ADC converter

1)

3.28 Analog-to-digital converter (ADC)

One 12-bit analog-to-digital converter is embedded and shares up to 16 external channels, performing conversions in the single-shot or scan mode. In scan mode, automatic conversion is performed on a selected group of analog inputs.

Table 66. ADC characteristics

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
V_{DDA}	Power supply	$V_{DDA} - V_{REF+} < 1.2$ V	1.7[1]	-	3.6	V
V_{REF+}	Positive reference voltage		1.7[1]	-	V_{DDA}	
V_{REF-}	Negative reference voltage	-	-	0	-	
f_{ADC}	ADC clock frequency	V_{DDA} = 1.7[1] to 2.4 V	0.6	15	18	MHz
		V_{DDA} = 2.4 to 3.6 V	0.6	30	36	MHz
f_{TRIG}[2]	External trigger frequency	f_{ADC} = 30 MHz, 12-bit resolution	-	-	1764	kHz
		-	-	-	17	$1/f_{ADC}$
V_{AIN}	Conversion voltage range[3]	-	0 (V_{SSA} or V_{REF-} tied to ground)	-	V_{REF+}	V
R_{AIN}[2]	External input impedance	See *Equation 1* for details	-	-	50	κΩ
R_{ADC}[2][4]	Sampling switch resistance	-	-	-	6	κΩ

104/139 DS9716 Rev 11

ADC resolution: 12bit

Maximum $Vref = 3.6V$

2)

For maximum precision we should choose $Vref = Vin$ because it covers the range of input and no more, so the resolution is highest therefore precision is maximum.

5)

Accuracy= $\frac{1.4}{4096} \approx 0.34mV$

But the accuracy is limited by the resolution of LCD.

force meter:

1)

$$10Kg \to 0.02cm,\ \ 2.5Kg \to \frac{0.02}{4} = 0.005cm$$

$$\Delta R = \epsilon.GF.R0 = \frac{0.005}{40} * 2.5 *\ 500 = 0.15625\Omega$$

$$quarter\ bridge \to\ R_G = 500.15625 \to Vout = Vin\left[\frac{500.15625}{500.15625 + 500} - \frac{1}{2}\right] = 0.78mV$$

$$half\ bridge \to\ Vout = Vin\left[\frac{500.15625}{500.15625 + 499.84375} - \frac{1}{2}\right] = 1.5625mV$$

$$full\ bridge \to\ Vout = Vin\left[\frac{500.15625}{500.15625 + 499.84375} - \frac{499.84375}{500.15625 + 499.84375}\right] = 3.125mV$$

2)

$$quarter\ bridge \to\ Vout = Vin\left[\frac{500.15625 + 2}{500.15625 + 500 + 2} - \frac{1}{2}\right] = 10.76mV$$

$$half\ bridge \to Vout = Vin\left[\frac{500.15625 + 2}{500.15625 + 499.84375 + 2 + 2} - \frac{1}{2}\right] = 1.556mV$$

$$full\ bridge \to Vout = Vin\left[\frac{500.15625 + 2}{500.15625 + 499.84375 + 2 + 2} - \frac{499.84375 + 2}{500.15625 + 2 + 499.84375 + 2}\right] = 3.113mV$$

we can see that full bridge circuit is better than half bridge and half bridge is better than quarter bridge in wire resistance compensation.

3)

$$quarter\ bridge \to\ Vout = Vin\left[\frac{500.15625 + 1}{500.15625 + 500 + 2} - \frac{1}{2}\right] = 0.78mV$$

We can see that this circuit can compensate wire resistance in quarter bridge circuit.

4)

Part 1 with temperature change

$$quarter\ bridge \rightarrow Vout = Vin\left[\frac{500.15625+1}{500.15625+1+500+2} - \frac{502}{1004}\right] = -4.21mV$$

$$half\ bridge \rightarrow\ Vout = Vin\left[\frac{500.15625+1}{500.15625+1+499.84375+1} - \frac{1}{2}\right] = 1.559mV$$

$$full\ bridge \rightarrow\ Vout = Vin\left[\frac{500.15625+1}{500.15625+1+499.84375+1} - \frac{499.84375+1}{500.15625+1+499.84375+1}\right] = 3.12mV$$

we can see that full bridge circuit is better than half bridge and half bridge is better than quarter bridge in resistance change due to temperature compensation.

5)

$$quarter\ bridge \rightarrow Vout = Vin\left[\frac{500.15625+1}{500.15625+1+500+1} - \frac{502}{1004}\right] = 0.779mV$$

We can see that this circuit can compensate resistance change due to temperature in quarter bridge circuit.

6)

$$quarter\ bridge \rightarrow Vout = Vin\left[\frac{500.15625+1+1}{500.15625+1+500+1+2} - \frac{502}{1004}\right] = 0.778mV$$

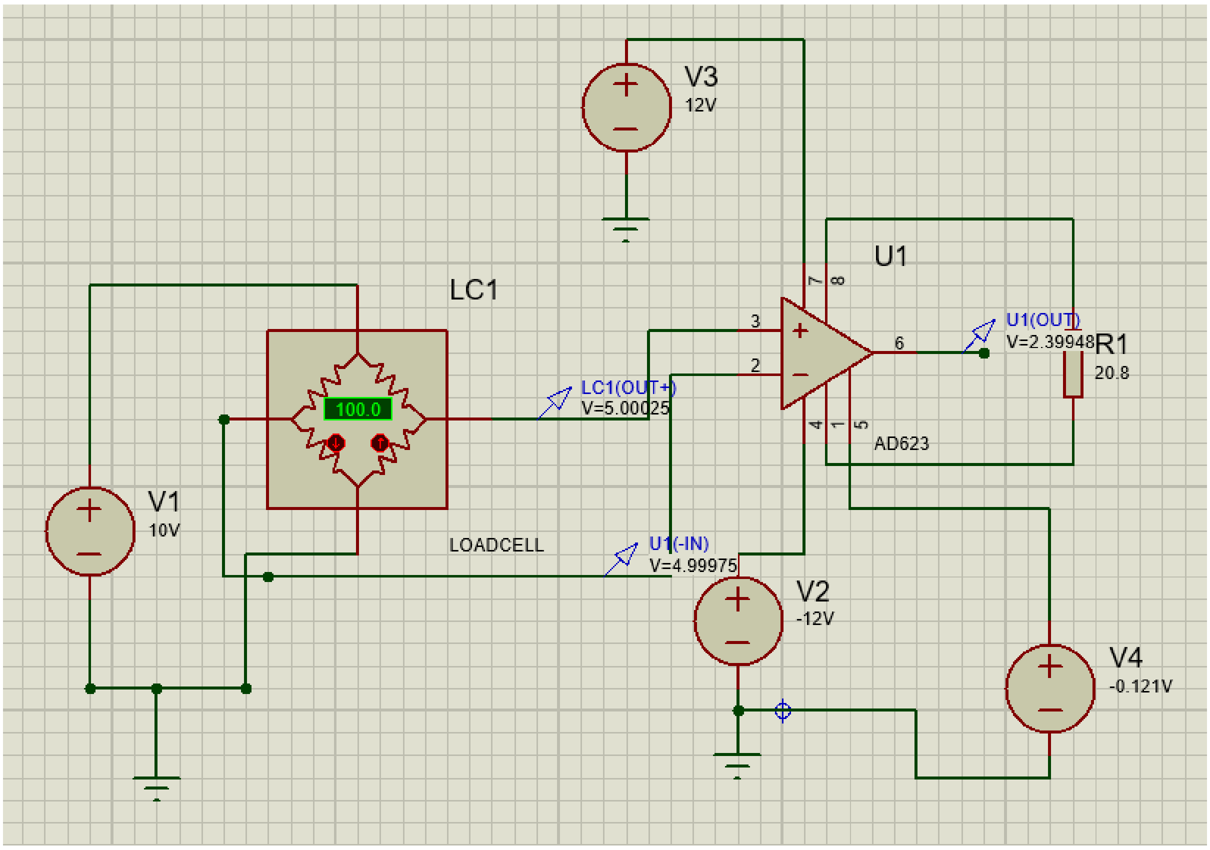
We can see that this circuit can compensate resistance change due to temperature and also wire resistance in quarter bridge circuit.

Load cell:

2)

Full scale % means that what percentage of full load is applied to the loadcell.

sensitivity of load cell means how much output voltage (mV) we get per voltage supplied to the circuit.



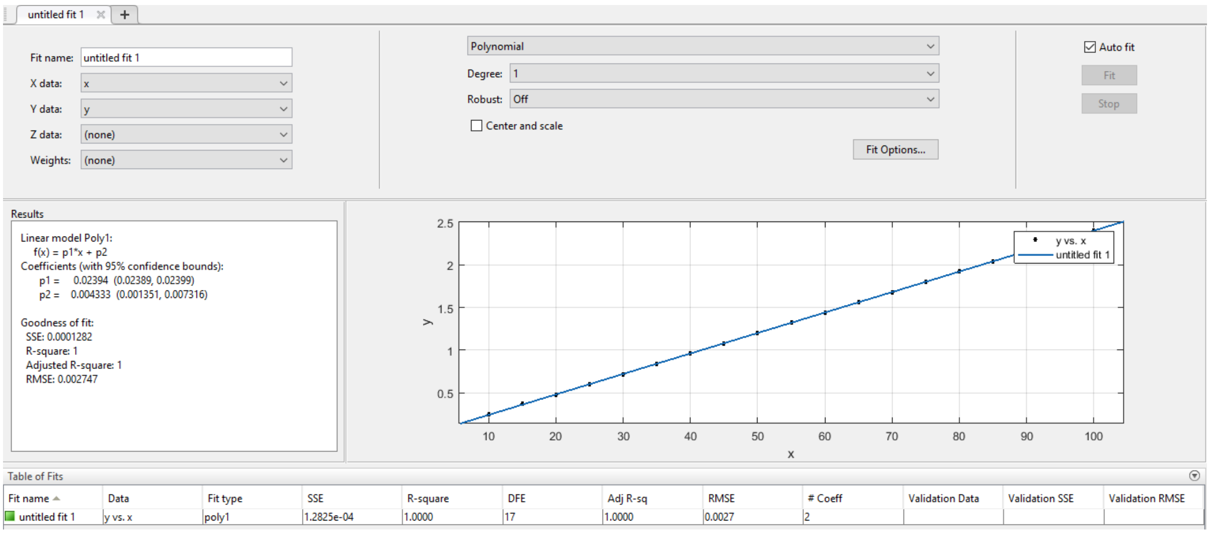
First we nullify the output of op amp at 0 input with offset voltage -0.121V.

We used a 10V supply therefore output voltage of loadcell is 0.5mV at full scale so we need the amplifier to amplify the voltage to 2.4V so the gain must be $\frac{2.4}{0.5mV} = 4800 \rightarrow R1 = 20.8$

We used datasheet to determine what value of R1 we need for 4800 gain.

10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100
0.25	0.37	0.48	0.6	0.72	0.84	0.96	1.08	1.20	1.32	1.44	1.56	1.68	1.8	1.92	2.04	2.16	2.28	2.4

4)



$$Y = 0.02394X + 0.004333 \rightarrow X = 41.77109Y - 0.18099$$

$$RMSE = 0.002747$$

7)

the LCD shows up to 2 decimal places so the resolution of the output is 0.01Kg =0.01%FS,

accuracy of ADC is $\frac{2.4}{4096} = 0.59mV \rightarrow\ 41.77109(0.59) = 0.025kg = 0.025\%FS$

sensor can measure 0.1 of full scale (step size is 0.1) so the resolution of sensor is 0.1% FS

so, the accuracy of the system is limited by Sensor because the sensor can't sense below 0.1kg.

Output = $Weight\ \pm 0.05kg$

8)

We can use more precise ADC with more bits, use more precise sensor, set $Vref$ of ADC close to 2.4V, use LCD with more digits, use LPF and shield to decrease noise.