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LJTick-InAmp

August 7, 2007 Revision 1.07

The LJTick-InAmp (LJTIA) is a signal-conditioning module that provides two instrumentation amplifiers ideal for low-level signals such as bridge circuits (strain gauges) and thermocouples. The LJTIA has 5 gain settings per channel and two selectable output voltage offsets (Voffset). The 4-pin design plugs into the standard AIN/AIN/GND/VS screw-terminal block found on newer LabJacks such as the U3 and UE9.

The pictures below show the LJTIA plugged into the U3 on the left and plugged into the UE9 on the right.

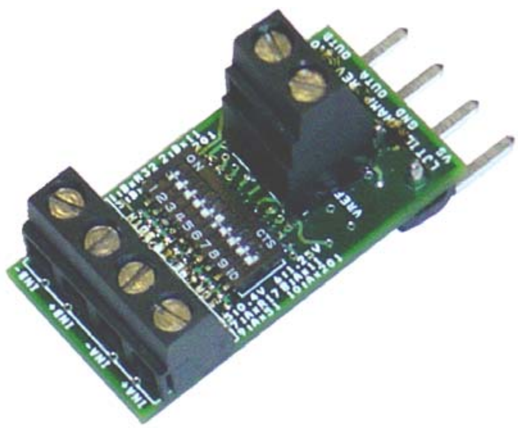


Figure 1: LJTick-InAmp (LJTIA)

Figure 2: LJTIA With U3

Figure 3: LJTIA With UE9

The block of 4 screw-terminals at the left edge of the LJTIA (Figure 1 above) provides a positive and negative input for each differential channel. Towards the LabJack side of the LJTIA is a pair of screw-terminals that provide a ground connection (GND) and a +2.50 volt reference (VREF). The reference is capable of sourcing enough current (see Specifications) to function as the excitation voltage for most common bridge circuits.

In between the blocks of screw-terminals is a 10-position DIP switch used to specify gain and offset.

Switch #	Name	Description	
1	BxR32	Custom gain determined by R32	Applies to channel B only. All off equals a gain of 1.
2	Bx11	Gain of 11	
3	Bx52	Gain of 51	
4	Bx201	Gain of 201	
5	0.4V	Output offset of +0.4 volts.	Voffset applies to both channels. Switch # 5 or 6 should always be on, but not both.
6	1.25V	Output offset of +1.25 volts.	
7	AxR17	Custom gain determined by R17	Applies to channel A only. All off equals a gain of 1.
8	Ax11	Gain of 11	
9	Ax51	Gain of 51	
10	Ax201	Gain of 201	

Table 1: DIP Switch Descriptions

Each channel has a switch (numbers 1 & 7) that has been left without factory-installed gain resistors. Resistors can be installed by the end-user to provide custom gains according to G=(1+(100k/R). For example, a resistance of 100 ohms would provide the maximum allowable gain of 1001.

Extending from the back of the LJTick-InAmp are four pins. The first two pins provide +5 volt power and ground from the LabJack. The other two pins are the instrumentation amplifier outputs and connect to analog inputs on the LabJack. The four pins plug directly into the 5.0 mm spaced screw-terminals on the LabJack U3, UE9, or other future devices as shown in Figure 4.

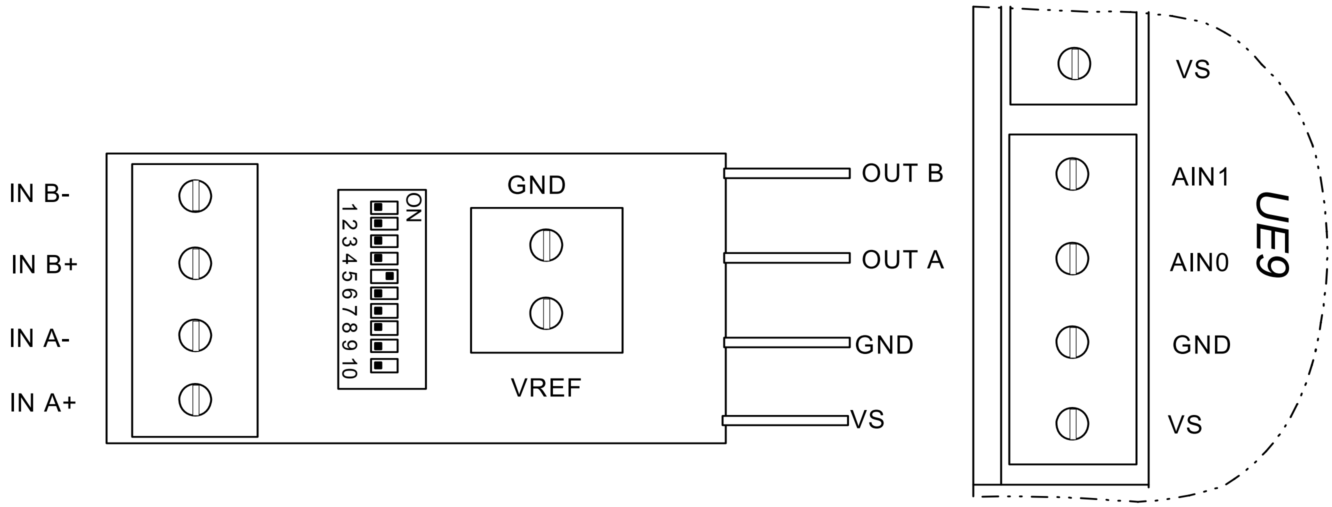


Figure 4: LJTick-InAmp schematic lined up to UE9

Each channel on the LJTIA has an AD623 instrumentation amplifier (in-amp) from Analog Devices. The allowable signal range (Vin) is determined by a combination of Gain, Voffset, Vcm, and Vout. See the Signal Range Tables in Appendix A.

Voffset: This is an offset voltage added to the in-amp output. If DIP switch #5 is on, the offset is +0.4 volts, and if DIP switch #6 is on, the offset is +1.25 volts. The same offset applies to both channels of the LJTick-InAmp. One offset must always be selected (0 volts is not an option), but both offsets should never be enabled at the same time. The +0.4 volt offset is generally used with signals that are mostly unipolar, while the +1.25 volt offset is generally used with bipolar signals.

Vcm: This is the common mode voltage of the differential inputs. For an in-amp, that is defined as the average of the common mode voltage of each input. For instance, if the negative input is grounded, and a single-ended signal is connected to the positive input, Vcm is equal to Vin/2. Another common situation is when using a wheatstone bridge where VREF=2.5 is providing the excitation. In this case, each input is at about 1.25 volts compared to ground, and thus Vcm is about 1.25 volts.

Vin: This is the voltage difference between IN+ and IN-. In the following Signal Range Tables, the “Low” column is the minimum Vin where Vout is 10 mV or higher, the “High 2.5V” column is the maximum Vin where Vout is 2.5 volts or less, and the “High 4.5V” column is the maximum Vin where Vout is 4.5 volts or less.

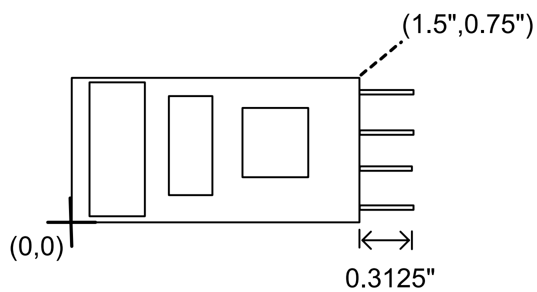
Vout: This is the single-ended (referred to ground) voltage output from the in-amp. Because of the power supply to the in-amp, the full output swing is about 0.01 volts to 4.5 volts. The “Low” and “High” columns in the Signal Range Tables give the output at the respective Vin.

Specifications:

Parameter	Conditions	Min	Typical	Max	Units
General					
Supply Voltage		3.6	5	5.5	volts
Supply Current (1)	No Loads		1.5		mA
Operating Temperature		-40		85	°C
Signal Specs					
Gain Accuracy			0.2		%
Offset Accuracy	G=1		0.5		%
	G=11		0.5		%
	G=51		2.5		%
	G=201		10		%
Input Bias Current			17		nA
Input Impedance			2		GΩ
Typical Output Range	Load ≥ 10 kΩ	0.01		VS - 0.5	
-3 dB Bandwidth	x1		18		kHz
	x11		18		kHz
	x51		18		kHz
	x201		10		kHz
Vref					
Output Voltage		2.495	2.50	2.505	volts
Initial Accuracy			0.2		%
Current Output (1)	For rated V accuracy	0		25	mA

(1) Higher currents will not cause damage, but the reference voltage will start to sag. The reference output can handle a continuous short-circuit to ground and has a short-circuit current of about 45 mA typically.

Dimensions:



<u>Declaration of Conformity</u>

Manufacturers Name: LabJack Corporation
Manufacturers Address: 13701 W Jewell Ave, STE 284, Lakewood, CO 80228, USA

Declares that the product

Product Name: LJTick-InAmp
Model Number: LJTIA

conforms to the following Product Specifications:

EMC Directive: 89/336/EEC

EN 55011 Class A
EN 61326-1: General Requirements

Appendix A - Signal Range Tables: The following tables cover most common situations with the LJTIA, but for other cases there is an online tool available at analog.com (AD623 Product Page => Gain Calculators => AD623 Single Supply):

http://www.analog.com/Analog_Root/static/techSupport/designTools/interactiveTools/inamp/inamp.html?inamp=AD623%205V
("Differential Voltage" = Vin, "Common Mode Voltage" = Vcm, "Reference Voltage" = Voffset, "Gain" = Gain)

Voffset=0.4 V						
Vcm	**Vin (differential) [volts]**			**Vout (single ended) [volts]**		
Gain	**Low**	**High 2.5 V**	**High 4.5 V**	**Low**	**High 2.5 V**	**High 4.5 V**
Zero						
1	-0.3	0.3	N/A	0.1	0.7	N/A
11	-0.0354	0.116	N/A	0.0106	1.58	N/A
51	-0.00764	0.0231	N/A	0.0104	1.58	N/A
201	-0.00194	0.00587	N/A	0.0101	1.58	N/A
1.25 V						
1	-0.39	2.1	3.68	0.01	2.5	4.08
11	-0.0354	0.191	0.334	0.0106	2.5	4.07
51	-0.00764	0.0412	0.0721	0.0104	2.5	4.08
201	-0.00194	0.0104	0.0183	0.0101	2.5	4.07
2.5 V						
1	-0.39	2.1	3.6	1.01	2.5	4
11	-0.0354	0.191	0.327	0.0106	2.5	4
51	-0.00764	0.0412	0.0803	0.0104	2.5	4.5
201	-0.00194	0.0104	0.0179	0.0101	2.5	4
Vin/2						
1	-0.15	2.05	4.1	0.25	2.5	4.5
11	-0.0354	0.118	N/A	0.0106	1.7	N/A
51	-0.00764	0.024	N/A	0.0104	1.59	N/A
201	-0.00194	0.0059	N/A	0.0101	1.59	N/A

Voffset=1.25 V						
Vcm	**Vin (differential) [volts]**			**Vout (single ended) [volts]**		
Gain	**Low**	**High 2.5 V**	**High 4.5 V**	**Low**	**High 2.5 V**	**High 4.5 V**
Zero						
1	-0.3	0.116	N/A	0.07	1.55	N/A
11	-0.107	0.107	N/A	0.073	2.43	N/A
51	-0.0231	0.0231	N/A	0.0719	2.43	N/A
201	-0.00587	0.00587	N/A	0.0701	2.43	N/A
1.25 V						
1	-1.24	1.25	3.25	0.01	2.5	4.5
11	-0.112	0.114	0.295	0.018	2.5	4.5
51	-0.0243	0.0245	0.0637	0.0107	2.5	4.5
201	-0.00616	0.00622	0.0162	0.0114	2.5	4.5
2.5 V						
1	-1.24	1.25	3.25	0.01	2.5	4.5
11	-0.112	0.114	0.295	0.018	2.5	4.5
51	-0.0243	0.0245	0.0637	0.0105	2.5	4.5
201	-0.00616	0.00622	0.0161	0.0114	2.5	4.5
Vin/2						
1	-0.15	0.6	3.2	1.1	2.5	4.5
11	-0.0983	0.113	0.118	0.169	2.5	2.55
51	-0.0226	0.0236	N/A	0.0974	2.45	N/A
201	-0.00584	0.0059	N/A	0.0762	2.44	N/A

Appendix B - Resolution Tables:

The following tables use typical noise measurements with the LabJack U3 and UE9 to determine the noise-free and effective resolutions that can be expected with the LJTick-InAmp (LJTIA). The LJTIA was connected to an analog input on the LabJack and had IN+ shorted to IN- shorted to GND.

The counts of peak-to-peak noise were determined by collecting 128 points from the analog input and subtracting the minimum binary value from the maximum binary value. For the U3 these are based on 12-bit values, while for the UE9 these are based on 24-bit values.

The noise-free resolution is based on the peak-to-peak noise counts, and corresponds to the resolution where no variation would be seen.

The RMS noise counts is the standard deviation of the 128 collected binary values, and the effective resolution values are based on this RMS value. The effective resolution can be thought of as a specification met by *most* points, while the noise-free specifications are met by *all* points.

The "@LJ Inputs" values are in terms of the LabJack U3/UE9 analog input, which is the LJTIA output. Those values are divided by the LJTIA gain to determine the "@LJTIA Inputs" values, which are the resolutions that apply to the signal input to the LJTIA. For instance, a single-ended channel on the LabJack U3 with an LJTIA gain of 201 has a noise-free resolution of about 9 µV and an effective resolution of about 1.8 µV.

LabJack U3:

LJTIA Gain = 1

Range	Peak-To-Peak Noise	Noise-Free Resolution	Noise-Free Res. @LJ Inputs	Noise-Free Res. @LJTIA Inputs	RMS Noise	Effective Resolution	Effective Res. @LJ Inputs	Effective Res. @LJTIA Inputs
volts	counts	bits	volts	volts	counts	bits	volts	volts
SE	2	11.0	0.001191	0.00119141	0.5	13.0	0.000298	0.00029785
Diff	2	11.0	0.002383	0.00238281	0.5	13.0	0.000596	0.00059570
0-3.6	2	11.0	0.002383	0.00238281	0.5	13.0	0.000596	0.00059570

LJTIA Gain = 11

Range	Peak-To-Peak Noise	Noise-Free Resolution	Noise-Free Res. @LJ Inputs	Noise-Free Res. @LJTIA Inputs	RMS Noise	Effective Resolution	Effective Res. @LJ Inputs	Effective Res. @LJTIA Inputs
volts	counts	bits	volts	volts	counts	bits	volts	volts
SE	2	11.0	0.001191	0.00010831	0.5	13.0	0.000298	0.00002708
Diff	2	11.0	0.002383	0.00021662	0.5	13.0	0.000596	0.00005415
0-3.6	2	11.0	0.002383	0.00021662	0.5	13.0	0.000596	0.00005415

LJTIA Gain = 51

Range	Peak-To-Peak Noise	Noise-Free Resolution	Noise-Free Res. @LJ Inputs	Noise-Free Res. @LJTIA Inputs	RMS Noise	Effective Resolution	Effective Res. @LJ Inputs	Effective Res. @LJTIA Inputs
volts	counts	bits	volts	volts	counts	bits	volts	volts
SE	2	11.0	0.001191	0.00002336	0.5	13.0	0.000298	0.00000584
Diff	2	11.0	0.002383	0.00004672	0.5	13.0	0.000596	0.00001168
0-3.6	2	11.0	0.002383	0.00004672	0.5	13.0	0.000596	0.00001168

LJTIA Gain = 201

Range	Peak-To-Peak Noise	Noise-Free Resolution	Noise-Free Res. @LJ Inputs	Noise-Free Res. @LJTIA Inputs	RMS Noise	Effective Resolution	Effective Res. @LJ Inputs	Effective Res. @LJTIA Inputs
volts	counts	bits	volts	volts	counts	bits	volts	volts
SE	3	10.4	0.001806	0.00000898	0.6	12.7	0.000367	0.00000182
Diff	3	10.4	0.003612	0.00001797	0.6	12.7	0.000733	0.00000365
0-3.6	3	10.4	0.003612	0.00001797	0.6	12.7	0.000733	0.00000365

Resolution Tables (Cont.):

LabJack UE9 & UE9-Pro (LJTIA Gain = 1 & 11):

All "counts" data in the following UE9 tables are from 24-bit values. To equate to counts at a particular resolution (Res) use the formula counts/(2^(24-Res)). For instance, with the UE9 set to 12-bit resolution and the 0-5 volt range, there are 8192 counts of noise when looking at 24-bit values. To equate this to 12-bit data, we take 8192/(2^12), which equals 2 counts of noise when looking at 12-bit values.

Resolution = 0-12, LJTIA Gain = 1

Range	Peak-To-Peak Noise	Noise-Free Resolution	Noise-Free Res. @LJ Inputs	Noise-Free Res. @LJTIA Inputs	RMS Noise	Effective Resolution	Effective Res. @LJ Inputs	Effective Res. @LJTIA Inputs
volts	counts	bits	volts	volts	counts	bits	volts	volts
0-5	12288	10.4	0.003700	0.00370048	2350	12.8	0.000701	0.00070111
0-2.5	20480	9.7	0.003006	0.00300572	4100	12.0	0.000610	0.00061035

Resolution = 17, LJTIA Gain = 1

Range	Peak-To-Peak Noise	Noise-Free Resolution	Noise-Free Res. @LJ Inputs	Noise-Free Res. @LJTIA Inputs	RMS Noise	Effective Resolution	Effective Res. @LJ Inputs	Effective Res. @LJTIA Inputs
volts	counts	bits	volts	volts	counts	bits	volts	volts
0-5	408	15.3	0.000124	0.00012394	78	17.7	0.000023	0.00002348
0-2.5	620	14.7	0.000094	0.00009393	120	17.1	0.000018	0.00001780

Resolution = 18+ (UE9-Pro), LJTIA Gain = 1

Range	Peak-To-Peak Noise	Noise-Free Resolution	Noise-Free Res. @LJ Inputs	Noise-Free Res. @LJTIA Inputs	RMS Noise	Effective Resolution	Effective Res. @LJ Inputs	Effective Res. @LJTIA Inputs
volts	counts	bits	volts	volts	counts	bits	volts	volts
0-5	96	17.4	0.000029	0.00002891	20	19.7	0.000006	0.00000587

Resolution = 0-12, LJTIA Gain = 11

Range	Peak-To-Peak Noise	Noise-Free Resolution	Noise-Free Res. @LJ Inputs	Noise-Free Res. @LJTIA Inputs	RMS Noise	Effective Resolution	Effective Res. @LJ Inputs	Effective Res. @LJTIA Inputs
volts	counts	bits	volts	volts	counts	bits	volts	volts
0-5	12288	10.4	0.003700	0.00033641	2350	12.8	0.000701	0.00006374
0-2.5	20480	9.7	0.003006	0.00027325	4100	12.0	0.000610	0.00005549

Resolution = 17, LJTIA Gain = 11

Range	Peak-To-Peak Noise	Noise-Free Resolution	Noise-Free Res. @LJ Inputs	Noise-Free Res. @LJTIA Inputs	RMS Noise	Effective Resolution	Effective Res. @LJ Inputs	Effective Res. @LJTIA Inputs
volts	counts	bits	volts	volts	counts	bits	volts	volts
0-5	408	15.3	0.000124	0.00001127	78	17.7	0.000023	0.00000213
0-2.5	620	14.7	0.000094	0.00000854	120	17.1	0.000018	0.00000162

Resolution = 18+ (UE9-Pro), LJTIA Gain = 11

Range	Peak-To-Peak Noise	Noise-Free Resolution	Noise-Free Res. @LJ Inputs	Noise-Free Res. @LJTIA Inputs	RMS Noise	Effective Resolution	Effective Res. @LJ Inputs	Effective Res. @LJTIA Inputs
volts	counts	bits	volts	volts	counts	bits	volts	volts
0-5	110	17.2	0.000033	0.00000302	20	19.7	0.000006	0.00000053

Resolution Tables (Cont.):

LabJack UE9 & UE9-Pro (LJTIA Gain = 51 & 201):

All "counts" data in the following UE9 tables are from 24-bit values. To equate to counts at a particular resolution (Res) use the formula counts/(2^(24-Res)). For instance, with the UE9 set to 12-bit resolution and the 0-5 volt range, there are 8192 counts of noise when looking at 24-bit values. To equate this to 12-bit data, we take 8192/(2^12), which equals 2 counts of noise when looking at 12-bit values.

Resolution = 0-12, LJTIA Gain = 51

Range	Peak-To-Peak Noise	Noise-Free Resolution	Noise-Free Res. @LJ Inputs	Noise-Free Res. @LJTIA Inputs	RMS Noise	Effective Resolution	Effective Res. @LJ Inputs	Effective Res. @LJTIA Inputs
volts	counts	bits	volts	volts	counts	bits	volts	volts
0-5	12288	10.4	0.003700	0.00007256	2350	12.8	0.000701	0.00001375
0-2.5	20480	9.7	0.003006	0.00005894	4100	12.0	0.000610	0.00001197

Resolution = 17, LJTIA Gain = 51

Range	Peak-To-Peak Noise	Noise-Free Resolution	Noise-Free Res. @LJ Inputs	Noise-Free Res. @LJTIA Inputs	RMS Noise	Effective Resolution	Effective Res. @LJ Inputs	Effective Res. @LJTIA Inputs
volts	counts	bits	volts	volts	counts	bits	volts	volts
0-5	472	15.1	0.000142	0.00000279	87	17.6	0.000025	0.00000049
0-2.5	776	14.4	0.000116	0.00000227	147	16.8	0.000022	0.00000043

Resolution = 18+ (UE9-Pro), LJTIA Gain = 51

Range	Peak-To-Peak Noise	Noise-Free Resolution	Noise-Free Res. @LJ Inputs	Noise-Free Res. @LJTIA Inputs	RMS Noise	Effective Resolution	Effective Res. @LJ Inputs	Effective Res. @LJTIA Inputs
volts	counts	bits	volts	volts	counts	bits	volts	volts
0-5	172	16.6	0.000050	0.00000099	29	19.2	0.000008	0.00000016

Resolution = 0-12, LJTIA Gain = 201

Range	Peak-To-Peak Noise	Noise-Free Resolution	Noise-Free Res. @LJ Inputs	Noise-Free Res. @LJTIA Inputs	RMS Noise	Effective Resolution	Effective Res. @LJ Inputs	Effective Res. @LJTIA Inputs
volts	counts	bits	volts	volts	counts	bits	volts	volts
0-5	16384	10.0	0.004883	0.00002429	3500	12.2	0.001063	0.00000529
0-2.5	32768	9.0	0.004883	0.00002429	6480	11.3	0.000992	0.00000493

Resolution = 17, LJTIA Gain = 201

Range	Peak-To-Peak Noise	Noise-Free Resolution	Noise-Free Res. @LJ Inputs	Noise-Free Res. @LJTIA Inputs	RMS Noise	Effective Resolution	Effective Res. @LJ Inputs	Effective Res. @LJTIA Inputs
volts	counts	bits	volts	volts	counts	bits	volts	volts
0-5	1232	13.7	0.000376	0.00000187	185	16.5	0.000054	0.00000027
0-2.5	2104	13.0	0.000305	0.00000152	376	15.4	0.000058	0.00000029

Resolution = 18+ (UE9-Pro), LJTIA Gain = 201

Range	Peak-To-Peak Noise	Noise-Free Resolution	Noise-Free Res. @LJ Inputs	Noise-Free Res. @LJTIA Inputs	RMS Noise	Effective Resolution	Effective Res. @LJ Inputs	Effective Res. @LJTIA Inputs
volts	counts	bits	volts	volts	counts	bits	volts	volts
0-5	484	15.1	0.000142	0.00000071	106	17.3	0.000031	0.00000015

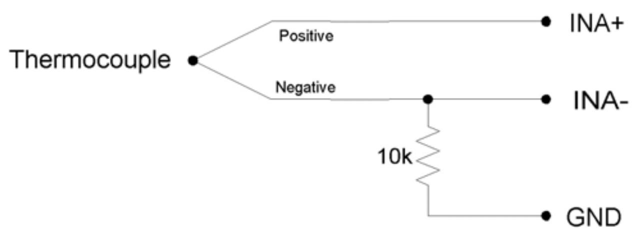
Appendix C - Thermocouples:

Thermocouples are not particularly accurate or easy to use, but they are a very common way to measure temperature. Some applications with extreme temperatures or specific mechanical requirements might require thermocouples, but whenever possible consider instead using a silicon type temperature sensor such as the EI-1022 (-40 to +100 degrees C) or the very accurate and waterproof EI-1034 (-17 to +150 degrees C). Both of those probes are available from LabJack, and provide a high-level linear voltage output that connects directly to analog inputs.

There are three main issues when making measurements with a thermocouple:

1) Cold Junction Effects: The voltage generated at the LJTIA by the thermocouple is related to the difference in temperature of the end of the thermocouple and the LJTIA. In order to know the temperature at the end of the thermocouple, the temperature of the LJTIA must also be known. The U3 and UE9 have an internal temperature sensor, or a simple silicon type sensor can be used. Once the cold junction temperature is known, it is easily handled in software.
2) Non-Linear Output: The output of a thermocouple is non-linear. NIST (nist.gov) provides tables and equations to convert a thermocouple voltage to a temperature. The LabJack UD driver provides a convenient function that uses the NIST equation to handle the conversion, and DAQFactory has built-in conversion functions of its own.
3) Small Output Voltage: The small output voltage of a thermocouple makes it difficult to get good temperature resolution. The LJTIA is used to amplify the thermocouple voltage before it is sent to an analog input.

The following diagram shows the typical connection of a thermocouple to the LJTIA:



The thermocouple is connected to IN+ (positive lead) and IN- (negative lead), and IN- is also connected to GND through a 10 kΩ resistor (meaning that Vcm=Vin/2).

Care must be taken when placing the negative thermocouple lead and resistor lead into the same screw-terminal, to make sure that both are solidly contacted. Sometimes the thermocouple wire is thicker than the resistor wire, making it easy for the resistor to lose contact. In such a case the LJTIA output will likely be stuck near 0 volts, Voffset, or 5 volts.

In most situations, a short can simply be used for the GND connection instead of a 10 kΩ resistor, but note that if a short is used the negative lead of the thermocouple is grounded at the LJTIA. This is not recommended when using multiple probes and when the probes could be contacting grounded metal somewhere in the system. The 10 kΩ resistor maintains some isolation between the negative thermocouple lead and ground, and yet provides a path for the LJTIA bias currents.

It is possible to install the 10 kΩ resistors (Digikey #P10KGCT) on the LJTIA PCB. For channel A, install the resistor on R8. For channel B, install the resistor on R23. Obviously this reduces the input impedance of the negative input of the LJTIA to 10 kΩ, which might not be desirable for some signals besides thermocouples.

Thermocouples (Cont.):

The output offset of the LJTIA can be set to 0.4 volts or 1.25 volts. For the best accuracy, the actual system offset should be measured. If the end of the thermocouple is at the same temperature as the cold junction, the thermocouple voltage should be zero, so place the end of the thermocouple near the LJTIA and note the voltage measured by the analog input (should be near 0.4 volts or 1.25 volts). This is the actual system offset, and should be subtracted from further analog input readings before dividing by the gain to get the thermocouple voltage.

The UD driver for Windows has a convenient function that takes in thermocouple type, thermocouple voltage, and cold junction temperature, and returns the thermocouple temperature. The following pseudocode demonstrates a measurement:

```
//Read the amplified and offset thermocouple voltage from an analog input.
eGet (lngHandle, LJ_ioGET_AIN, tcChannel, &valueAIN, 0);

//Get the internal temperature reading (channel 133 on the UE9 or channel 30 on the U3).
eGet (lngHandle, LJ_ioGET_AIN, internalTempChannel, &cjTempK, 0);

//To get the thermocouple voltage we subtract the offset from the AIN voltage
//and divide by the LJTIA gain.
tcVolts = (valueAIN - offsetVoltage)/51;

//Convert TC voltage to temperature.
TCVoltsToTemp (LJ_ttK, tcVolts, cjTempK, &TCTempK);
```

Go to labjack.com for thermocouple examples in C, VB, LabVIEW, and more. For DAQFactory examples go to daqexpress.com.

The following table shows the minimum and maximum allowable temperatures (from NIST) for some common thermocouple types. The table also shows the thermocouple voltages generated at those limits. Note that these extremes might not be allowed continuously, and thermocouple manufacturers will often provide a reduced range that is recommended for continuous use.

	Min		Max	
Type	Temp [deg C]	Voltage [mV]	Temp [deg C]	Voltage [mV]
B	0	0.000	1820	13.820
E	-270	-9.835	1000	76.373
J	-210	-8.095	1200	69.553
K	-270	-6.458	1372	54.886
N	-270	-4.345	1300	47.513
R	-50	-0.226	1768	21.101
S	-50	-0.236	1768	18.693
T	-270	-6.258	400	20.872

Thermocouples (Cont.):

The following tables show the measurement range for different thermocouple types with different gain and offset settings for the LJTick-InAmp. Also shown is the resulting temperature resolution.

For example, from the LJTIA Signal Range Tables the max input voltage (for an output of 2.5 volts or less) is about 5.9 mV with a gain of 201, an offset of 0.4 volts, and a common mode voltage of Vin/2. From the NIST K-type thermocouple table the temperature corresponding to 5.9 mV is about 144 degrees C. The basic resolution of a K-type thermocouple is roughly 37 uV/degC, so since this example has a gain of 201 the resulting resolution is about 7.5 mV/degC. From the Resolution Tables in Appendix B, the U3 has a noise-free single-ended resolution of about 1.2 mV, so the noise-free temperature resolution would be about 0.16 degrees C. The UE9 has a noise-free resolution of about 94 uV (0-2.5 volts, 17-bit), so the noise-free temperature resolution would be about 0.013 degrees C. The UE9-Pro has a noise-free resolution of about 29 uV (0-5 volts, 18-bit), so the noise-free temperature resolution would be about 0.004 degrees C. These calculations assume no noise from the thermocouple signal itself.

	LJTIA Gain = 1, Voffset = 0.4		
Type	Min [deg C]	Max [deg C]	Resolution [uV/degC]
B	0	1820	8
E	-270	1000	68
J	-210	1200	55
K	-270	1372	37
N	-270	1300	33
R	-50	1768	12
S	-50	1768	10
T	-270	400	40

	Gain = 11, Voffset = 0.4		
Type	Min deg C	Max deg C	Resolution ~uV/degC
B	0	1820	84
E	-270	1000	747
J	-210	1200	606
K	-270	1372	411
N	-270	1300	363
R	-50	1768	129
S	-50	1768	115
T	-270	400	445

	Gain = 51, Voffset = 0.4		
Type	Min deg C	Max deg C	Resolution ~uV/degC
B	0	1820	387
E	-160	337	3462
J	-189	438	2809
K	-270	578	1905
N	-270	686	1685
R	-50	1768	598
S	-50	1768	531
T	-270	400	2065

	Gain = 201, Voffset = 0.4		
Type	Min deg C	Max deg C	Resolution ~uV/degC
B	0	1112	1526
E	-34	93	13644
J	-39	111	11069
K	-51	144	7509
N	-78	199	6639
R	-50	627	2358
S	-50	664	2093
T	-53	133	8139

	Gain = 201, Voffset = 1.25		
Type	Min deg C	Max deg C	Resolution ~uV/degC
B	0	1112	1526
E	-113	93	13644
J	-131	111	11069
K	-196	144	7509
N	-270	199	6639
R	-50	627	2358
S	-50	664	2093
T	-216	133	8139

Appendix D – Bridge Circuits:

A bridge circuit generally outputs a small differential voltage. The LJTick-InAmp provides the amplification needed to acquire such a signal, converts the differential signal to single-ended, and provides a 2.5 volt reference voltage (VREF) that can be used for excitation.

A common example would be a Wheatstone bridge made of 350 ohm strain gauges. If VREF/GND is used to provide the excitation voltage for the bridge, it will draw about 2.5/350 = 7 mA, and the common mode voltage (Vcm) of the differential signal will be about 1.25 volts. The outputs would be connected to IN+ and IN-. If Voffset is set to 1.25 volts and the gain is set to 201, the allowable input range for the LJTIA is –0.00616 to +0.00622 volts (with 0-2.5 volt output).