

LEVEL 4 ASSESSMENT SPECIFICATION

Student name:	Lee Williams	Student ID number:	
Programme:	HNC Electrical/Electronic Engineering, Power Systems Engineering & Instrumentation Engineering		
Module:	Industrial Measuring Systems		
Module code:	PCEE4003	Contribution to Overall Module Assessment (%):	100%
Lecturer:	Adam Jenkins	Internal Verifier:	Jason Pointer
Assignment Title:	Measurement Systems	Word count (or equivalent):	2000
Submission deadline:	15/05/20	Return date of provisional marks & written feedback:	29/05/2020
Submission method:	All written assessments, where practical and possible, must be submitted via Turnitin unless otherwise instructed by the Lecturer. (Please DO NOT put this assessment specification into Turnitin or it will match many similarities with other students' submissions.) Alternative submission method (if applicable): Late submission of the assessment will result in a late penalty mark. Penalties for late submission: Up to one week late, maximum mark of 40%. Over one week late, 0%. Only the Extenuating Circumstances Panel may approve a change to submission dates.		
Academic honesty / referencing:	Academic honesty is required. In the main body of your submission you must give credit to authors on whose research and ideas your work is based. Append to your submission a reference list that indicates the books, articles, etc. that you have used, cited or quoted in order to complete this assessment.		

Module Learning Outcomes (from module syllabus)

LO1, LO2.

STUDENT FEEDBACK FORM

This section details the *extent* to which the assessment criteria are demonstrated by you, which in turn determines your mark. The marks available for each category of skill are shown. Lecturers will use the space provided to comment on the achievement of the task(s), including those areas in which you have performed well and areas that would benefit from development/improvement.

Generic Assessment Criteria	Marks available	Marks awarded
1. Engagement with Literature Skills	20	14
Engagement with an extensive range of relevant and credible literature. An excellent mixture of relative sources including a range of text books and web sites.		
2. Knowledge and Understanding Skills	30	21.5
Task 1 achieved 75%. Task 2 achieved 70%. Task 4 achieved 75%. Task 5 achieved 70%. Task 6 achieved 68%. Excellent knowledge and understanding of the basic underlying concepts and principles to covering the assignment tasks.		
3. Cognitive and Intellectual Skills	10	6.3
Sound evaluation of the underlying concepts and principles.		
4. Practical Application Skills	30	25.5
Excellent approach to developing the calculations to obtain the relative solution for task 3. Excellent use of spreadsheets to obtain a range of solutions and to present these results.		
5. Transferable Skills for Life and Professional Practice	10	8
Work is coherent, very fluent and is presented professionally. Excellent layout making the assignment easy to read.		

Assessment Mark (Assessment marks are subject to ratification at the Exam Board. These comments and marks are to give feedback on module work and are for guidance only until they are confirmed.)	Late Submission Penalties (tick if appropriate)		75%
	Up to 1 week late (40% Max)		
	Over 1 week late (0%)		

Learner Name: Lee Williams

Course: HNC Instrumentation Engineering Year 1

Module Code: PCEE4003

Module Name: Industrial Measurement Systems

Assignment: Task 1: Pressure Sensors

Task 2: Position Sensors

Task 3: Temperature Sensor Characteristics

Task 4: Indicators

Task 5: Signal Transmission

Task 6: Basic Control Systems

Contents

Task 1	Page 3
Task 2	Page 6
Task 3	Page 8
Task 4	Page 14
Task 5	Page 17
Task 6	Page 23
References	Page 25
Bibliography.....	Page 26
Appendices.....	Page 27

Task One – Pressure Sensors

Both analogue and digital instruments are used in industrial measurement systems. Whilst analogue instruments produce 'an output that varies continuously as the quantity being measured changes' (Morris, 2003), digital instruments have outputs that 'vary in discrete steps and so can only have a finite number of values' (Morris, 2003). Analogue outputs can have an infinite number of values within the range of the instrument. The bourdon tube is an example of an analogue instrument used to measure pressure. This consists of an almost rectangular or elliptical cross section tube, often constructed of steel or phosphor bronze. Figure 1 illustrates the C-shaped construction and operation of the device. As the pressure inside the tube increases 'the closed end of the C opens out, thus the displacement of the closed end becomes a measure of the pressure' (Bolton, 2015). A connected shaft can rotate via gearing, thereby enabling a pointer to move across a scale. A data sheet for such a gauge can be found in Appendix 1. ✓

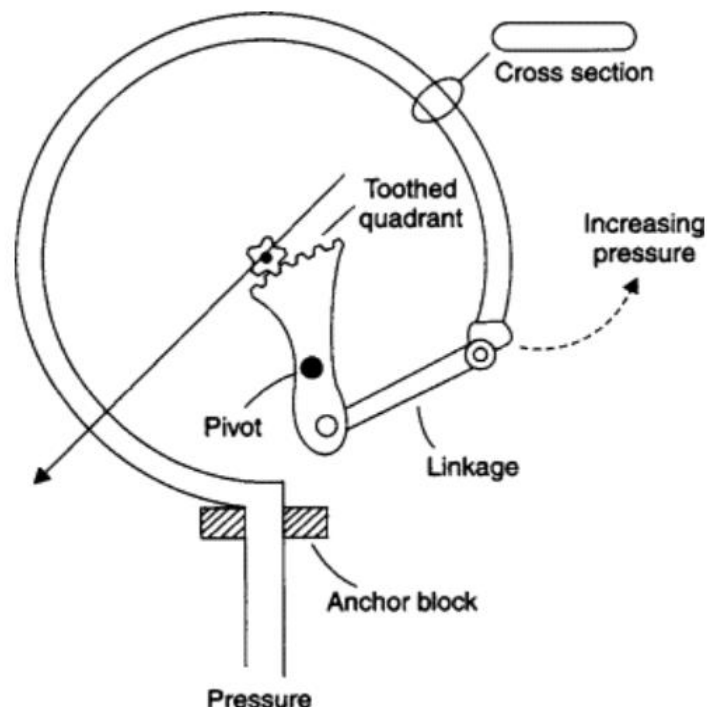


Figure 1 – A Bourdon tube (Laughton and Warne, 2003)

Whereas as Bourdon tube can be considered a passive instrument, digital pressure gauges are examples of active instruments. A passive instrument is one where the output is wholly created by the quantity being measured. However, in an active instrument, this quantity modulates or adapts to the magnitude of an external power source. ✓

Digital pressure gauges are devices that convert applied pressure into signals. These signals are displayed numerically on a display. Such instruments are usually powered by battery, loop or solar. Typically, these devices will contain a strain gauge – a sensor whose resistance varies with applied force. It then converts this force into a change in electrical resistance which can then be measured. Figure 2 illustrates such a set up along with a bridge circuit which detects the associated voltage change. A data sheet for such a gauge can be found in Appendix 2. ✓

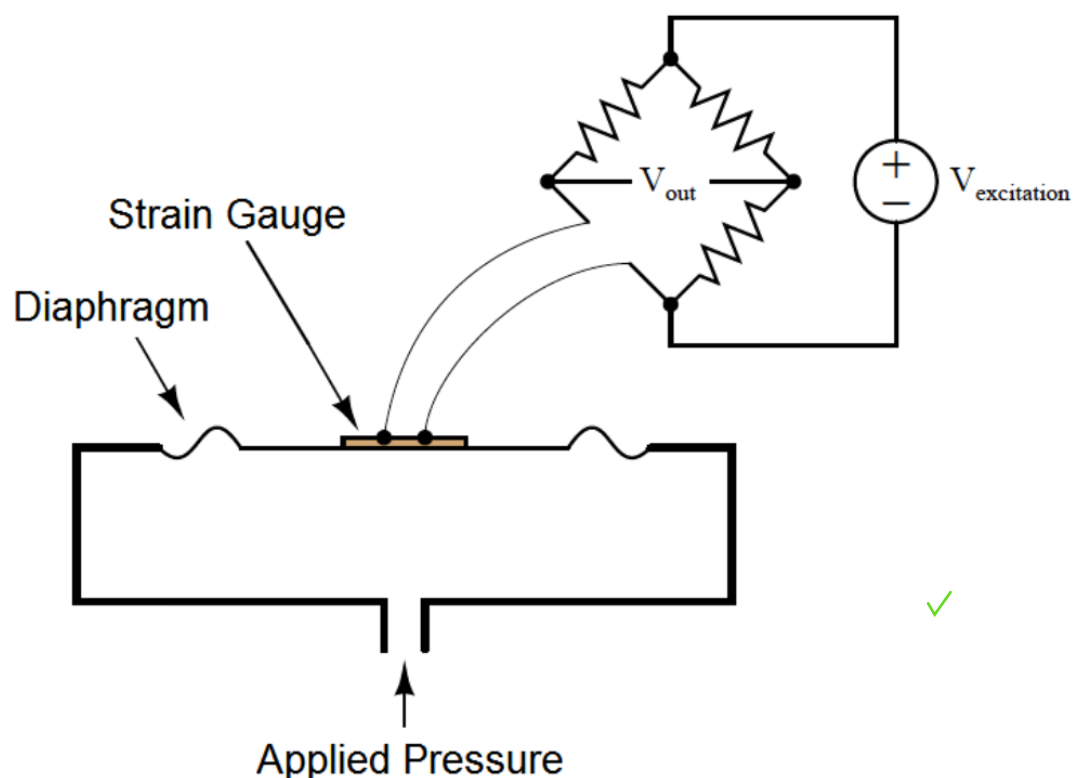


Figure 2 – A strain gauge working principle (Instrumentationtools.com, 2020)

We should also consider the static and dynamic characteristics of both gauge types. Morris (2003) states that 'the static characteristics of measuring instruments are concerned only with the steady state reading that the instrument settles down to, such as the accuracy of the reading etc.' These characteristics also include precision, tolerance and linearity amongst others. Dynamic characteristics 'describe its behaviour between the time a measured quantity changes value and the time when the instrument output attains a steady value in response' (Morris, 2003). These include response time, rise time and settling time. ✓

Both the analogue and digital gauges have advantages and disadvantages. Analogue gauges are easy and relatively inexpensive to use, whilst not requiring a power supply. However, parallax errors are possible when viewing the needle which also has a limited resolution. They are also prone to damage due to their mechanical nature and are susceptible to damage in harsh environments. Analogue gauges also require calibration which is prone to human error. Meanwhile, digital gauges are more accurate and provide less ambiguity when reading a value. They are also durable, much less susceptible to damage due to vibration than its analogue counterpart. It is also possible to collect data from these devices as they include outputs for sending results to computers or other data logging methods. However, digital gauges are costlier in the short term, although that initial cost may be compensated for as their reliability is greater. They also will always require a power source which may limit their use in some environments. ✓



Task 2 - Position Sensors

a)

An example of a sensor that could be used to measure the angular velocity of an electric motor is the tachometer. Bird (2017) defines a tachometer as 'an instrument that indicates the speed, usually in revolutions per minute, at which an engine shaft is rotating'. Appendix 3 contains a datasheet for a mechanical tachometer produced by Electromatic Equipment Co., Inc. This is a hand-held device which is attached via a rubber cone to the rotating shaft of the motor. Figure 3 illustrates its operation - the rotating shaft drives the indicator shaft through a slipping clutch. A pointer is attached to the indicator shaft against the torque of a spring. This gives the pointer a larger deflection as the angular velocity increases. An additional feature is that the pointer only moves as the motor is active and connected. Therefore, on this model of tachometer there is a button to freeze the pointer at the desired reading for recording purposes. These are relatively cheap devices that are easy to operate. However, they do have to be manually operated and are less accurate than more modern angular velocity measuring methods. They are also prone to mechanical loading which can produce significant errors depending on the size of motor used. ✓

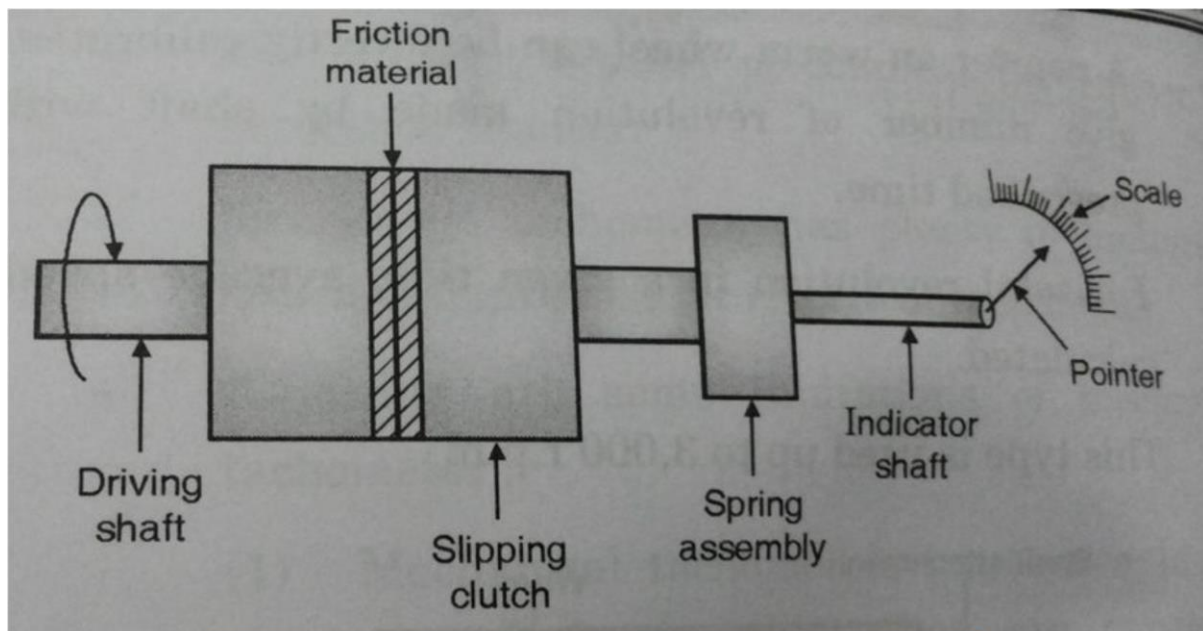


Figure 3 – Operation of a slipping clutch tachometer (Wells, 2020)



b)

In order to measure the rotation of a 3-way ball valve through 180 degrees of operation, an optical encoder could be used. This device 'provides a digital output as a result of an angular or linear displacement' (Bolton, 2015). There are two categories - incremental and absolute. An incremental encoder detects displacement relative to a datum position whereas an absolute encoder will give the actual position. Figure 4 illustrates the basic principle of an incremental encoder ✓

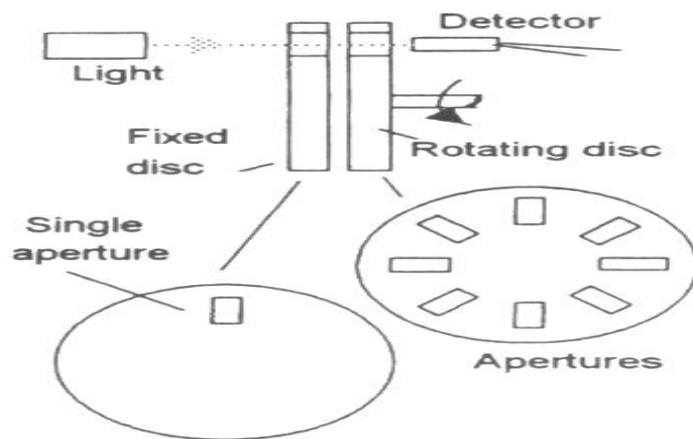


Figure 4 – An incremental encoder (Bolton, 2015)

In the case of our 3-way ball valve, the shaft of the actuator is connected to the rotating disc shown in figure 4. The disc has several windows through which a beam of light can pass through. A light sensor on the opposite side to the beam detects this light as it passes through the windows. As the shaft and disc rotate, a pulsed output is produced by the sensor, the number of which is proportional to the angle that the disc rotates. Therefore, for an incremental encoder, the angular displacement of the disc/shaft is found using the number of pulses produced from the displacement from a datum position. A data sheet for such an encoder can be found in Appendix 4. ✓

Task 3: Temperature Sensor Characteristics

a)

Please see Appendix 5 for an PT100 RTD example data sheet.

Use the formula $R_m = R_{Ref} (1 + \alpha (T_m - T_{Ref}))$ to calculate the resistance when temperature = 20 °C

Coefficient of resistance (α) = $3.85 \times 10^{-3} \text{ } ^\circ\text{C}$ ✓

$T_{Ref} = 0 \text{ } ^\circ\text{C}$

$R_{Ref} = 100 \text{ } \Omega$

$T_m = 20 \text{ } ^\circ\text{C}$

$R_m = 100 (1 + 3.85 \times 10^{-3} (20-0))$

$R_m = 100 (1.077)$

$R_m = 1.077 \text{ } \Omega$ ✓

The complete table of values from 0 °C – 100 °C can be found in the table in Figure 8.

The graph of these values is found below in Figure 5.

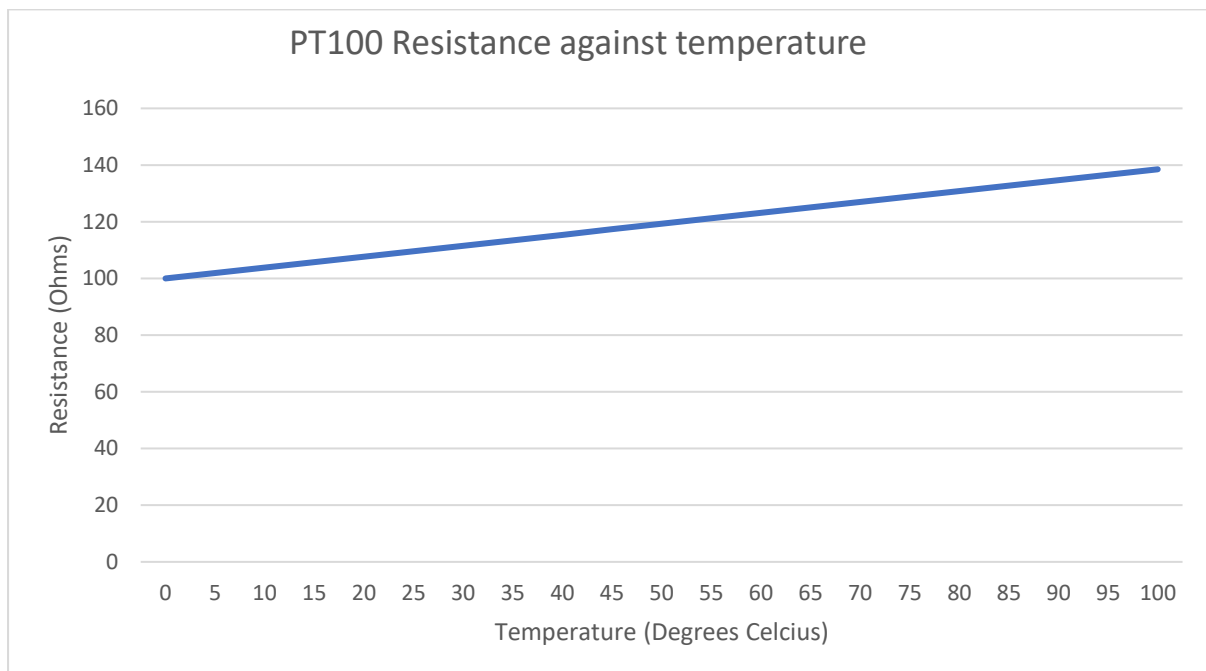
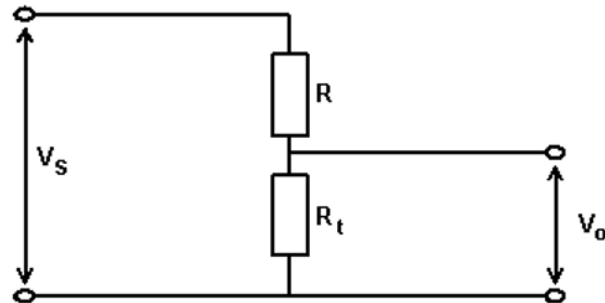


Figure 5 – Resistance plotted against temperature

b)

Figure 6 (Below) - Voltage Divider



Use figure 8 for R_t

Use the formula $V_{out} = \frac{V_{in} \times R_t}{R + R_t}$ to calculate the voltage when the temperature = 20°C

$$R = 100\Omega$$

$$V_{in} = 10\text{v}$$

$$V_{out} = \frac{10 \times 107.7}{100 + 107.7}$$

$$V_{out} = \frac{1077}{207.7}$$

$$V_{out} = 5.185\text{v}$$

The complete table of values from 0 °C – 100 °C can be found in the table in Figure 8.
The graph of these values is found below in Figure 7.

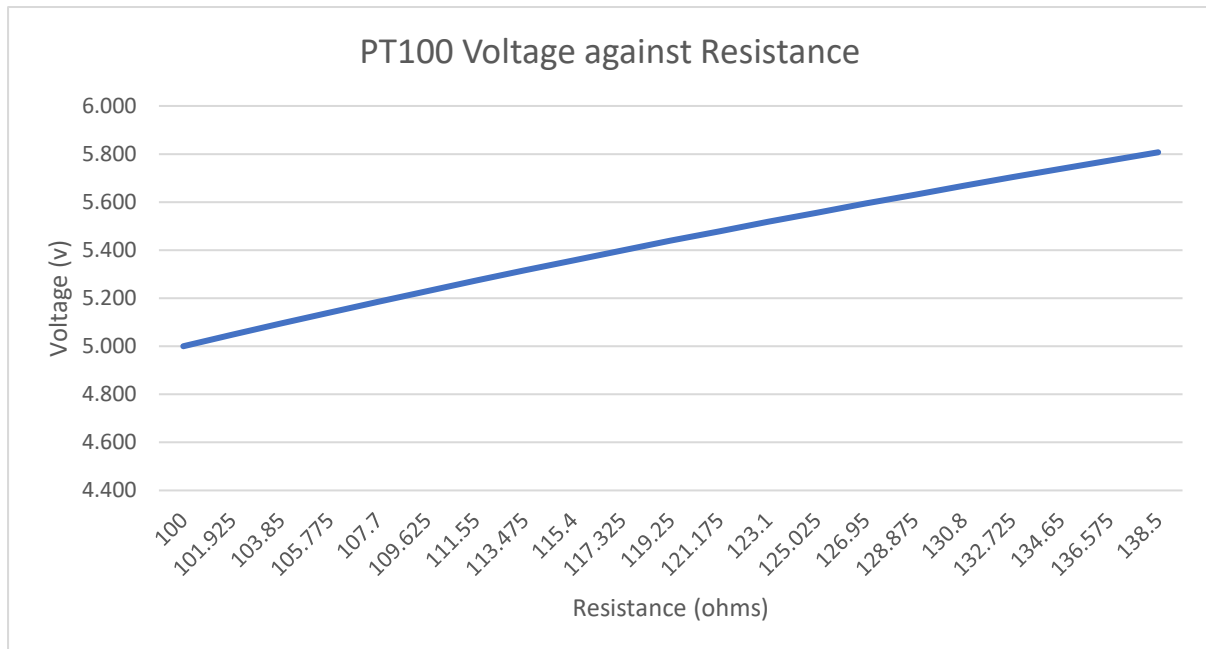


Figure 7 – Voltage plotted against resistance

c)

Sensitivity of the linear circuit = $\frac{\text{Change in output}}{\text{Change in input}}$ ✓

From the values displayed in Figure 7, we can deduce that when $T_m = 20^\circ\text{C}$ –

Change in Output $V = 5.185 - 5 = 0.185\text{v}$ ✓

Change in Input $T = 20 - 0 = 20^\circ\text{C}$

Therefore - Sensitivity = $\frac{0.185}{20} = 0.00925 \text{ V}/^\circ\text{C}$ ✓

Temp (oC)	Resistance (ohms)	V out (v)
0	100	5.000
5	101.925	5.048
10	103.85	5.094
15	105.775	5.140
20	107.7	5.185
25	109.625	5.230
30	111.55	5.273
35	113.475	5.316
40	115.4	5.357
45	117.325	5.399
50	119.25	5.439
55	121.175	5.479
60	123.1	5.518
65	125.025	5.556
70	126.95	5.594
75	128.875	5.631
80	130.8	5.667
85	132.725	5.703
90	134.65	5.738
95	136.575	5.773
100	138.5	5.807

Figure 8 – Table of all calculated values used so far for task 3

d)

Time Constant (τ) = 5ms

For a first order response –

$$T_m = T_{ss} (1 - e^{-\frac{t}{\tau}}) \quad \checkmark$$

T_{ss} is the steady state value at 50°C

At $t = 2\text{ms}$

$$T_m = 50 (1 - e^{-\frac{2}{5}})$$

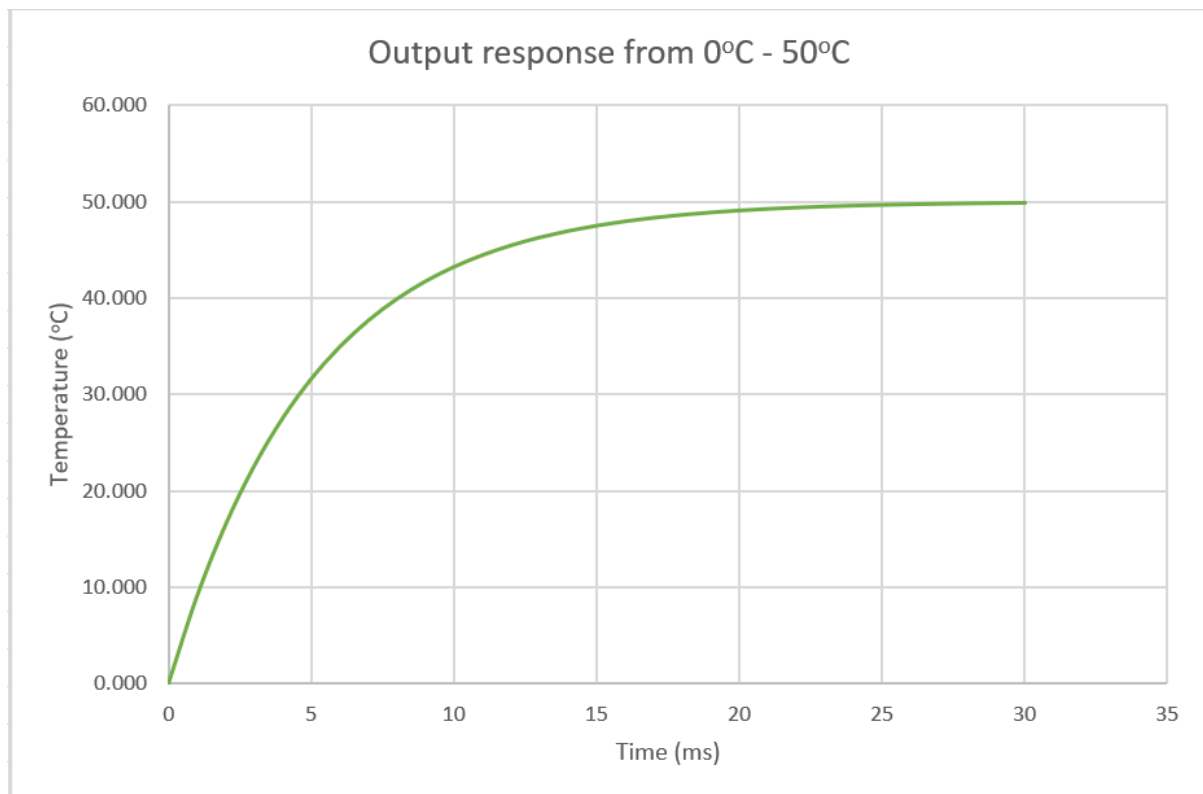
$$T_m = 16.484^\circ\text{C} \quad \checkmark$$

Although a steady state is achieved at approximately 25ms, Figure 9 below contains all the values up until 30ms. Figure 10 plots these values for illustration.

Time (ms)	Temperature (°C)
0	0.000
1	9.063
2	16.484
3	22.559
4	27.534
5	31.606
6	34.940
7	37.670
8	39.905
9	41.735
10	43.233
11	44.460
12	45.464
13	46.286
14	46.959
15	47.511
16	47.962
17	48.331
18	48.634
19	48.881
20	49.084
21	49.250
22	49.386
23	49.497
24	49.589
25	49.663
26	49.724
27	49.774
28	49.815
29	49.849
30	49.876

✓

Figure 9 – Table of time against temperature



✓

Figure 10 – First order response with time plotted against temperature



Task 4: Indicators

a)

Light emitting diodes (LED's) and Liquid crystal displays (LCD's) are two types of indicator widely used to present data. LED's are 'basically pn junction diodes which emit light when a suitable voltage is applied. The voltage enables electrons recombine with holes within the device and release the energy in the form of photons' (Bolton, 2015). They are used as alphanumeric displays, meaning they can display both numbers and letters. Figure 11 below illustrates a seven-segment type of LED array. The segments are illuminated in various patterns to form letters or numbers. ✓

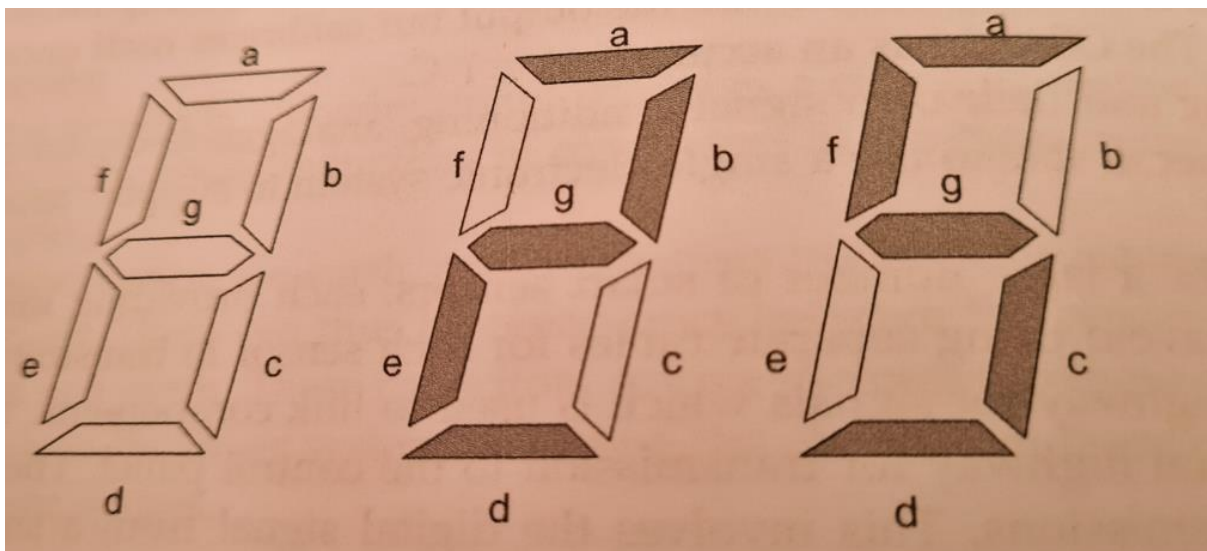


Figure 11 – A seven segment LED display (Bolton, 2015). ✓

Unlike LED's, LCD's do not use light of their own. Instead, they reflect light but can also be arranged in segments similar to LED's. These displays consist of crystal segments on a reflecting sheet. If an electric field is applied to a segment, light is unable to penetrate through to the reflecting sheet. Therefore, no light is reflected, and the crystal appears dark. ✓

LED's are cheap and require only a low current and voltage to operate. They also are simple devices which are reliable and efficient. However, they are limited to only displaying the 16 hexadecimal characters which restricts their use. The ease and low cost of manufacture has also led to the production of sub-standard LED's. Conversely, LCD's can display more complex information but has slower response times, typically about 100 to 150ms. They are even lower powered than LED's and have a wider ✓

viewing angle. However, most LCD's contain mercury, a potentially dangerous and polluting substance.

b)

In many applications, there is a requirement to convert the analogue signal (e.g. 4-20mA) from a sensor into a digital signal suitable for a microprocessor. This is carried out using a device called an Analogue to Digital converter (ADC). Figure 12 below displays four graphs. The first (A) demonstrates a constantly variable analogue signal. The second (B) shows a digital signal, increasing in jumps rather than the smooth movement in (A). The first stage of an ADC process is shown in (C). The analogue signal is sampled at regular intervals via an onboard clock, with a 'series of narrow pulses with heights which vary in accord with the variation of the analogue signal' (Bolton, 2015). These pulses are then held as illustrated in (D). This allows the conversion from an analogue value into a binary, digital sequence of pulses within the ADC converter.

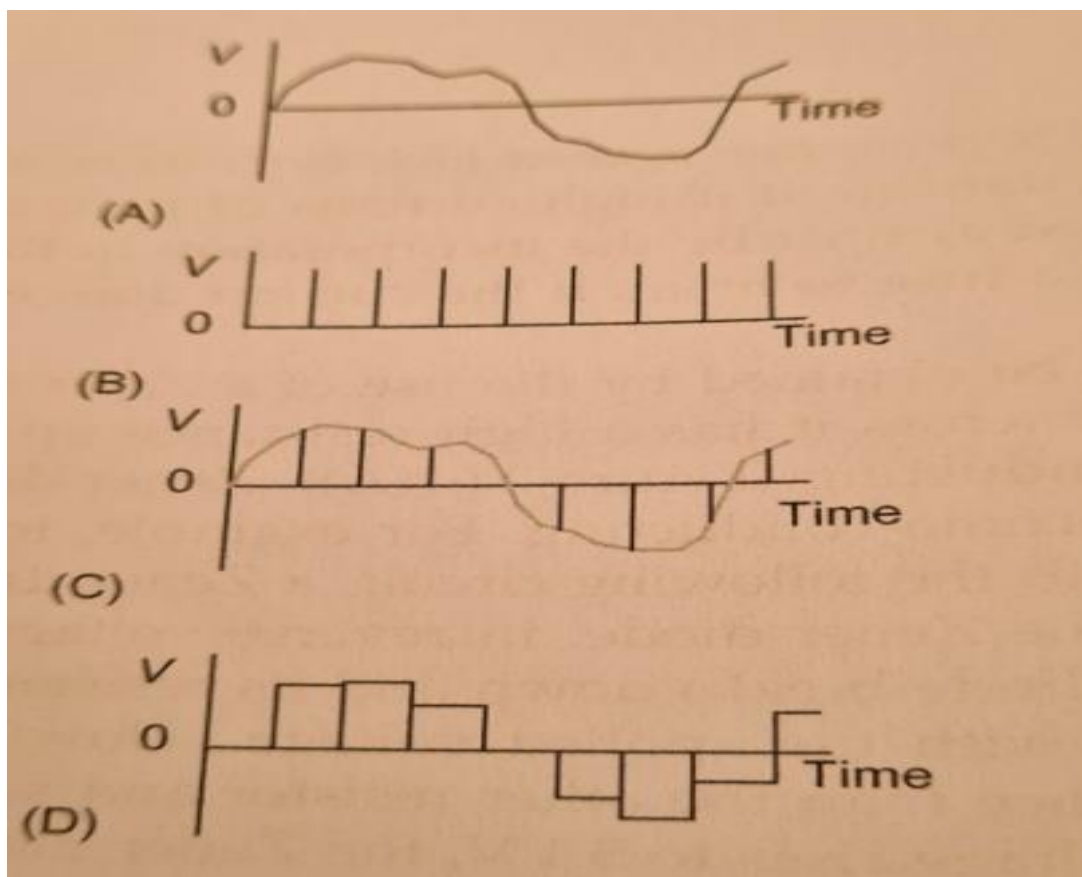


Figure 12 – Signals within the ADC process (Bolton, 2015).

Figure 13 below illustrates the full process with reference to figure 12. The analogue input below refers to (A) whilst the sample and hold box refers to (D)

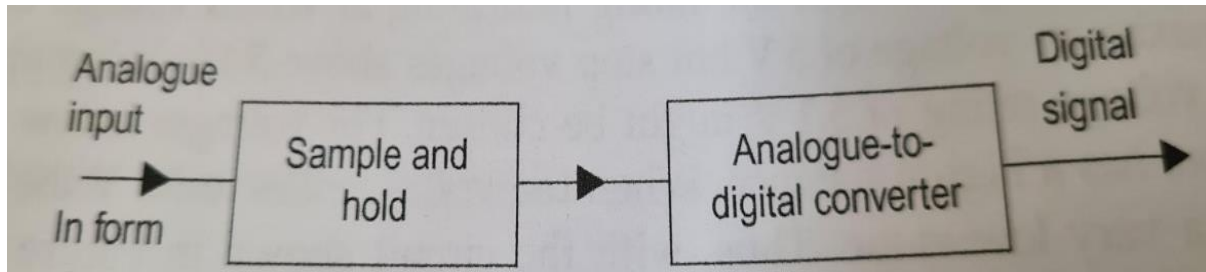


Figure 13 – ADC conversion (Bolton, 2015).

This process of converting a continuous range of values into a finite range of discrete values is known as quantization. The rounding error that is introduced during this process is known as the quantization error. This can be reduced by increasing the sampling rate. At a minimum, the sample rate must be above the Nyquist rate to capture all signal cycles. ✓

The resolution of the ADC depends on the number of bits it can process. In the case of a commonly used 10-bit ADC, its resolution is 1 part in 1024. Therefore, this is the smallest change in the analogue voltage that would result in a change in the digital output. Whereas, resolution is a relative quantity, sensitivity is an absolute quantity. Sensitivity describes the smallest absolute amount of change that can be detected by a measurement, often expressed in terms of millivolts, microohms, or tenths of a degree. ✓

Task 5: Signal Transmission

a)

Both voltage and current methods can be used to transmit measurement signals from sensors to measuring and control units. Using voltage transmission (Figure 14) has the advantage of being easily measured and transmitted, along with the ability to be simply amplified. However, voltage signals are prone to attenuation by long transmission runs and high resistance joints. They are also susceptible to noise interference and could ignite combustible gases. ✓

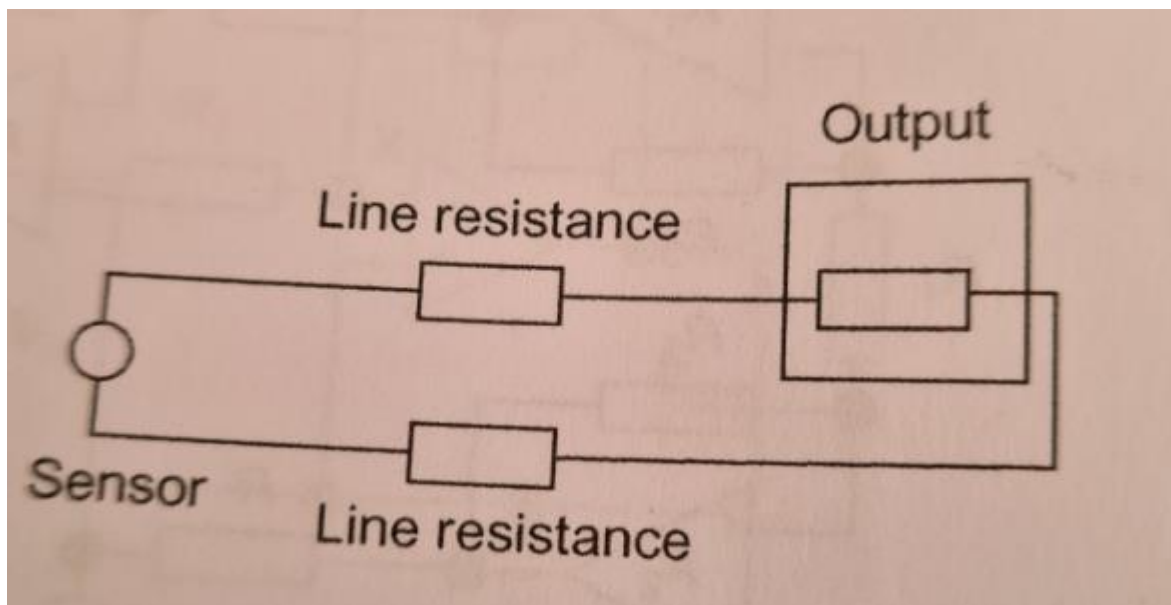


Figure 14 – Voltage transmission (Bolton, 2015).

Attenuation can be reduced if a current signal is used instead. A voltage to current converter is used to achieve a 4-20mA signal as shown in Figure 15. ✓

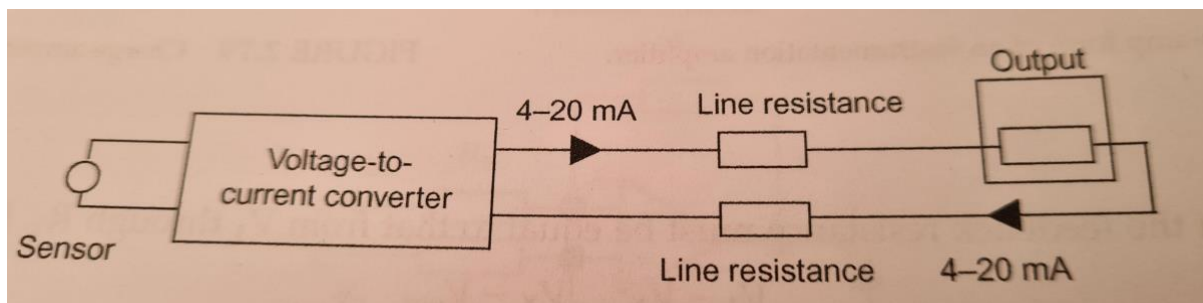


Figure 15- Current loop transmission (Bolton, 2015)

Although this conversion adds further complexity, using 4-20mA allows the distinction between a zero-signal level and a break in the transmission. A further advantage is that current loop instruments tend to have lower impedances and as a consequence, they are less susceptible to electrical noise. However, as with voltage transmission, there is a risk of igniting hazardous gases. ✓

b)

Morris (2003) states that 'Signal processing is concerned with improving the quality of the reading or signal at the output of a measurement system, and one particular aim is to attenuate any noise in the measurement signal that has not been eliminated by careful design of the measurement system'. In the market today, there are several smart systems which carry out measurement, transmission and signal processing as an integrated unit. However, there are several separate processes that can be applied to a signal and these are described below –

i) Conversion – As discussed in Task 4b, there is often a requirement to convert a signal before it can be used in another process. As well as ADC, Digital to analogue (D/A) conversion is required for certain applications. For example, where a digital signal has to be presented to an analogue control actuator or display device. A common form of D/A converter is shown in figure 16 and consists of a resistor ladder network on the input to an operational amplifier. ✓

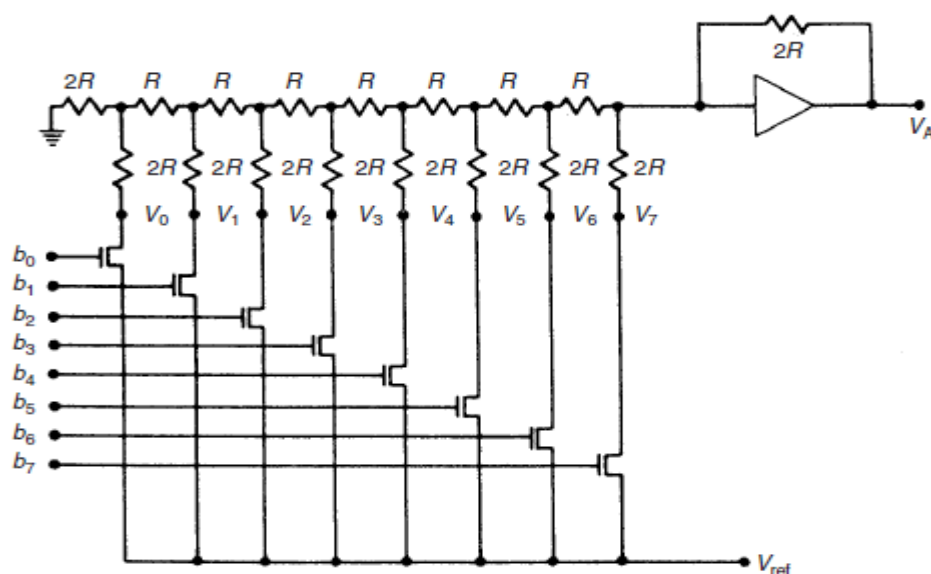


Figure 16 – A digital to analogue converter (Morris, 2003)

Other forms of conversion include resistance to voltage such as in a thermistor or wheatstone bridge. In a thermistor, the resistance change can be converted into voltage using a potential divider circuit as illustrated in figure 17.

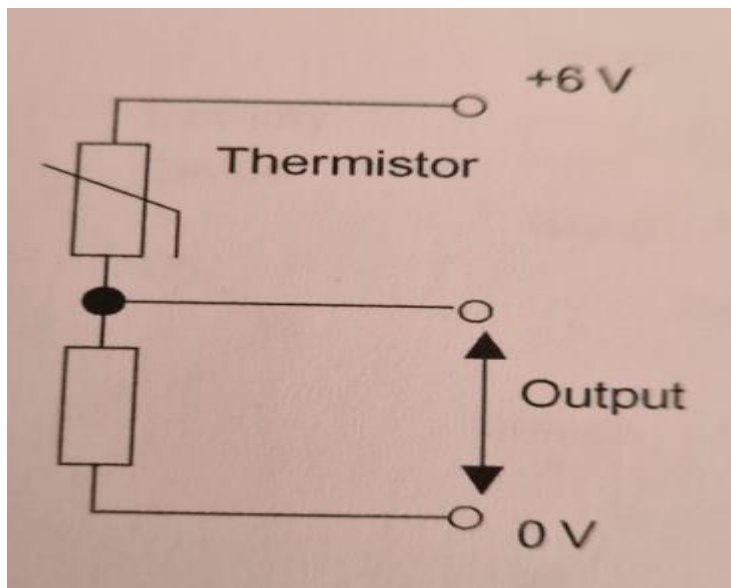


Figure 17 – Resistance to voltage conversion for a thermistor (Bolton, 2015)

ii) Amplification – ‘Signal amplification is carried out when the typical signal output level of a measurement transducer is considered to be too low.’ (Morris, 2003). For analogue signals, an operational amplifier or Op-Amp is commonly used (See figure 18). So that its loading effect on the transducer output signal is minimised, an Op-Amp is normally required to have a high input impedance. ✓

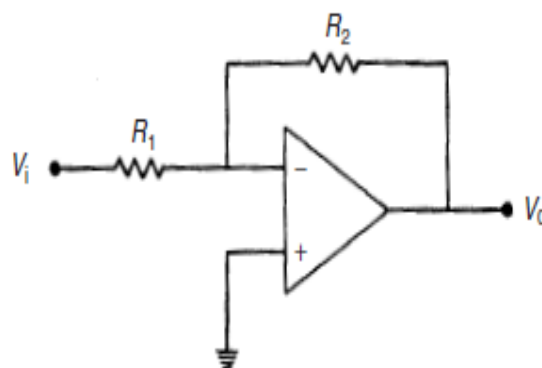


Figure 18 – Operational amplifier connected for signal amplification (Morris, 2003)

The processed signal V_o can be expressed thus –

$$V_o = \frac{R_2 V_i}{R_1}$$

An Instrumentation amplifier can also be used where the signals are particularly low level (Figure 19). This device consists of 3 Op-amps, thereby significantly increasing its differential impedance.

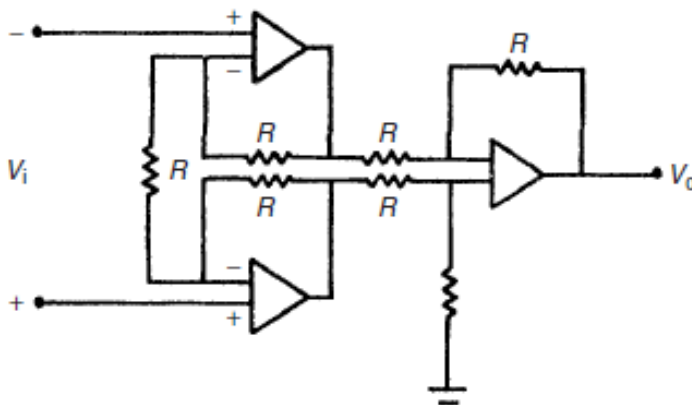


Figure 19 - Instrumentation amplifier (Morris, 2003)

iii) Elimination – This refers to the requirement to remove or reduce unwanted elements from a signal such as noise and/ or a certain band of frequencies. In the later case, signal filtering can be used to process the signal to remove these unwanted frequencies. Depending on the band requiring elimination, either low pass filters, high pass filters, band pass filters and band stop filters may be used (See figure 20). Morris (2003) states that ‘Signal filtering consists of selectively passing or rejecting low-, medium- and high frequency signals from the frequency spectrum of a general signal. The range of frequencies passed by a filter is known as the pass-band, the range not passed is known as the stop-band, and the boundary between the two ranges is known as the cut-off frequency.’ ✓

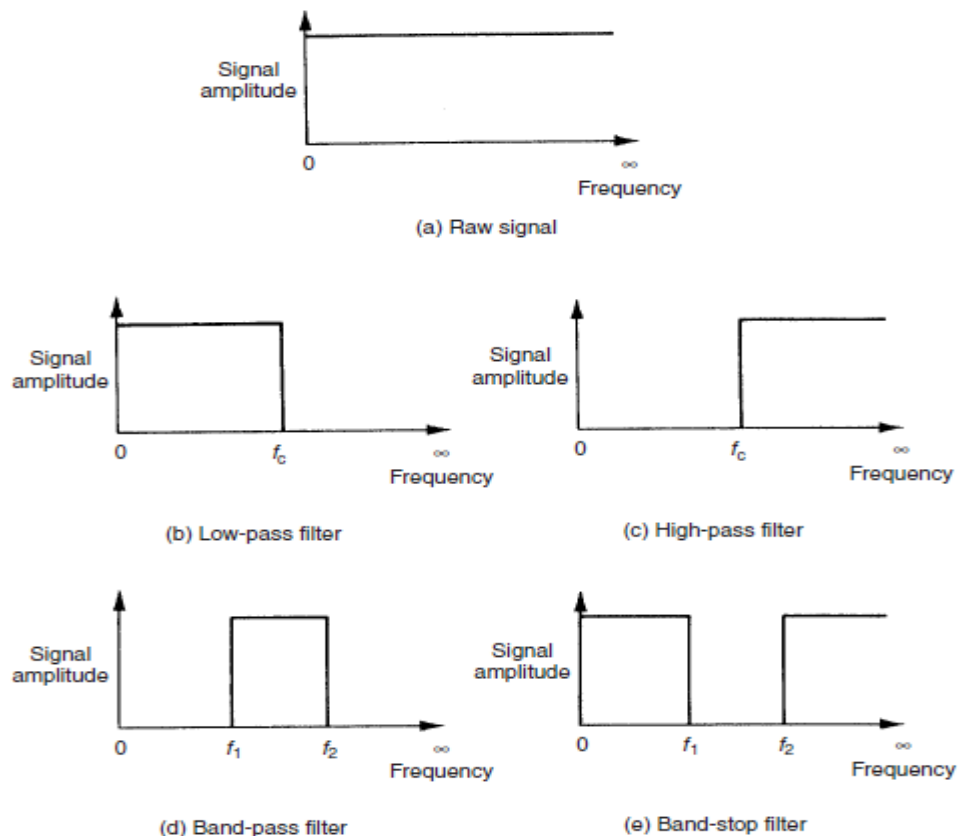


Figure 20 – Outputs from the filters defined above (Morris, 2003)

iv) Manipulation – Otherwise known as signal conditioning, this is the process where a signal is changed to meet the requirements of the next stage for further processing. This include the concepts discussed above but also attenuation, linearization and signal addition\multiplication. Attenuation, essentially the opposite of amplification, is needed where the voltages to be digitised are above the ADC range. When discussing linearization, Morris (2003) states that ‘Several types of transducer used in measuring instruments have an output that is a non-linear function of the measured quantity input. In many cases, this non-linear signal can be converted to a linear one by special operational amplifier configurations that have an equal and opposite non-linear relationship between the amplifier input and output terminals.’ Such a configuration is illustrated in figure 21. ✓

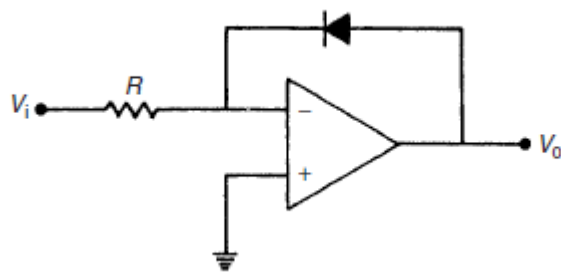


Figure 21 – Operational amplifier connected for signal linearization

v) Protection – A measurement system will ordinarily require features that protect it from high voltages and current. For example, a microprocessor may be damaged from high current or voltage signals from a sensor. This risk can be mitigated by the incorporation of a series resistor and/or fuse within the circuit. A Zener diode circuit (Figure 22) can be used to protect against high voltages and wrong polarity voltages.

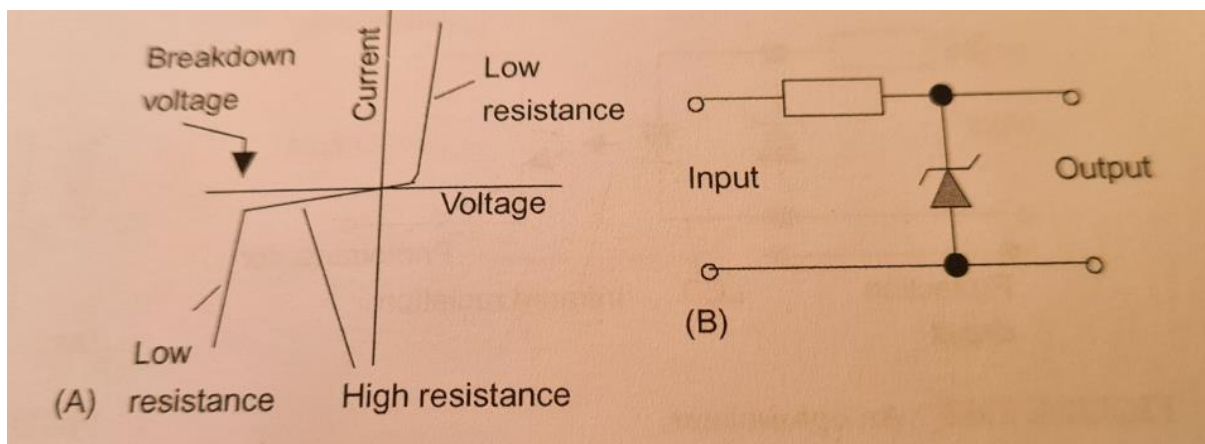


Figure 22 – Zener diode: (A) current voltage relationship, (B) protection circuit, (Bolton, 2015)

If a reverse polarity or excessively high voltage is applied across the diode, it will break down and become conducting. Consequently, most of the voltage is dropped across the resistor causing a similar drop across the diode. Therefore, the output voltage drops, and the circuit is protected. ✓

Task 6: Basic Control systems

a)

Hughes (2008) defines a control system as 'one which undertakes some function, checks its success and takes further action until the objective is attained. And if in the meantime the objective varies then the system will respond to the change'. Two types of control system exist – Open and closed loop. An open loop system is one where the output has no influence on the control action of the input signal. There is no feedback from the output and the system will continue to perform its input command regardless of said output. An example of an open loop system is an electric fire which is shown in Figure 23. ✓

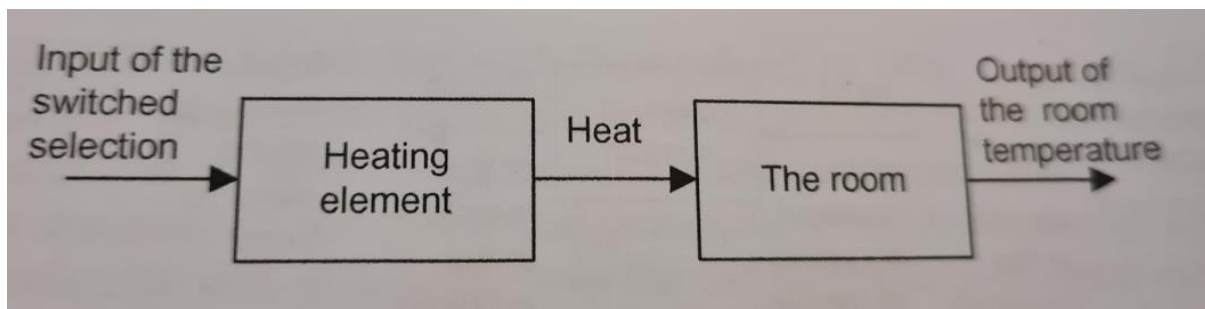


Figure 23 – Open loop control - Electric fire, (Bolton, 2015).

The output of the room temperature has no bearing on the input, in this case a switch selection. The advantages of open loop systems are that they are simple, relatively cheap and reliable. However, due to the lack of comparison and feedback, they are also inaccurate and require manual intervention to change the input value or correct errors. ✓

b)

A closed loop system depends on two key functions. Firstly, feedback from the output to the input and secondly, a difference (error) 'between the feedback and the desired outcome specified by the input control signal' (Hughes, 2008). Figure 24 illustrates an example of a closed loop system in the form of shaft rotation speed control. ✓

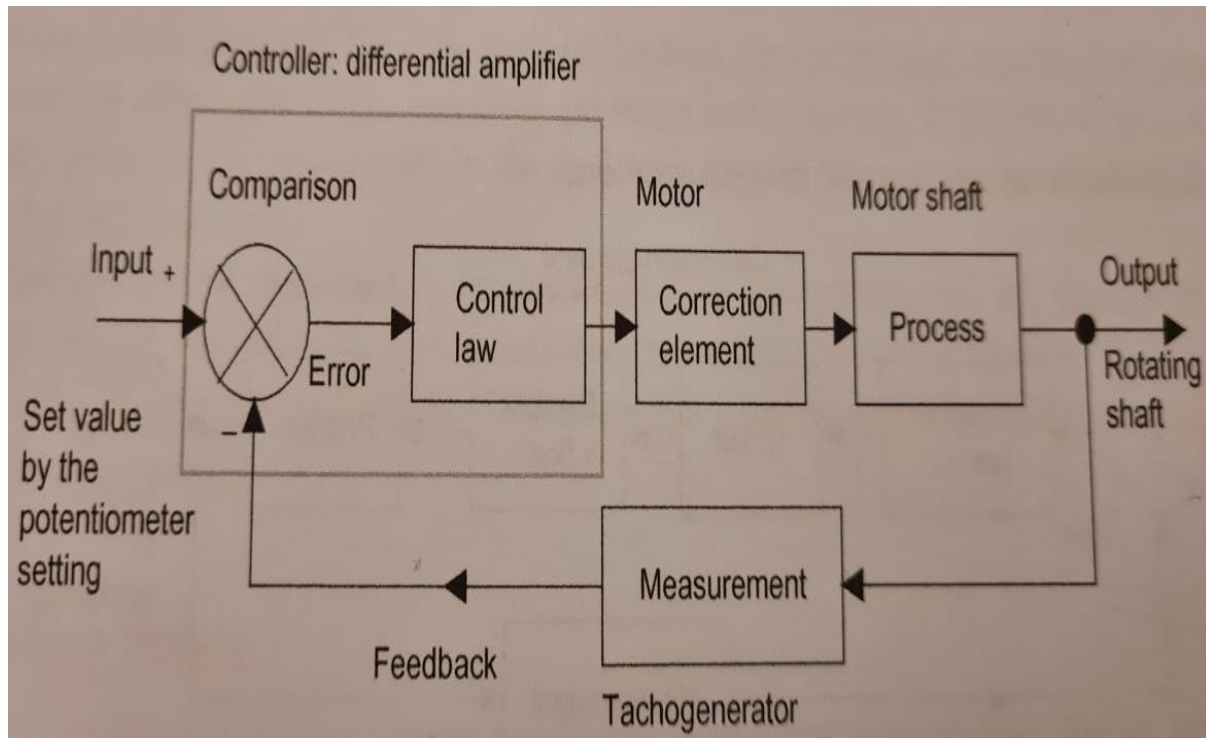


Figure 24 - Shaft rotation speed control, (Bolton, 2015).

The first function of this system is the comparison element. The element, in this case the differential amplifier, compares the required value of the shaft speed with the actual measured value. An error signal is then produced which is the difference between the required and actual values. The second element is control law implementation. This determines the action taken when an error signal is received. In the case of the example above, the differential amplifier is also the controller. It will 'produce an amplified output which is proportional to the difference between its two inputs' (Bolton, 2015). This output is fed into the motor (correction element) which adjusts the shaft speed (Process) accordingly. The final element is the measurement, in this case a Tachogenerator. This will feedback the actual speed of the shaft to the differential amplifier or comparison element and the loop will perform another iteration. ✓

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Appendices

Appendix 1 – Data sheet for a RS Pro analogue pressure gauge (RS Components, 2020)



ENGLISH

Datasheet

Bourdon tube pressure gauge Back mount, standard version Model 111.12

- For gaseous and liquid media that are not highly viscous or crystallising and will not attack copper alloy parts
- Pneumatics
- Heating and air-conditioning technology
- Small-capacity compressors
- Medical engineering

Special features

- Reliable and cost-effective
- Design per EN 837-1
- Nominal size 40, 50, 63, 80 and 100
- Scale ranges up to 0 ... 400 bar

Description

Design
EN 837-1

Nominal size in mm
40, 50, 63, 80 and 100

Accuracy class
2.5

Scale ranges
0 ... 0.6 to 0 ... 400 bar
or all other equivalent vacuum or combined pressure and vacuum ranges

Pressure limitation
Steady: 3/4 x full scale value
Fluctuating: 2/3 x full scale value
Short time: Full scale value



Bourdon tube pressure gauge model 111.12

Permissible temperature
Ambient: -20 ... +60 °C
Medium: +60 °C maximum

Temperature effect
When the temperature of the measuring system deviates from the reference temperature (+20 °C): max. $\pm 0.4 \text{ \%}/10 \text{ K}$ of the span

RS, Professionally Approved Products, gives you professional quality parts across all products categories. Our range has been testified by engineers as giving comparable quality to that of the leading brands without paying a premium price.

Standard version

Process connection

Copper alloy,
centre back mount (CBM)
NS 40: G 1/8 B (male), 14 mm flats
NS 50, 63: G 1/4 B (male), 14 mm flats
NS 80, 100: G 1/4 B (male), 14 mm flats

Pressure element

Copper alloy,
≤ 60 bar: C-type
> 60 bar: Helical type

Movement

Copper alloy

Dial

NS 40, 50, 63: Plastic, white, with pointer stop pin
NS 80, 100: Aluminium, white, with pointer stop pin
Black lettering

Pointer

Plastic, black

Case

Plastic, black
NS 100: Steel, black

Window

Plastic, crystal-clear, snap-fitted in case

Options

- Other process connection
- Accuracy class 1.6
- Case steel, black
- Triangular bezel with mounting bracket

Special versions

For closed heating systems

NS 63, 80
with red mark pointer and adjustable green sector,
scale range 0 ... 4 bar, red mark at 2.5 or 3 bar

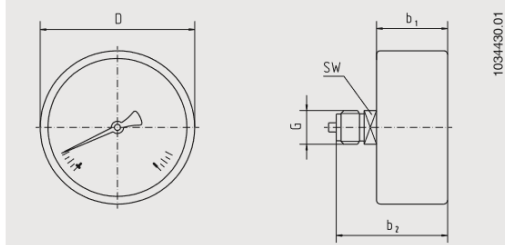
For water-level indication (hydrometer)

NS 80
Scale ranges 0 ... 0.6 to 0 ... 40 bar, with second scale in
mWS

Dimensions in mm

Standard version

Centre back mount (CBM)



NS	Dimensions in mm		D	G	SW	Weight in kg
	b ₁ ±0.5	b ₂ ±1				
40	26	42	39	G 1/8 B	14	0.06
50	29.5	47.5	49	G 1/4 B	14	0.07
63	29	47	62	G 1/4 B	14	0.08
80	32	49	79	G 1/4 B	14	0.11
100	31	49	99	G 1/4 B	14	0.26

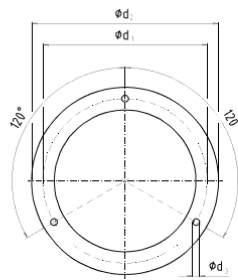
Process connection per EN 837-1 / 7.3

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3-hole panel or surface mounting flanges for round case gauges

Not applicable for gauges with electrical accessories

3-hole panel mounting flange ¹⁾



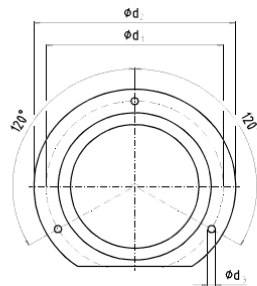
1035 886

Narrow rim bezel with clamp ¹⁾



1241 800

3-hole panel mounting flange ²⁾

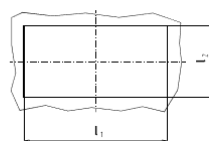


1035 894

Size	Dimensions [mm]					
	d_1	d_2	d_3	d_4 max.	Panel cut-out to suit back entry gauges	
					3-hole mounting	Clamp mounting
40	51	61	3.6	44	44 ± 0.3	41.5 ± 0.5
50	60	71	3.6	55.5	54 ± 0.3	51 ± 0.5
63	75	85	3.6	69	67 ± 0.3	64.5 ± 0.5
80	95	110	4.8	88	84 ± 0.3	82 ± 1
100	116	132	4.8	108	104 ± 0.5	102 ± 1
160	178	196	5.8	168	164 ± 0.5	162 ± 1
250	270	285	5.8	-	254 ± 0.5	-

2) Some gauges may feature lugs instead of a full size rim.

Panel cut-out dimensions per DIN 43 700 for square and edgewise panel mounting gauges



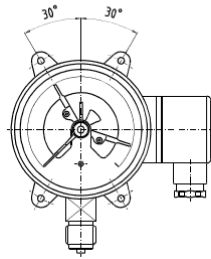
1035 878

Size	Dimensions [mm]			
	l_1		l_2	
		Tolerance + ... 0		Tolerance + ... 0
48 x 24	45	+ 0.6	22.2	+ 0.3
72 x 36	68	+ 0.7	33	+ 0.6
72 x 72	68	+ 0.7	68	+ 0.7
96 x 96	92	+ 0.8	92	+ 0.8
144 x 144	138	+ 1.0	138	+ 1.0
144 x 72	138	+ 1.0	68	+ 0.7

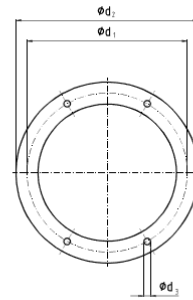
RS, Professionally Approved Products, gives you professional quality parts across all products categories. Our range has been testified by engineers as giving comparable quality to that of the leading brands without paying a premium price.

3-hole panel mounting flange Round case gauges with electrical accessories

Mounting lugs at case of gauge
(holding gauge in panel)



Outer panel ring
(covering panel cut-out)



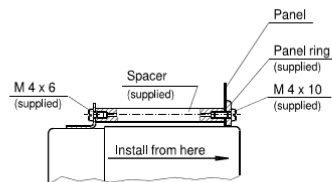
1294 687

Size	Dimensions [mm]			
	d ₁	d ₂	d ₃	Panel cut-out Ø
100	116	132	4.8	105
160	178	196	5.8 ¹⁾	165

1) Mounting lugs with internal thread M 5.

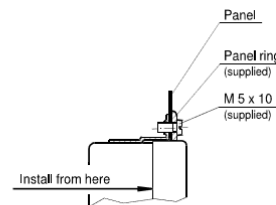
Panel assembly for gauges with inbuilt electrical accessories

100 mm diameter



1294 695

160 mm diameter



1294 709

The assembly consists of
Outer panel ring
4 spacers
8 screws M 4

The assembly consists of
Outer panel ring
4 spacers
Additionally required
4 screws M 5 x 10

Note: In addition to this data sheet, mounting drawings referring to the respective models can be supplied.

Specifications and dimensions given in this leaflet represent the state of engineering at the time of printing.
Modifications may take place and materials specified may be replaced by others without prior notice.

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Appendix 2 – Data sheet for a Fluke Pneumatic Digital Pressure Gauge (RS Components, 2020)

FLUKE®

Fluke 700G Series Precision Pressure Test Gauges

Technical Data



Features

- Precision pressure measurement from 15 psi/1 bar to 10,000 psi/690 bar
- Accuracy to 0.05 % of full scale
- Easy to use, rugged construction for reliable performance
- CSA; Class 1, Div 2, Groups A-D rating
- ATEX: rating: II 3 G Ex nA IIB T6
- Combine with the 700PTPK or 700HTPK pump kits for a complete pressure testing solution for up to 600 psi with the PTP-1 pneumatic pump and up to 10,000 psi with the HTP-2 hydraulic pump
- Log up to 8493 pressure measurements to memory (requires 700G/TRACK software)
- Three-year warranty



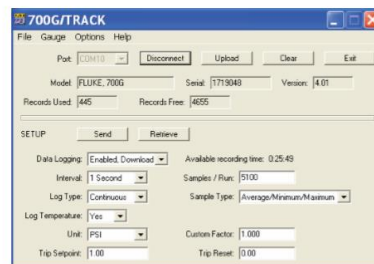
Fluke-700PTPK Pneumatic Test Kit

- Combine with any Fluke-700G Series Gauge, 1,000 psi or less, to make a complete pressure testing kit
- Generate pressure up to 600 psi, 40 bar with the 700PTP-1 test pump.
- Connect the 700G Series gauge directly to the included PTP-1 hand pump
- Includes hoses and adapters for connecting to the pressure device to be tested
- Hard case protects pump and gauge and allows gauge to remain connected to the pump



Fluke-700HTPK Hydraulic Test Kit

- Combine with any Fluke-700G Series Gauge, 1,000 psi range or greater, to make a complete pressure testing kit
- Generate pressure up to 10,000 psi, 690 bar with the included 700HTP-2 test pump
- Connect the 700G Series gauge directly to the HTP-2 hand pump
- Includes 700HTH-1 hose kit and adapters for connecting to the pressure device to be tested
- Hard case protects pump and gauge and allows gauge to remain connected to the pump



700G/TRACK Logging Software

- Use with 700G Series gauges to perform real time data logging to a PC
- Download logging configurations to the 700G Series gauges for a remote logging event
- Configure logging event reading rate, duration and measurement units
- Upload measurements logged remotely and display or export measurements
- Includes communication cable for connection to a PC

Specifications

Model	Range	Resolution	Accuracy	Burst Pressure
700G04	-14 psi to 15 psi -.97 bar to 1 bar	0.001 psi 0.0001 bar	Positive pressure ± 0.05 % FS	500 psi 34 bar
700G05	-14 psi to 30 psi -.97 bar to 2 bar	0.001 psi 0.0001 bar		500 psi 34 bar
700G06	-12 psi to 100 psi -.83 bar to 6.9 bar	0.01 psi 0.0001 bar		1000 psi 69 bar
700G27	-12 psi to 300 psi -.83 bar to 20 bar	0.01 psi 0.001 bar		2000 psi 138 bar
700G07	-12 psi to 500 psi -.83 bar to 34 bar	0.01 psi 0.001 bar	Vacuum ± 0.1 % FS	2000 psi 138 bar
700G08	-14 psi to 1000 psi -.97 bar to 69 bar	0.1 psi 0.001 bar		10000 psi 690 bar
700G29	-14 psi to 3000 psi -.97 bar to 200 bar	0.1 psi 0.01 bar		10000 psi 690 bar
700G30	-14 psi to 5000 psi -.97 bar to 340 bar	0.1 psi 0.01 bar		10000 psi 690 bar
700G31	-14 psi to 10000 psi -.97 bar to 690 bar	1 psi 0.01 bar		15000 psi 1035 bar
Temperature compensation: 15 °C to 35 °C (59 °F to 95 °F) to rated accuracy For temperatures from -10 °C to 15 °C and 35 °C to 55 °C, add .003 % FS/°C				
Media compatibility • 15, 30 psi: any clean dry non-corrosive gas • 100, 300, 1000 psi: any liquids or gases compatible with 316 stainless steel and start above 1000 psi ;any non-flammable, non-toxic, non-explosive, non-oxidizing liquid or gas compatible with 316 stainless steel.				
Mechanical specifications				
Dimensions (HxWxD)	12.7 cm x 11.4 cm x 3.7 cm (5 in x 4.5 in x 1.5 in)			
Pressure connection	¼ in NPT Male			
Housing/Weight	Cast ZNAL/0.56 kg (1.22 lb) with holster			
Display	5-1/2 digits, 16.53 mm (0.65 in) high 20-segment bar graph, 0 to 100 %			
Power	Three AA alkaline batteries			
Battery life	1,500 hours without backlight (continuous on), 2,000 hours at slow sample rate			

Ordering information

Model

FLUKE-700G04 Pressure Gauge, 15 PSIG
 FLUKE-700G05 Pressure Gauge, 30 PSIG
 FLUKE-700G06 Pressure Gauge, 100 PSIG
 FLUKE-700G27 Pressure Gauge, 300 PSIG
 FLUKE-700G07 Pressure Gauge, 500 PSIG
 FLUKE-700G08 Pressure Gauge, 1,000 PSIG
 FLUKE-700G29 Pressure Gauge, 3,000 PSIG
 FLUKE-700G30 Pressure Gauge, 5,000 PSIG
 FLUKE-700G31 Pressure Gauge, 10,000 PSIG
 700G/TRACK Data logging software and cable
 FLUKE-700PTPK Pneumatic test pump kit, 0 TO 600 PSI/40 BAR
 FLUKE-700HTPK Hydraulic test pump kit, 0 TO 10,000 PSI/690 BAR

Included accessories (Gauges)

Manual on CD-ROM in 14 languages
 NIST traceable certificate of calibration
 1/4" NPT to 1/4" ISO adapter

Fluke. *Keeping your world up and running.®*

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Appendix 3 – Data sheet for the HTM Hand-Held Mechanical Tachometer (Electromatic Equipment Co., Inc, 2020)

PRECISION QUALITY CONTROL INSTRUMENTS SINCE 1958

CHECK-LINE®

Hand-Held Mechanical Tachometer

Four Models Available

HTM-100F
10 to 10,000 rpm
5 to 5,000 ft/min

HTM-500F
30 to 50,000 rpm
15 to 25,000 ft/min

HTM-100M (Metric)
10 to 10,000 rpm
1 to 1,000 m/min

HTM-500M (Metric)
30 to 50,000 rpm
3 to 5,000 m/min

Features

- Accuracy of $\pm 0.5\%$ Full Scale.
- CE-Certified with 18 month warranty.
- 3-Position Range Selector Switch provides highest possible resolution for each application.
- Supplied as a complete kit with cone and funnel tip adapters, shaft extension and surface speed wheel in foam-fitted carrying case.
- No batteries required.
- Rubber shell on housing provides extra protection and improved grip.
- 3-inch oversized dial uses two separate color scales to display rpm (black) and surface speed (red).
- Memory button holds pointer in "last" position until reset.
- NIST-Traceable Calibration and Test Report optionally available.

The HTM mechanical hand-tachometer accurately measures RPM and surface speed on a wide range of applications.

Favored in several industries, including elevator maintenance and mining, HTM Mechanical Tachometers use a pointer and dial to display RPM or surface speed—without the need for batteries!

In addition to reading speeds on the dial, the user can note the range and frequency of variation of the measurements by watching the speed and span of the pointer movement. A Peak-Hold (memory) button freezes the pointer in "last" position until reset. A 3-inch oversized dial uses two separate color scales to measure rpm (black) and surface speed (red) quickly and easily.

A 3-Position Range Selector Switch allows the operator to select highest possible resolution for each application by providing a multiplier of 1X, 10X or 100X for reading the dial. All HTM models are rated at an accuracy of $\pm 0.5\%$ Full Scale or better.

The HTM is fitted with a durable rubber sleeve, providing extra ergonomic benefits for comfortable and secure hand-held use. This also provides an additional measure of physical and environmental protection.

Model HTM Specifications

Accuracy	±0.5% Full Scale			
RPM Ranges	HTM-100 models 10-10,000 rpm		HTM-500 models 30-50,000 rpm	
Multipliers (rpm)	x 1 x 10 x 100	1 – 100 100 – 1,000 1,000 – 10,000	x 1 x 10 x 100	30 – 500 300 – 5,000 3,000 – 50,000
Surface Speed Ranges 100 Series Models	HTM-100F 5-5,000 ft/min		HTM-100M 1-1,000 m/min	
Multipliers (fpm / mpm)	x 1 x 10 x 100	5 – 50 50 – 500 500 – 5,000	x 1 x 10 x 100	1 – 10 10 – 100 100 – 1,000
Surface Speed Range 500 Series Models	HTM-500F 15-25,000 ft/min		HTM-500M 3-5,000 m/min	
Multipliers (fpm / mpm)	x 1 x 10 x 100	15 – 250 150 – 2,500 1,500 – 25,000	x 1 x 10 x 100	3 – 50 30 – 500 300 – 5,000
Surface Speed Range Metric Models	Must divide value on dial by 10			
Weight	10.6 oz (300 g)			
Housing Material	Plastic, with outer rubber shell			
Dimensions (Tach)	6.1" x 3.4" x 2.2" (155 x 85 x 55mm)			
Dimensions (Case)	9.9" x 8.2" x 2.4" (252 x 207 x 60mm)			
Certifications	CE			
Warranty	18 months			
Operating Temperature	32 °F to 104 °F (0 °C to 40 °C)			
Storage Temperature	14 °F to 104 °F (-10 °C to 40 °C)			



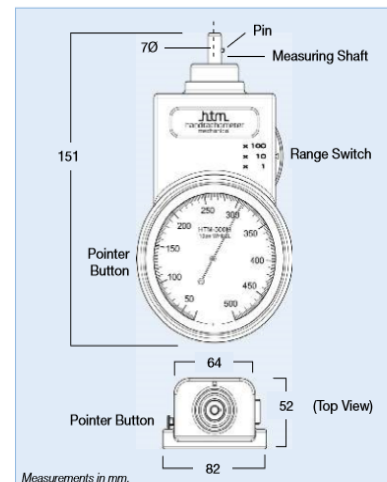
Complete Kit

All models are supplied as a complete kit in a foam-fitted carrying case including cone tip and funnel tip adapters, shaft extension and instruction manual.

Calibration Certificate is optional.

	HTM-100F	HTM-500F	HTM-100M	HTM-500M
6" Wheel	•	•		
0.1 M Wheel			•	•
Cone Tip	•	•	•	•
Funnel Tip	•	•	•	•
Shaft Extension	•	•	•	•

Fast, accurate and easy-to-use



1. Slide the **Red Range Switch** to select a suitable multiplier for your application.
2. Manually rotate the measuring shaft to engage the gear for the selected range.
3. Slide contact adapter/wheel over the shaft of the HTM.
4. Bring the tip adapter into contact with the moving surface of the material being measured. The gauge will display a reading, either RPM, ft/min, min/min).
5. To lock in the reading, press and hold the **Red Pointer Button** to activate the pointer. When the pointer button is released, the pointer will remain in the last position.
6. To reset the pointer, press and release red button again.



For additional information or to place an order **CALL TOLL FREE 1-800-645-4330**

Electromatic Equipment Co., Inc.
600 Oakland Ave.
Cedarhurst, N Y 11516 —USA

Tel: (800) 645-4330 (USA & Canada)
Tel: (516) 295-4300
Fax: (516) 295-4399

Email: info@checkline.com
Website: www.checkline.com

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Appendix 4 – Data sheet for the AEDB-9140 Series Optical Encoder (RS Components, 2020)

AEDB-9140 Series Three Channel Optical Incremental Encoder Modules with Codewheel, 100 CPR to 500 CPR



Data Sheet



Description

The AEDB-9140 series are three channel optical incremental encoder modules offered with a codewheel. When used with a codewheel, these low cost modules detect rotary position. Each module consists of a lensed LED source and a detector IC enclosed in a small plastic package. Due to a highly collimated light source and a unique photodetector array, these modules are extremely tolerant to mounting misalignment.

The AEDB-9140 has two channel quadrature outputs plus a third channel index output. This index output is a 90 electrical degree high true index pulse which is generated once for each full rotation of the codewheel.

The AEDB-9140 is designed for use with a codewheel which has an optical radius of 11.00 mm (0.433 inch).

The quadrature signals and the index pulse are accessed through five 0.46 mm square pins located on 1.27 mm (pitch) centers.

Features

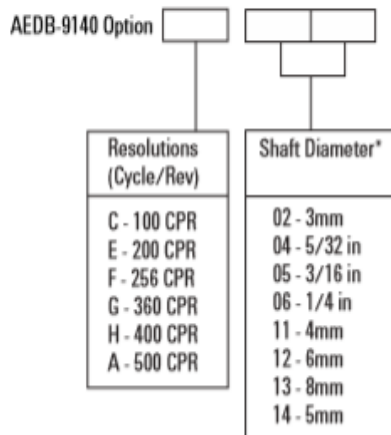
- Two Channel Quadrature Output with Index Pulse
- Resolution from 100 CPR to 500 CPR (Counts Per Revolution)
- Low Cost
- Easy to Mount
- No Signal Adjustment required
- Small Size
- Operating Temperature: -10°C to 85°C
- TTL Compatible
- Single 5V Supply

Applications

The AEDB-9140 provide sophisticated motion control detection at a low cost, making them ideal for high volume applications. Typical applications include printers, plotters, tape drives, and industrial and factory automation equipment.

Note: Avago Technologies encoders are not recommended for use in safety critical applications. Eg. ABS braking systems, power steering, life support systems and critical care medical equipment. Please contact sales representative if more clarification is needed.

Ordering Information



Three Channel Encoder Modules with Codewheel, 11 mm Optical Radius

* Please contact factory for other shaft diameters

Available Options

Part No	CPR	Shaft Diameter Options							
		02	04	05	06	11	12	13	14
AEDB-9140	C		•		•		•	•	
	E				•	•	•		•
	F		•				•		•
	G				•		•		•
	H				•				•
	A	•	•	•	•	•	•	•	•

Theory of Operation

The AEDB-9140 are emitter/detector modules. Coupled with a codewheel, these modules translate the rotary motion of a shaft into a three-channel digital output.

As seen in Figure 1, the modules contain a single Light Emitting Diode (LED) as its light source. The light is collimated into a parallel beam by means of a single polycarbonate lens located directly over the LED. Opposite the emitter is the integrated detector circuit. This IC consists of multiple sets of photodetectors and the signal processing circuitry necessary to produce the digital waveforms.

The codewheel rotates between the emitter and detector, causing the light beam to be interrupted by the pattern of spaces and bars on the codewheel.

The photodiodes which detect these interruptions are arranged in a pattern that corresponds to the radius and design of the code-wheel. These detectors are also spaced such that a light period on one pair of detectors corresponds to a dark period on the adjacent pair of detectors.

The photodiode outputs are then fed through the signal processing circuitry resulting in A, Abar, B, Bbar, I and Ibar. Comparators receive these signals and produce the final outputs for channels A and B. Due to this integrated phasing technique, the digital output of channel A is in quadrature with that of channel B (90 degrees out of phase).

Block Diagram

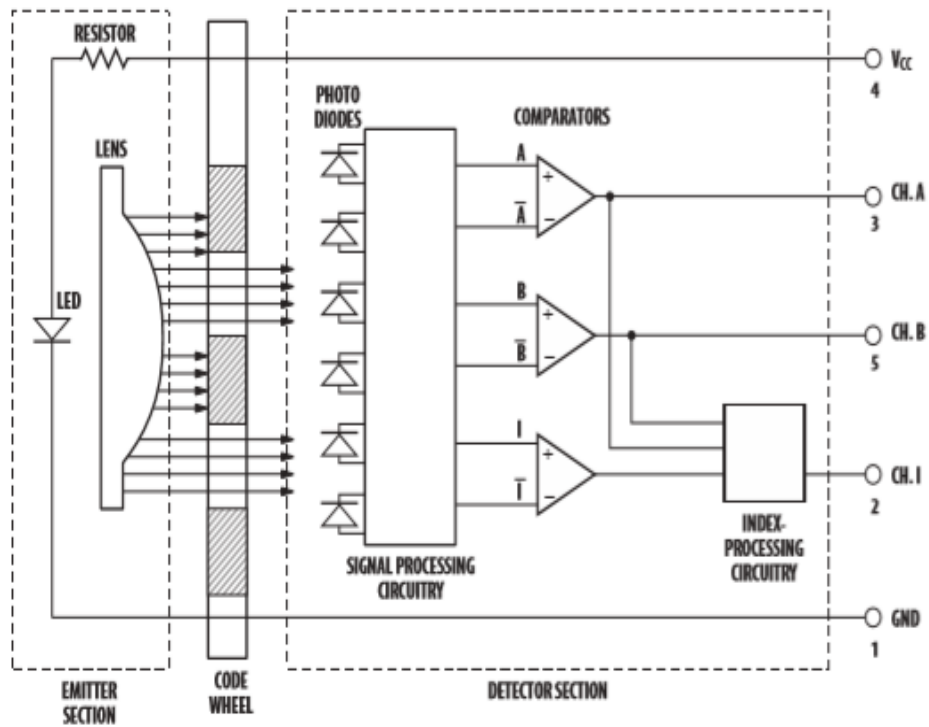


Figure 1.

Output Waveforms

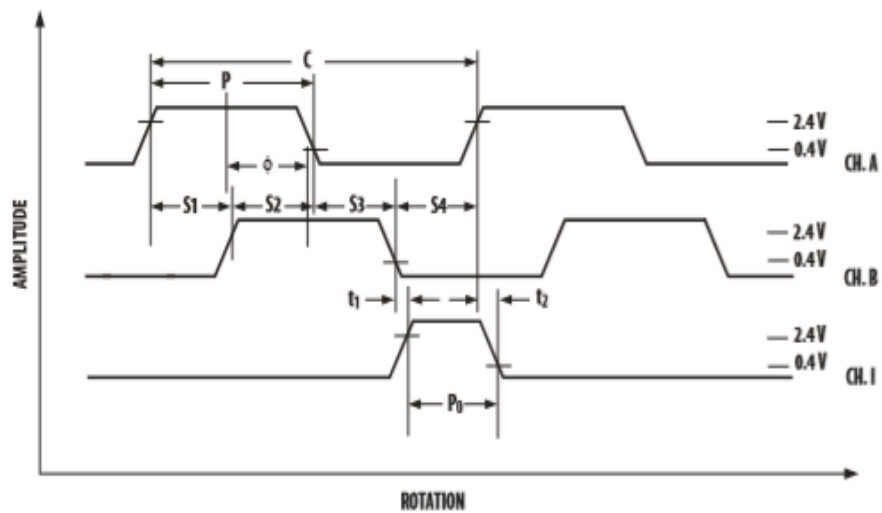


Figure 2.

Definitions

Note: Refer to Figure 2

Count (N): The number of bar and window pairs or counts per revolution (CPR) of the codewheel.

One Cycle (C): 360 electrical degrees ($^{\circ}$ e), 1 bar and window pair.

One Shaft Rotation: 360 mechanical degrees, N cycles.

Position Error ($\Delta\Theta$): The normalized angular difference between the actual shaft position and the position indicated by the encoder cycle count.

Cycle Error (ΔC): An indication of cycle uniformity. The difference between an observed shaft angle which gives rise to one electrical cycle, and the nominal angular increment of $1/N$ of a revolution.

Pulse Width (P): The number of electrical degrees that an output is high during 1 cycle. This value is nominally 180° e or $1/2$ cycle.

Pulse Width Error (ΔP): The deviation, in electrical degrees, of the pulse width from its ideal value of 180° e.

State Width (S): The number of electrical degrees between a transition in the output of channel A and the neighboring transition in the output of channel B. There are 4 states per cycle, each nominally 90° e.

State Width Error (ΔS): The deviation, in electrical degrees, of each state width from its ideal value of 90° e.

Phase (f): The number of electrical degrees between the center of the high state of channel A and the center of the high state of channel B.

This value is nominally 90° e for quadrature output.

Phase Error ($\Delta\phi$): The deviation of the phase from its ideal value of 90° e.

Direction of Rotation: When the codewheel rotates in the clockwise direction viewing from top of the module (direction from V to G), channel A will lead channel B. If the codewheel rotates in the opposite direction, channel B will lead channel A.

Optical Radius (Rop): The distance from the codewheel's center of rotation to the optical center (O.C) of the encoder module.

Index Pulse Width (Po): The number of electrical degrees that an index is high during one full shaft rotation. This value is nominally 90° e or $1/4$ cycle.

Absolute Maximum Ratings

Parameter	Symbol	Minimum	Typical	Maximum	Units	Notes
Storage Temperature	T _S	-10		85	°C	
Operating Temperature	T _A	-10		85	°C	
Supply Voltage	V _{CC}	-0.5		7	Volts	
Output Voltage	V _O	-0.5		V _{CC}	Volts	
Output Current per Channel, I _{OUT}	I _{OUT}	-1.0		18	mA	

Recommended Operating Conditions

Parameter	Symbol	Min.	Typ.	Max.	Units	Notes
Temperature	T _A	-10		85	°C	
Supply Voltage	V _{CC}	4.5	5.0	5.5	Volts	Ripple < 100mVp-p
Load Capacitance	C _L			100	pF	2.7 kΩ pull-up
Frequency	f			100	kHz	Velocity (rpm) x N/60
Shaft Perpendicularity Plus Axial Play				± 0.20(± 0.008)	mm(in.)	Refer to Mounting Consideration
Shaft Eccentricity Plus Radial Play				± 0.04(± 0.0015)	mm(in.)	

Electrical Characteristics

Electrical Characteristics Over the Recommended Operating Range. Typical Values at 25°C.

Parameter	Symbol	Minimum	Typical	Maximum	Units	Notes
Supply Current	I _{CC}	30	57	85	mA	
High Level Output Voltage	V _{OH}	2.4			V	Typ. I _{OH} = -0.5 mA
Low Level Output Voltage	V _{OL}			0.4	V	Typ. I _{OL} = 10 mA
Rise Time	t _r		180		ns	C _L = 25 pF R _L = 2.7 kΩ pull-up
Fall Time	t _f		50		ns	

Note: Typical values specified at V_{CC} = 5.0 V and 25 °C

Encoding Characteristics

Encoding Characteristics Over the Recommended Operating Conditions and Recommended Mounting Tolerances unless otherwise specified.

Parameter	Symbol	Minimum	Typical	Maximum	Units	Notes
Cycle Error	ΔC		3	10	$^{\circ}e$	
Pulse Width Error	ΔP		7	30	$^{\circ}e$	
Logic State Width Error	ΔS		5	30	$^{\circ}e$	
Phase Error	$\Delta \phi$		2	15	$^{\circ}e$	
Position Error	$\Delta \theta$		10	40	min. of arc	
Index Pulse Width	P_0	60	90	120	$^{\circ}e$	
CH I rise after CH B or CH A fall	t_1	10	100	1000	ns	-10 $^{\circ}C$ to +85 $^{\circ}C$
CH I fall after CH A or CH B rise	t_2	10	300	1000	ns	-10 $^{\circ}C$ to +85 $^{\circ}C$

Electrical Interface

To insure reliable encoding performance, the AEDB-9140 three channel encoder modules require 2.7 k Ω ($\pm 10\%$) pull-up resistors on output pins 2, 3, and 5 (Channels A, I and B) as shown in Figure 3. These pull-up resistors should be located as close to the encoder module as possible (within 4 feet). Each of the three encoder module outputs can drive a single TTL load in this configuration.

Customized Solutions

Customization of codewheel CPR is possible. It has to be based on the encoder LPI table given below:

Part Number	LPI
AEDB-9140 # C	36.7
AEDB-9140 # E	73.5
AEDB-9140 # F	94
AEDB-9140 # G	132.3
AEDB-9140 # H	147
AEDB-9140 # A	183

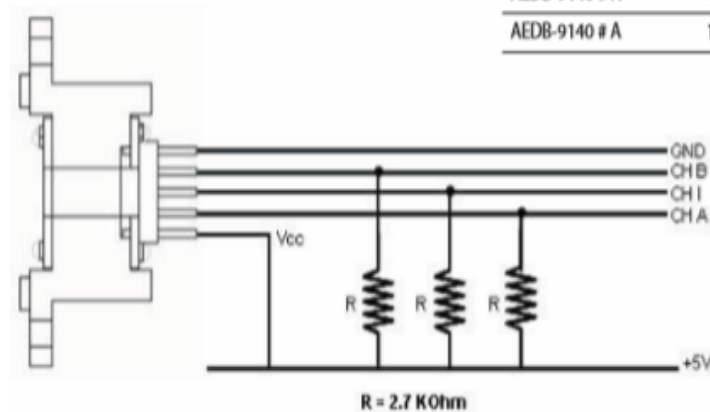


Figure 3.

CPR calculation formula:

$$CPR = (LPI \times 25.4) \times 2 \times \pi \times ROP$$

Where:

CPR = Counts Per Revolutions

LPI = Encoder LPI provided in the table

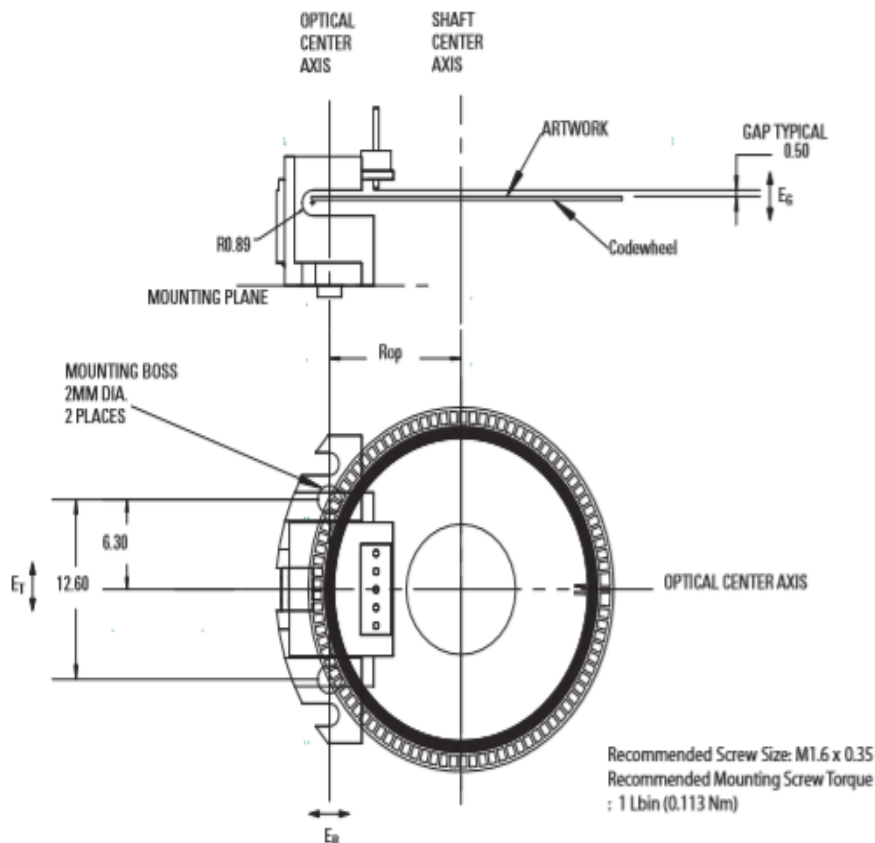
ROP = Encoder Optical Radius in mm

* Recommended maximum Codewheel diameter should not exceed 30mm

Note: The customization of codewheel method is valid from theoretical standpoint. However Avago Technologies strongly recommends a full characterization to be done to determine the actual performance of the encoder with customized codewheel.

Characterization means validating the encoding performance (consist of cycle error, pulse width error, logic state width error, phase error, position error & index pulse width, index channel rise and fall time) over the recommended operating conditions and recommended mounting tolerances.

Mounting Considerations

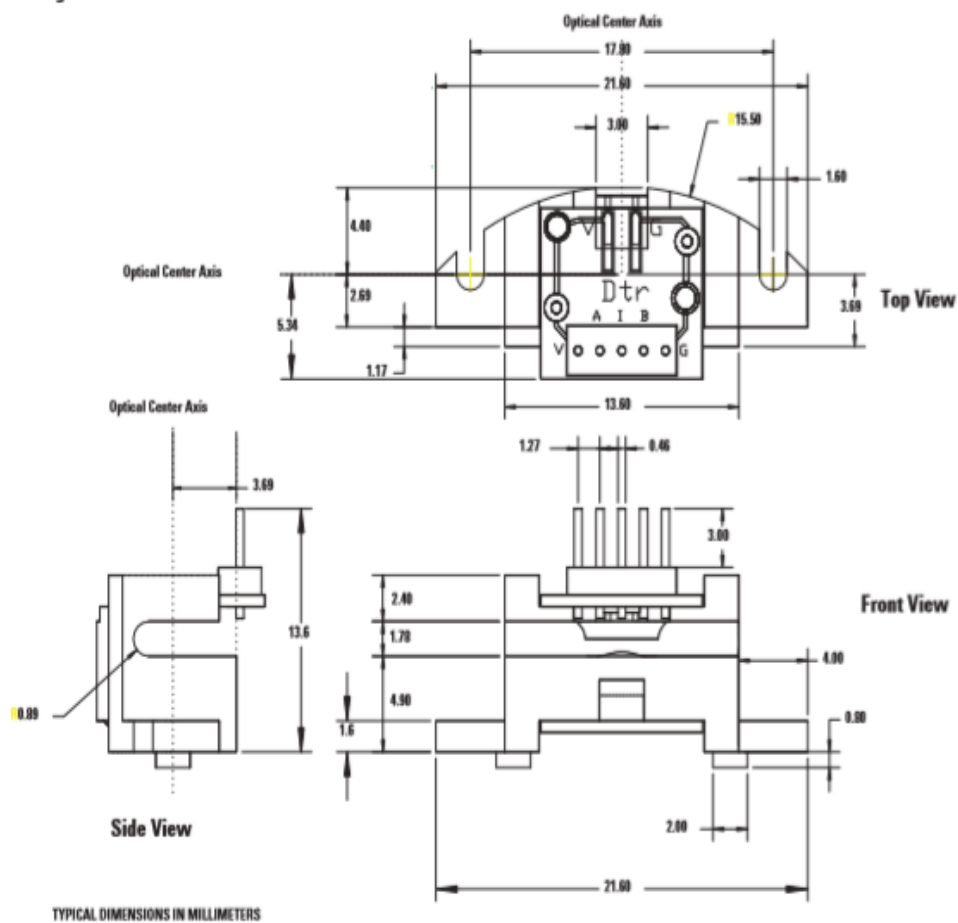


Note:

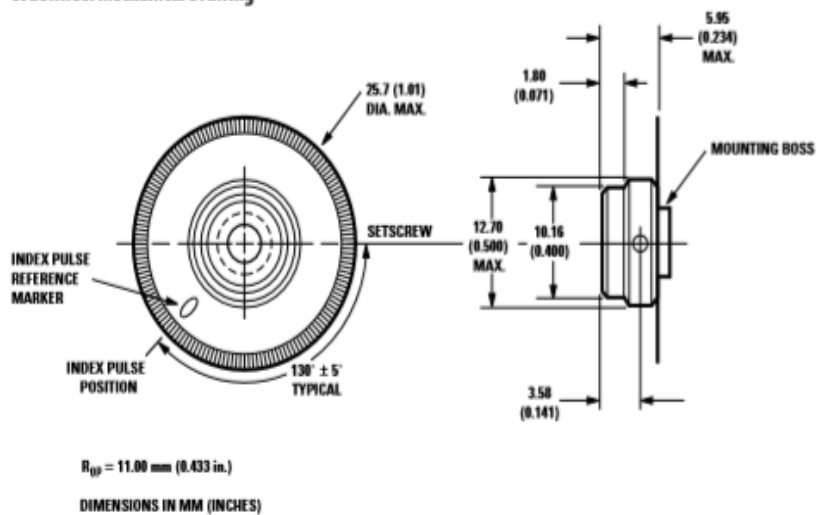
These dimensions include shaft endplay and codewheel warp. All dimension for mounting the module and codewheel should be measured with respect to two mounting boss, as shown above.

Error		ROP = 11mm	Unit	Notes
E _G	Gap	± 0.20	mm	Recommend to mount the codewheel closer to the detector side (upper side) for optimum encoder performance.
E _R	Radial	± 0.13	mm	
E _T	Tangential	± 0.13	mm	

Package Dimension



Codewheel Mechanical Drawing



Appendix 5 – Data sheet for the Carel HTC temperature probe (RS Components, 2020)



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2

Temperature Probes

Tempatron temperature probes include thermistors, 3-wire PT100 resistance thermometer devices (RTDs) and J and K type thermocouples. The thermistors are available in negative temperature coefficient (NTC) or positive temperature coefficient (PTC) versions.

All probes are available with a 6mm diameter stainless steel sheath and the NTC thermistors are also available with a plastic sheath. The probes are available in 1.5m, 3m and 6m lengths and optional industrial probe heads, thermowells and compression fittings are also available.

Customer specified probes are also available - please contact our sales team for further details.

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Temperature probes for detection of temperature in industrial applications

Models Available

- NTC 10K NTC Probe
- PTC 1K PTC Probe
- PT100 3 Wire PT100 Probe
- THJ J Type Thermocouple
- THK K Type Thermocouple

Product Features

- Plastic or stainless steel sheaths
- NTC probes in 1.5m, 3m or 6m lengths
- PTC probes in IP65 or IP67 versions
- Stainless steel braided cable option
- Custom specified probes also available

Specification

Temperature Range:

- NTC plastic sheath:
 - 50°C to +50°C in water
 - 50°C to +105°C in air
- NTC S/S sheath: -50°C to +105°C
- PTC0150000: 0°C to +150°C
- PTC015W000: -50°C to +100°C
- PT100000A1: -50°C to +250°C
- PT100000A2: -50°C to +400°C
- THJ030A1: -50°C to +200°C
- THK030A1: -50°C to +400°C

Thermistor Resistance:

- NTC: 10kohms at 25°C
- PTC: 1kohm at 25°C

PT100 RTD:

- 3 wire (2 or 4 wire by request)
- 100ohms at 0°C
- Platinum detector - class A accuracy to BS EN 60751:1996 (see table)

J Type Thermocouple:

- PTFE insulated cable

K Type Thermocouple:

- Glass fibre insulated cable

Weight:

- NTC: 50g
- PTC: 50g
- PT100: 125g
- J/K Thermocouple: 125g

Specification subject to change without notice.

Ordering information

Model	Code	Description
NTC		NTC 10K Thermistor
PTC		PTC 1K Thermistor
PT100		PT100 3 Wire RTD
THJ		J Type Thermocouple
THK		K Type Thermocouple

Probe Length	Code	Description
000		3.0 metres (PT100 only)
015		1.5 metres (NTC & PTC only)
030		3.0 metres (NTC, THJ & THK only)
060		6.0 metres (NTC only)

Sheath/Temperature	Code	Description
0000		6x40mm Stainless Steel IP65 Sheath 0 to 150°C (PTC only)
HP00		6x15mm Plastic IP67 Sheath (NTC only)
WH01		6x50mm Stainless Steel IP68 Sheath (NTC only)
W000		6x40mm Stainless Steel IP67 Sheath (PTC only) -50 to 100°C (PTC only)
A1		6x100mm Stainless Steel IP65 Sheath -50 to 200°C (PT100 & THJ only)
A2		6x100mm Stainless Steel IP65 Sheath -50 to 400°C (PT100 & THK only)

Example PT100000A1

Thermocouple Cable Insulation Colour Standards

Thermocouple Type	Conductor Materials (+/-)	BS1843	ANSI MC96.1	DIN43714	IEC584
B	Plat Rhodium Plat Rhodium				
E	Ni Chromium Constantan				
J	Iron Constantan				
K	Ni Chromium Ni Aluminium				
N	Nicrosil Nisil				
R/S	Plat Rhodium Platinum				
T	Copper Constantan				
U Compensating cable for Types R/S	Copper Copper Nickel				
Vx Compensating cable for Type K	Copper Constantan				

Notes:

1. Thermocouples must be directly connected to the temperature controller and not joined, unless correct compensating cable is used.
2. The colours shown above may not exactly match the insulation colour due to printing reproduction limitations.

Tempatron: Eltime House, Hall Road, Maldon, Essex, CM9 4NF UK.

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