (128)	2 + (138)	28
25 V	16	3 + (28)	3 + (128)	3 + (138)	28
12.5 V	32	5 + (28)	5 + (128)	5 + (138)	28
6.25 V	64	6 + (28)	6 + (128)	6 + (138)	28

* After **4 hour** warm up time.
* Selfcal done before reading.
* Accuracy relative to calibration source.
* Basic **24 hour** erorr in **1.25 volt** scale is **0.0006%**.
* To calculate **% error** from **PPM error** divide by **10,000**.

Drift over time will trend **lower** over time. The Tekdaqc error will drift about **10 ppm/ √kHr**. So you can expect about a **10 PPM** drift in the first **1000 hours** but it will take about **4000 hours** to drift **20 PPM** or **9000 hours** to drift **30 PPM**. Recalibration after a year is advised but further recalibration may not be necessary as often after that if the unit is kept powered on and in a stable temperature environment. Recalibration is highly recommended if the Tekdaqc is exposed to wide temperature fluctuations (*> 50 °C or < 0 °C*).

Appendix A: Measurement Theory

The Tekdaqc is capable of measurements well into the nv range, but getting accurate measurements at this level requires considerable care on the part of the user. For example, on the **78mv scale** (*x64 gain*) the Tekdaqc is capable of **less than 100nv noise**. To put this level of precision in perspective, a **1 degree Celsius** temperature differential across a solder connection will cause several microvolts of low frequency electrical noise. Achieving maximum precision measurements with the Tekdaqc requires very careful analysis and control of all electrical noise sources and temperature differentials.

It is extremely difficult to set up an experiment that will not introduce errors and noise that are much larger than the Tekdaqc's internal errors. Simply exposing sensor leads and connections to normal indoor ambient temperature variations can cause low frequency noise of **tens of microvolts** (*from thermoelectric effect; see below*). If sensors are placed outdoors, or in an unconditioned space, you can expect the noise generated to be several milivolts or more. To be clear, the noise reduction precautions needed to ensure maximum possible performance are not due to any limitation of the Tekdaqc, they address inherent issues involved with any voltage measuring device.

Some general tips on getting the best possible performance:

- Always use the **shortest possible** sensor leads.

- Route sensor leads away from sources of electrical noise (*high voltages, transformers, etc.*) If you must run sensor leads near electrical noise sources, use shielded cables with the shield connected only to the Tekdaqc ground connection (*although shielded cable is always acceptable, it's particularly necessary in noisy environments*).

- Route sensor leads away from areas of high or low temperatures. If you must run sensor leads near a high or low temperature source than use leads made from ultra pure copper (*or, if using thermocouples, special limited-error thermocouple wire*).

- If possible, sample at a rate that will alias (*minimize*) A/C line noise. If in the **US** (*or other locations with 60Hz line frequency*) sample at **60**, **30**, **15**, **10**, **5**, or **2.5sps**. If in **Europe** (*or other locations with 50Hz line frequency*) sample at **50**, **25**, **10**, **5**, or **2.5sps**. **10**, **5**, or **2.5sps** will minimize line noise in all locations.

- Always operate the Tekdaqc with the enclosure closed.

- Always use the lowest possible sample rate, commensurate with experiment requirements.

- Always use the highest gain possible (*lowest voltage range*)

- Always leave the Tekdaqc running whether sampling or not. If you must remove power to the Tekdaqc then reapply power **long before collecting data**. (*The Tekdaqc draws only a few watts of power.*) There is no warm up period for the Tekdaqc but thermoelectric noise from internal fluctuations will introduce errors. These errors are reduced to a minimum as the Tekdaqc temperature stabilizes after several minutes.

Thermal EMF:

The thermoelectric effect is a physical phenomenon where thermal differences are converted into electrical voltage. Every junction between dissimilar metals will generate a voltage; the greater the temperature differential, the greater the voltage produced. This effect is purposely exploited in thermocouples, which generate precise voltages based on the temperature difference between the hot junction and the cold junction. Unfortunately, unintentional thermocouple junctions exist in all wiring and on all circuit boards. Within the Tekdaqc, these thermocouple voltages are either eliminated through careful design and thermal stabilization, or accounted for through **SELFCAL** calibration (*during a SELFCAL the Tekdaqc measures the voltage generated through the signal path from the input terminals to the ADC and subtracts it from the reading*).

No measurement system can eliminate **thermal EMF** errors in the external wiring connected to the input terminals. Below is a list of thermal EMF values of some common metal found in wiring, terminals and connectors. The voltages generated per degree of temperature differential seem relatively small, but consider that the Tekdaqc's internal errors are several orders of magnitude less. For example, in the case of a corroded copper connection (*copper to copper oxide*), the error caused by a single connection could be several millivolts (*thousands of times the error of the Tekdaqc*). Even a clean copper to copper connection made with copper wire of slightly different compositions can generate 300nv per degree (*an order of magnitude higher than the noise floor of the Tekdaqc*).

Copper-to	Approx. μ V/C°
Copper	< 0.3
Gold	0.5
Silver	0.5
Brass	3
Beryllium Copper	5
Aluminum	5
Kovar or Alloy 42	40
Silicon	500
Copper-Oxide	1,000
Cadmium-Tin Solder	0.2
Tin-Lead Solder	5

If attempting maximum precision measurements, the user will need to take extreme care to try to reduce the impact of the thermoelectric effect. The following rules will help you minimize or eliminate thermal noise sources:

1. Never take measurements with the Tekdaqc enclosure open.

2. Always let the temperature of the Tekdaqc associated wiring stabilize as much as possible before taking measurements.

3. Never route wiring near thermal sources.

4. Use wiring and connectors with thermal EMF values as similar as possible. Copper, gold and silver are best wire metals, but brass is not bad. Nickel and chrome plated connectors are generally a bad idea, while gold or silver plated are best.

5. Try to make even numbers of matching junctions; a junction on one input wire and a matching junction on the other input wire should generate equal but opposite EMF voltages, effectively eliminating the thermoelectric noise.

6. Ensure that any junctions made on the two inputs are located in the same physical location, and are thus exposed to the same environmental temperature. In this way they will not generate different magnitude voltages.

Don't let this discussion of **thermal EMF** and electrical noise make you think that every measurement you make needs to include a complex analysis of thermal EMF and noise sources. Most measurements will not be noticeably affected by these error sources, since the error is so minimal compared to the desired precision level. In addition, most sensors are not inherent errors significantly larger than the contribution from noise and thermal EMF.

Additional info on thermal EMF:
http://zone.ni.com/reference/en-XX/help/375472A-01/switch/thermal_voltages

Isolation

Many users may not realize that the most common voltage measuring device, the simple battery powered **digital multimeter** (*DMM*), is an isolated signal measurement device. The battery provides isolation from an external power source, while the plastic case of the DMM provides isolation from the user. Because of the inherent isolation, the average DMM user has not faced the issues involved with using a non-isolated data acquisition system. Any voltage applied to the DMM simply causes the internal circuitry to "float" to the voltage of that signal, so common mode voltages (*voltages common to both test leads*) are simply not seen by the DMM. One could use several DMMs to measure multiple signals simultaneously but this would be impractical for a host of reasons (*including the poor performance of simple DMMs, inability to record data, and high cost per channel*).

So what happens when we try to measure many channels of analog data with a **non-isolated A/D converter** of the type commonly seen on microcontrollers, Arduino boards, or the vast majority of DAQC boards from NI and others? Without going too deeply into the theory (*if you want more detail you can check out the links at the end of this section*), current from one channel of a non-isolate measurement system flows to the other channels due to potential differences between the channels. It is essentially impossible to get accurate, low-noise readings in real world applications with a non-isolated A/D system. There are always common mode voltage differences between sensors. In the worst case, these common mode differences (*or ground potential differences*) can be large enough to actually destroy the input multiplexer of a **non-isolated DAQC system**; even in the best case, there will be smallvh ground potential differences between channels that will cause noise and measurement errors.

The bottom line: You simply cannot make precision measurements without an isolated measurement system. Below are a series of articles and papers on the importance of isolation in signal conditioning:

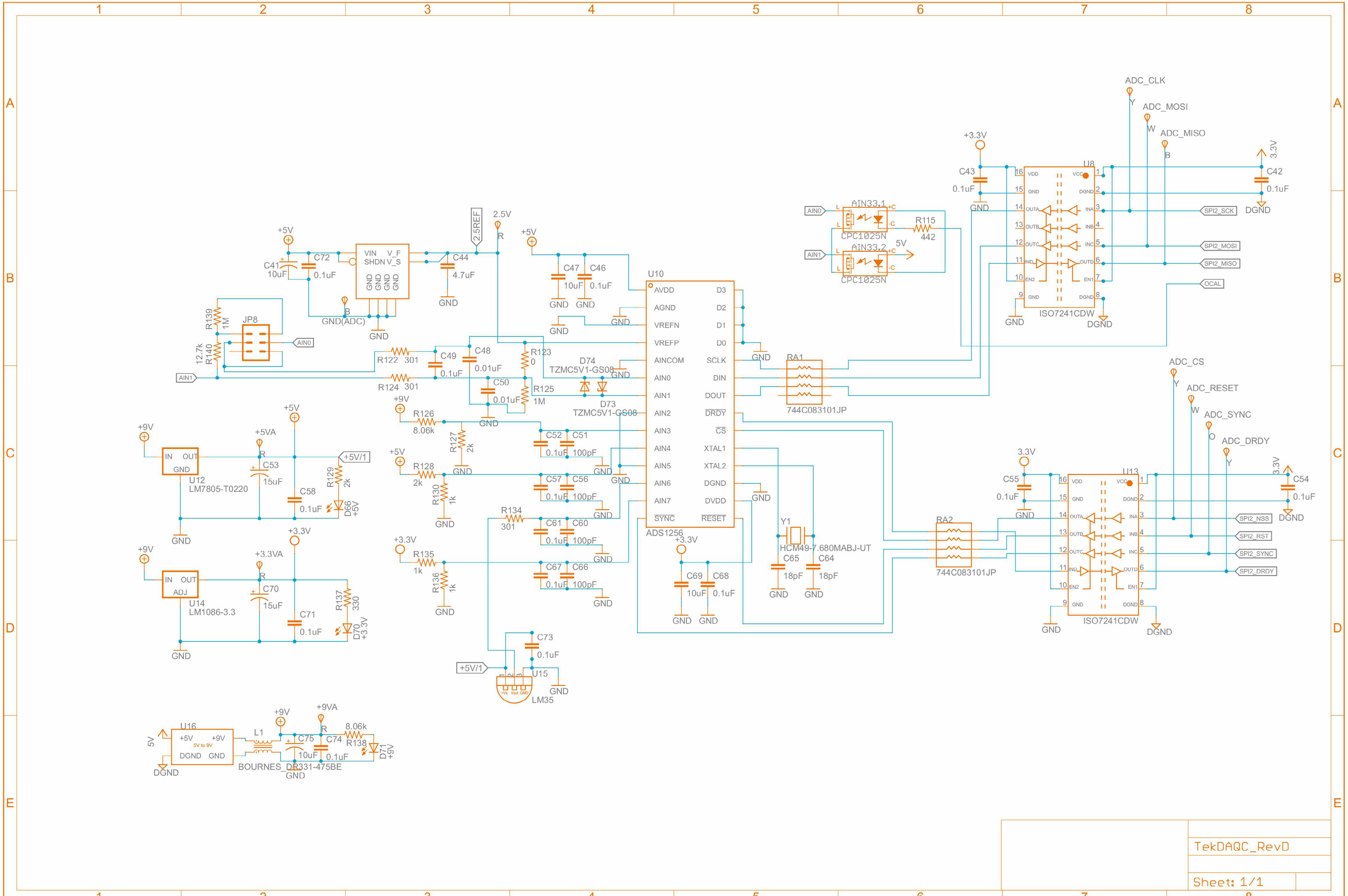
http://www.sensorsmag.com/da-control/why-use-isolated-signal-conditioners-part-1-crosstalk-and-co-10531

http://www.sensorsmag.com/da-control/why-use-isolated-signal-conditioners-part-2-dc-and-ac-common-10590

http://mail.dataq.com/support/documentation/pdf/article_pdfs/isolation.pdf

http://www.ni.com/white-paper/3546/en

http://www.scientific-devices.com.au/pdfs/WeTransfer-NZvJB6Cw/Basic/Why%20use%20Isolated%20Signal%20Conditioners.pdf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D3
D2
D1
D0
SCLK
DIN
DOUT
DRDY
CS
XTAL1
XTAL2
DGND
DVDD
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ISO7241CDW
U13
ISO7241CDW
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ADC_MISO
ADC_CS
ADC_RESET
ADC_SYNC
ADC_DRDY
SPI2_SCK
SPI2_MOSI
SPI2_MISO
OCAL
SPI2_NSS
SPI2_RST
SPI2_SYNC
SPI2_DRDY
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R115
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RA2
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LM1086-3.3
U15
LM35
U16
L1
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D74
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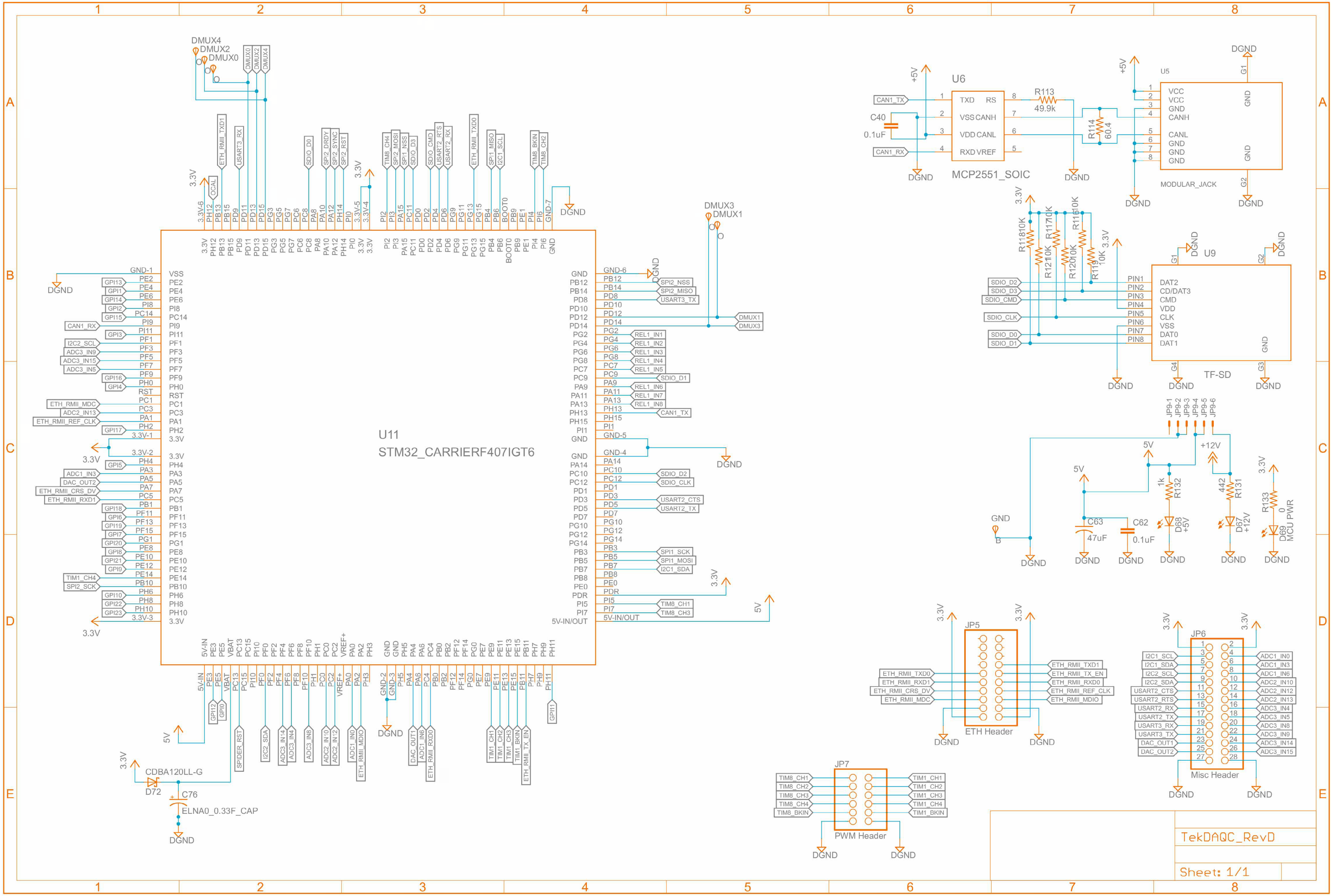
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JP7
PWM Header
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C76
ELNA0_0.33F_CAP
C40
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R113
49.9k
R114
60.4
C63
47uF
C62
0.1uF
R132
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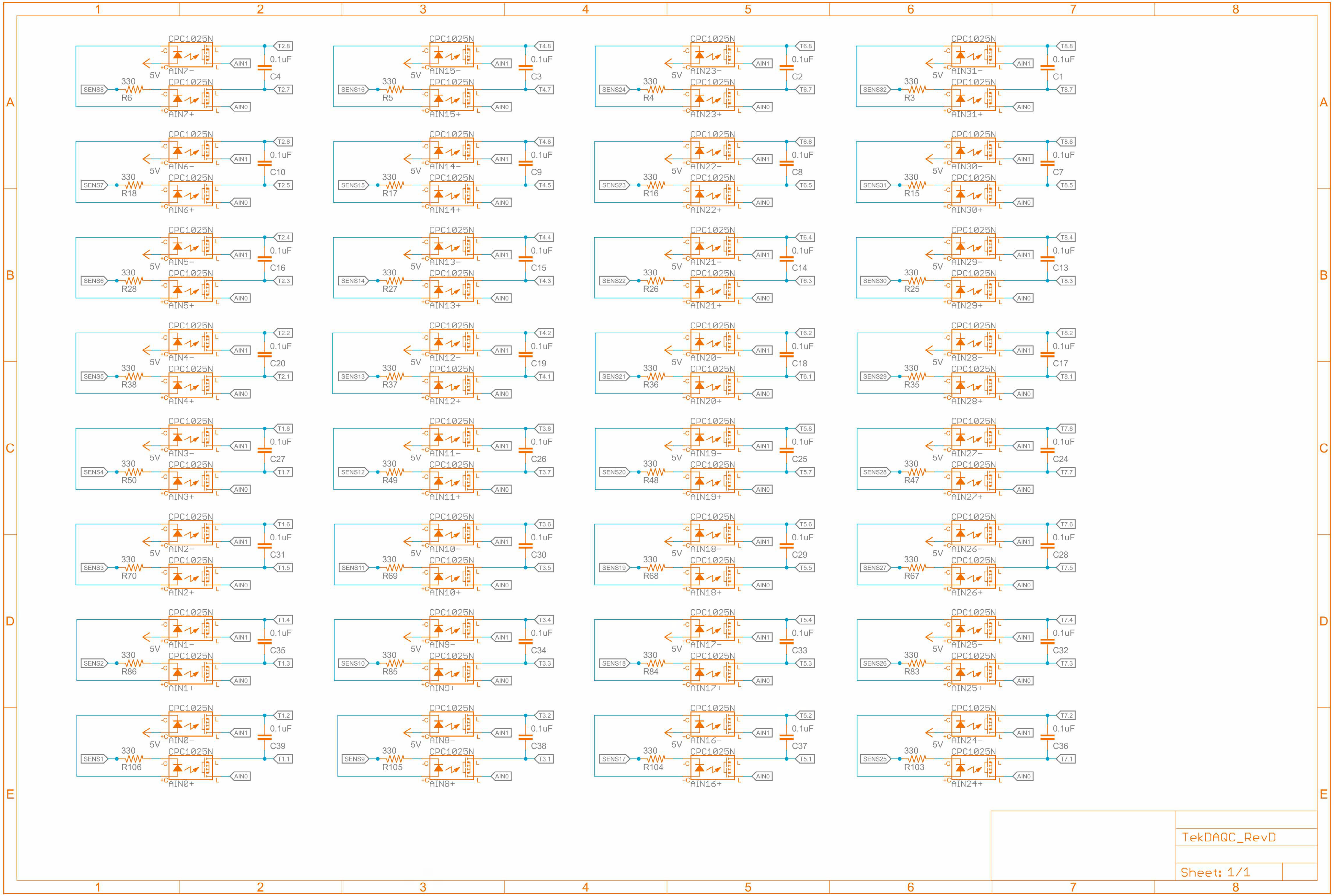
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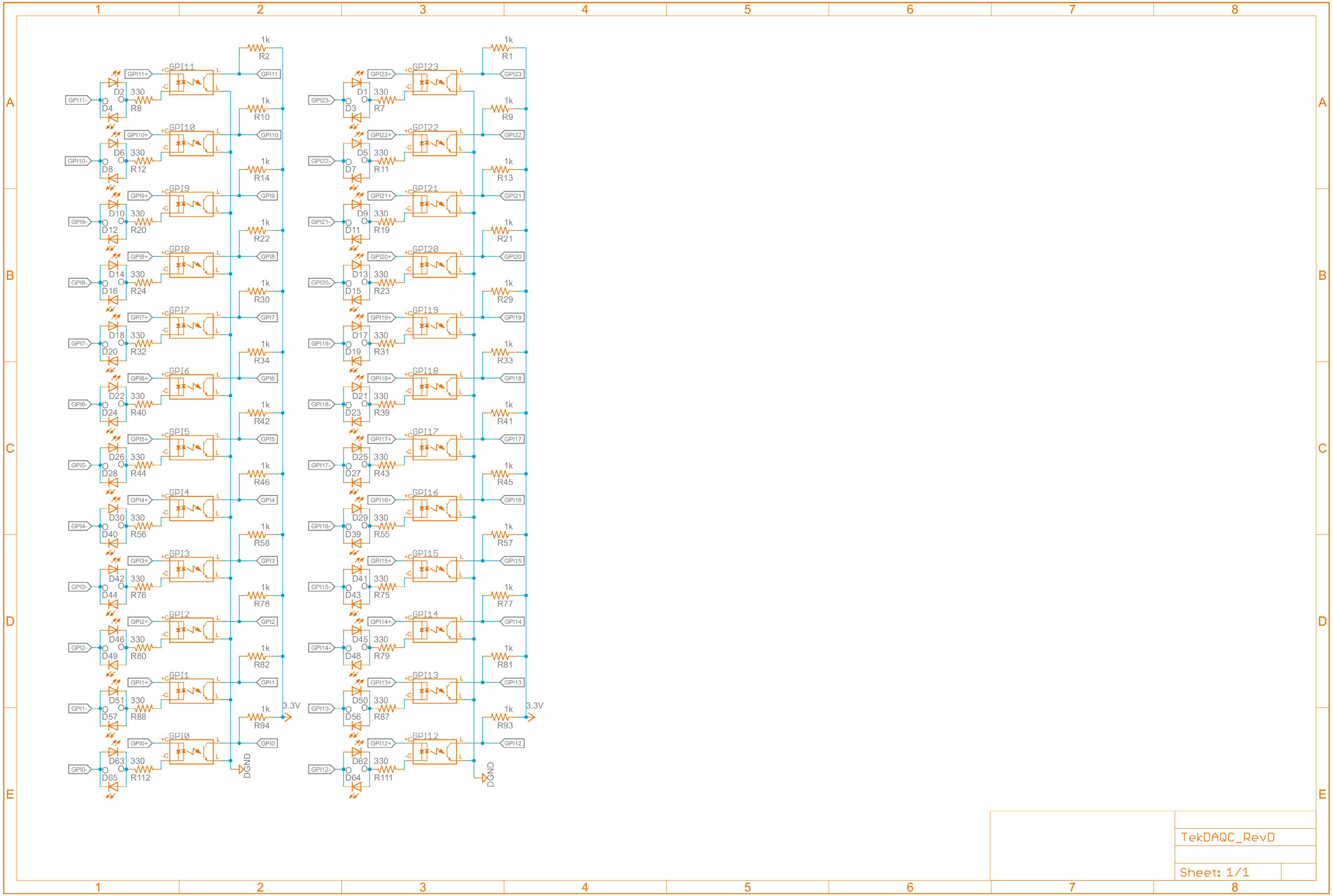
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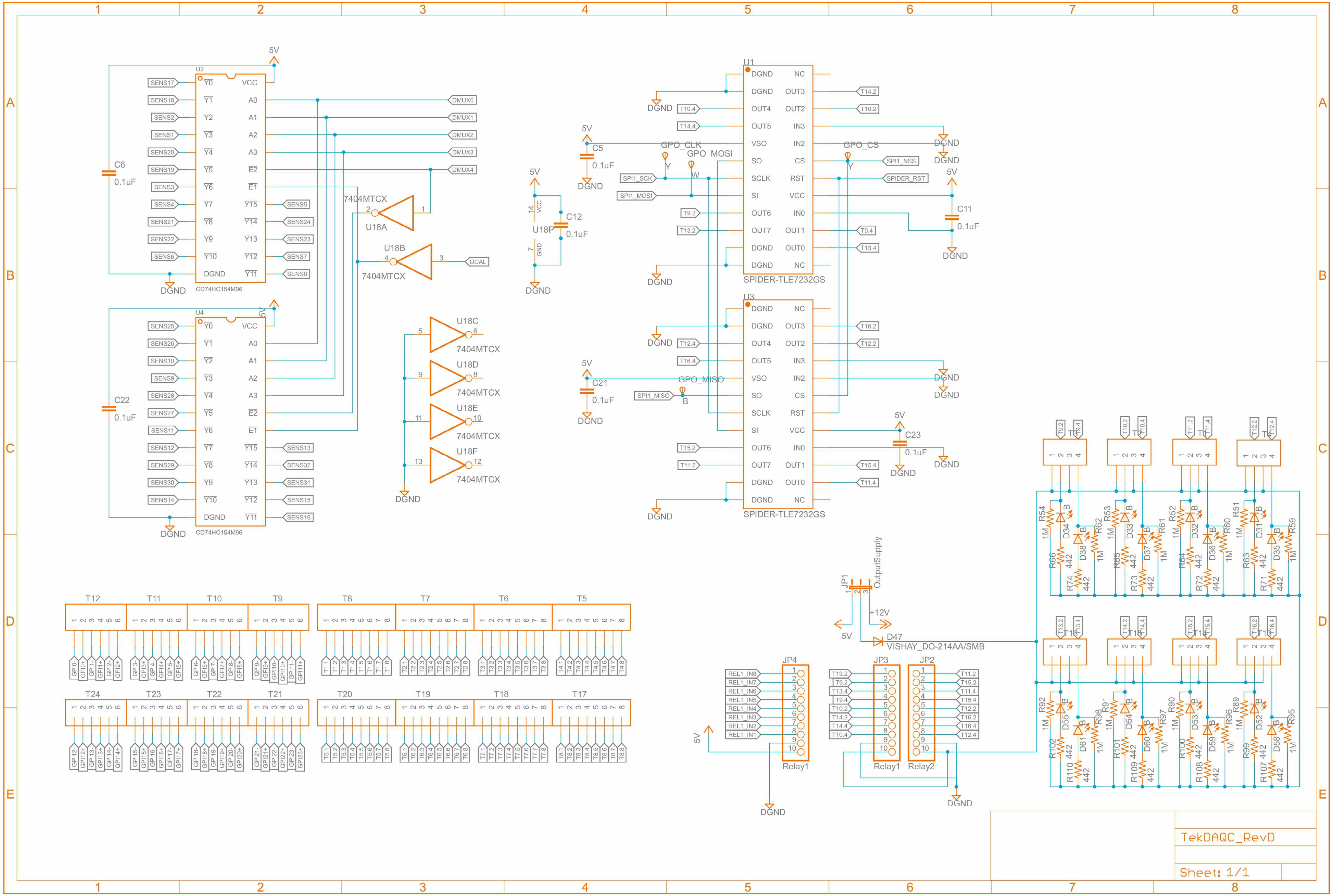
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U18D
U18E
U18F
U18P
C12
0.1uF
U1
SPIDER-TLE7232GS
U3
SPIDER-TLE7232GS
C5
0.1uF
C21
0.1uF
C11
0.1uF
C23
0.1uF
GPO_CLK
GPO_MOSI
GPO_MISO
GPO_CS
OCAL
DGND
5V
+12V
JP1
OutputSupply
D47
VISHAY_DO-214AA/SMB
JP4
JP3
JP2
Relay1
Relay2
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