USC701 Functions Manual

The Universal Signal Conditioner USC701 is a programmable signal conditioner that combines measurement and control functions in a single instrument and provides user selectable solutions for most signal conditioning applications.

The configuration can be set up and altered by:

- The plug-on Access Module AM702
- The plug on Computer Adaptor COA703 with the USC700 programmer software.
- A Select switch and encoder accessible on top of the USC used to alter a number of calibration parameters.

Installation

Mounting:

The Universal Signal Conditioner USC701 has a “Snap-On” mounting to a DIN 35mm rail (DIN EN 5002).

To mount the USC701 on the DIN rail:

- Clip the two notches at the bottom of the USC701 under the bottom notches of the DIN rail;
- Push back the top of the USC701 until the two top notches clip around the top notches of the DIN rail.
- The spring foot of the USC701 holds the USC701 in place.

To remove the USC701 from the DIN rail:

- Push the USC701 in an upward direction relative to the rail. This compresses the spring clip and allows the top USC701 notches to come away from the rail notches.
- The USC701 can then be pulled forward at the top and pushed down to release the bottom notches.
- Alternatively, if space and position allow, slide side wards off the DIN rail.

Connections

The USC701 has with two plug-in screw terminal blocks. The plug-in screw terminal blocks can be removed from the USC701 by gently levering the blocks away from the main body using a small screwdriver. The terminal cross section is 1.5mm^2.

Connections are made to the USC701 using wires that are screwed into the terminal blocks. The wires should be stripped back 6mm and crimped ferrules are recommended. For safety, termination should only be done in a powered-down state.

It is recommended, especially in noisy environments, that shielded wires (especially for input sensor connections) be used and that signal cables be separated from power cables.

For part number USC701-1xxx, either a dc supply of any value between 80 to 300V or an ac supply of any value between 80 and 280Vac 50/60Hz has to be connected to terminals 1 (positive or active) and 2 (negative or neutral).

For part number USC701-2xxx, either a dc supply of any value between 10 to 60V or an ac supply of any value between 16 and 42Vac 50/60Hz has to be connected to terminals 1 (positive or active) and 2 (negative or neutral).

In either case, for safety and shielding, terminal 3 has to be connected to a good earth.

These are discussed in the appropriate sections.

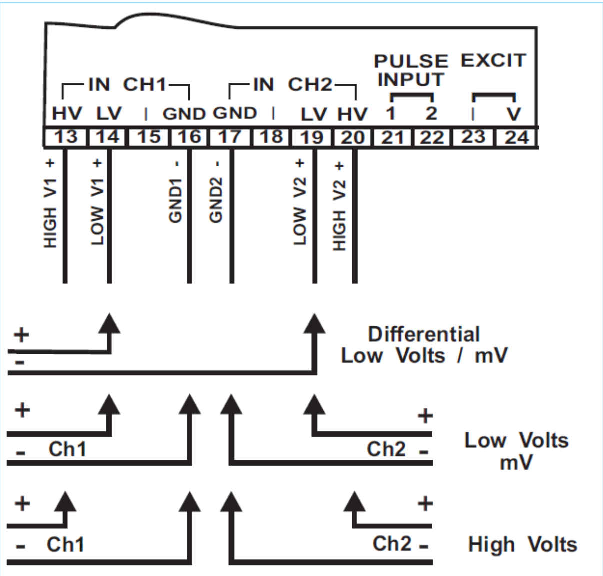
Two Analogue Inputs

There are two analogue input channels. Each channel can interface with the most common process control inputs. These include:

- dc or ac voltage
- dc or ac current
- Resistance or potentiometer
- Resistance bridge or strain gauge sensors
- Temperature using either thermocouple or RTD sensors

Other sensors can be interfaced to the USC providing the measurement signal can be identified as a voltage or current or resistance. The USC can provide a voltage and current source if the measuring sensor needs an excitation voltage or current.

Voltage Connection



Measurement of dc Voltage

On both analogue input channels there is a **low voltage** input terminal for measurement of voltages up to ±4.5V and a **high voltage** input terminal for measurement of voltages up to ±400Vdc.

Low Voltage dc Input:

- Two single-ended inputs can be connected (one to each channel) or
- Two inputs are connected differentially to create one differential input channel. Both voltages must be within 4.5V referred to AGND in order to stay within the common mode operating range.
- Input ranges are:

  4.5V (input impedance = 2MΩ)

  1 V (input impedance = 570kΩ)

  300mV (input impedance = 160kΩ)

  100mV (input impedance = 53kΩ)

  30mV (input impedance = 15kΩ)

High Voltage dc Input:

Two single-ended inputs can be connected (one to each channel). Input ranges:

400V (input impedance = 4M4Ω)

100V (input impedance = 4M4Ω)

30V (input impedance = 4M4Ω)

10V (input impedance = 4M4Ω)

The appropriate range is selected by the USC after the user selects the minimum and maximum input values in the selection software.

Measurement of ac voltage

On both analogue input channels there is a **low voltage** input terminal for measurement of voltages up to 3Vac and a **high voltage** input terminal for measurement of voltages up to 300Vac (25-70Hz).

Low Voltage ac Input:

- Two single-ended inputs can be connected (one to each channel) or
- Two inputs are connected differentially to create one differential input channel. Both voltages must be within 4.5Vpeak referred to AGND in order to stay within the common mode operating range.
- Input ranges:

  3V (input impedance = 2MΩ)

  0.7 V (input impedance = 570kΩ)

  250mV (input impedance = 160kΩ)

  75mV (input impedance = 53kΩ)

  20mV (input impedance = 15kΩ)

High voltage ac Input:

- Two single-ended inputs can be connected (one to each channel).
- Input ranges:

  300V (input impedance = 4M4Ω)

  75V (input impedance = 4M4Ω)

  25V (input impedance = 4M4Ω)

  7V (input impedance = 4M4Ω)

The appropriate range is selected by the USC after the user selects the minimum and maximum input values in the selection software.

Measurement of Current

Separate terminals are provided on both analogue input channels for dc or ac current measurement. Ranges:

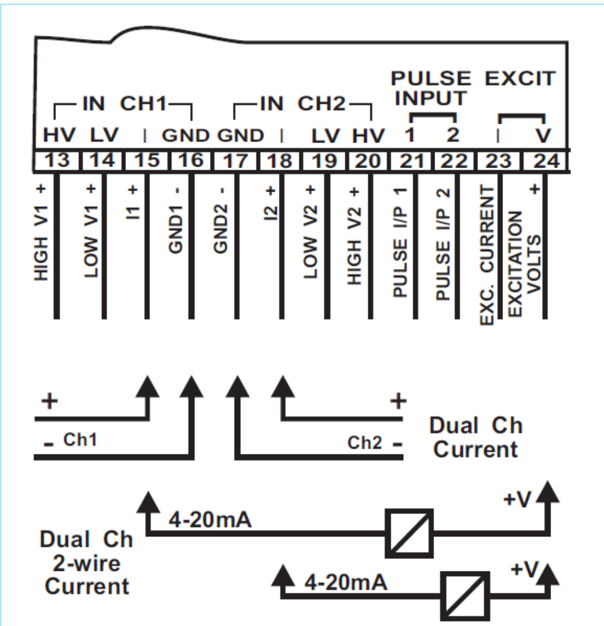
- dc current: ±75mA, ±30mA, ±10mA, ±1mA
- ac current: 50mA, 20mA, 7mA, 0.7mA ac.

The appropriate range is selected by the USC after the user selects the minimum and maximum input values in the selection software.

Input impedance:

33Ω measurement resistor plus 50Ω protection thermistor.

Input Current Connection



The current can be connected directly across the current terminal and ground or two wire field transmitters can be connected from the excitation voltage to the current terminal.

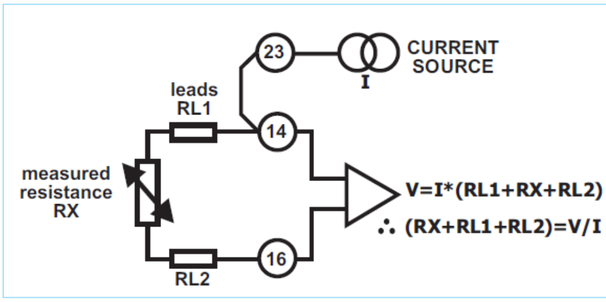
For measurement of currents (ac or dc) higher than the ranges above, an external shunt must be connected across the low voltage (LV) terminal to the GND terminal. The external current is then wired in parallel with this external resistor. This develops a voltage so the USC is configured in voltage mode. The precision of this measurement with external shunt depends on the precision of the shunt resistor.

Measurement of resistance

The measurement of resistance is converted to the measurement of voltage by energising the resistance with one or two 100μAdc current sources.

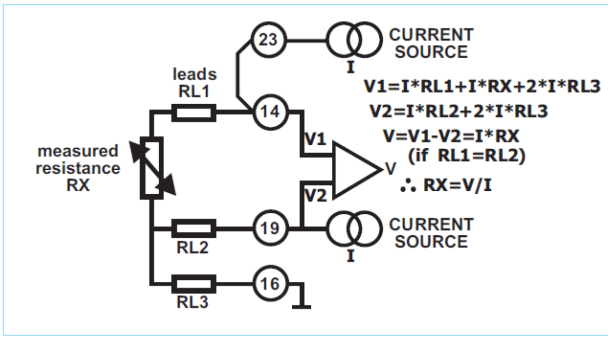
The USC supports the measurement of resistance in 2-wire, 3-wire or 4-wire mode

Two-Wire Resistance Measurement



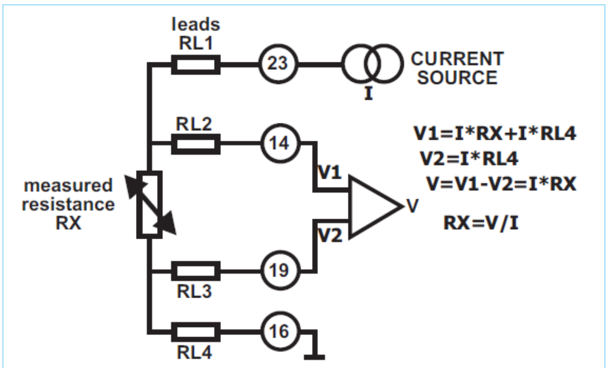
Two separate resistors can be connected (one to each channel). In this mode the resistance of the connection leads to the "resistor" is also measured. This will influence the accuracy of the measurement.

Three-Wire Resistance Measurement



Only one resistor can be measured since both input channels are used in differential mode. In this mode the resistance of the connection leads to the "resistor" is also measured. However, as long as the leads are of the same length and type, the error due to leads is cancelled.

Four-Wire Resistance Measurement

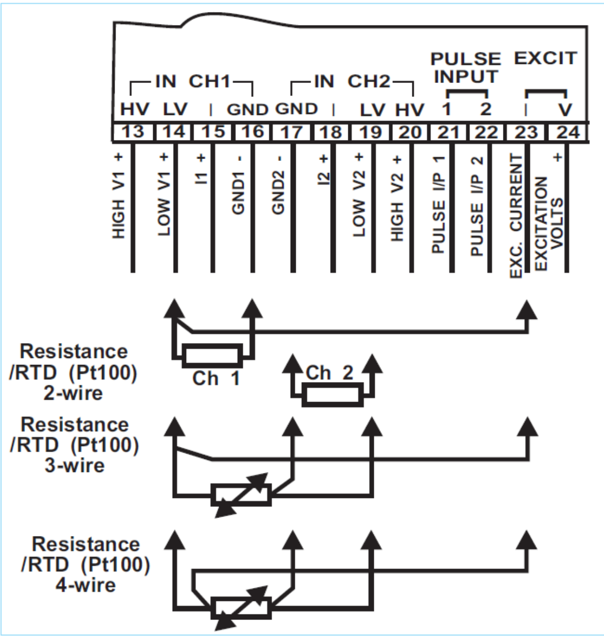


Only one resistor can be measured since both input channels are used in differential mode. In this mode the voltage drop across the resistor is measured directly by the USC and the resistance of the connection leads causes no error.

Resistance ranges are: 30 kΩ, 10 kΩ, 3 kΩ, 1 kΩ and 0.3 kΩ

The appropriate range is selected by the USC after the user selects the minimum and maximum input values in the selection software.

Resistance Measurement Connections

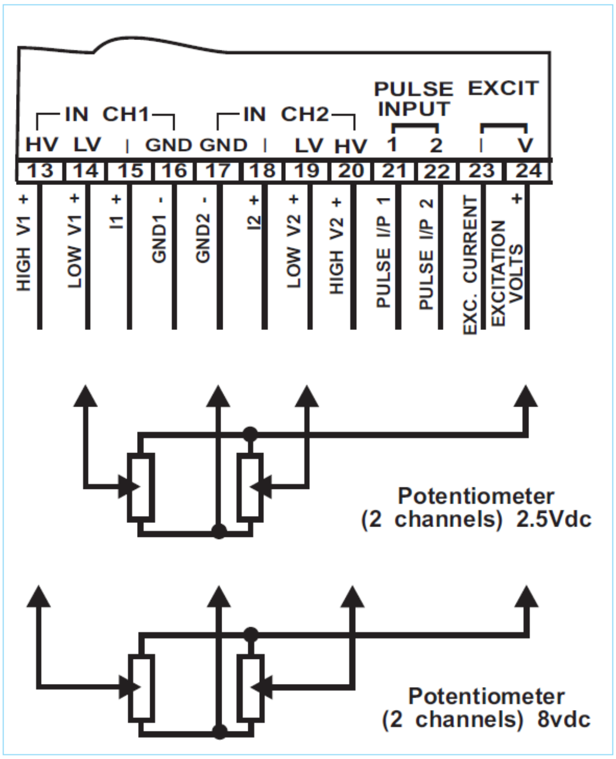


Measurement of Potentiometer

The potentiometer is connected across an excitation output. The voltage at the wiper of the potentiometer is then measured. This measured voltage is proportional to the amount the wiper of the potentiometer has been moved from the end. The resistance of the connection leads to the potentiometer will influence the accuracy of the measurement. Ranges:

- 2.5V potentiometer with resistance down to 100Ω.
- 8V potentiometer with resistance down to 350Ω.

Potentiometer Connection



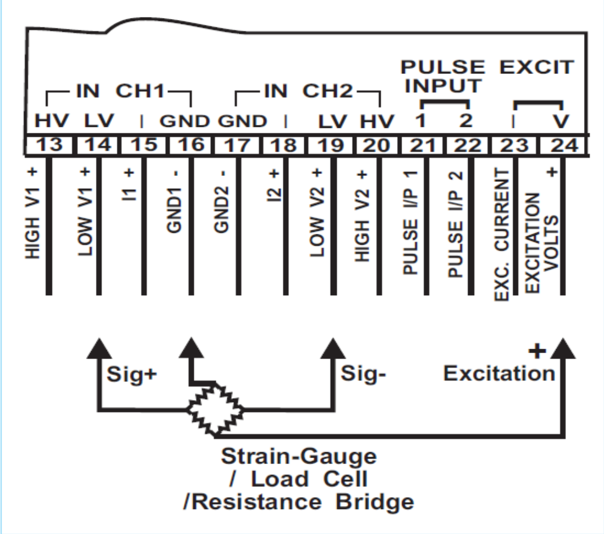
Resistance Bridge or Strain Gauge

The bridge is connected across an excitation voltage of 5Vdc. Only one bridge can be measured since both input channels are used in differential mode in order to measure the two output arms of the bridge.

Ranges:

- The excitation voltage can support a 50mA load. Therefore, the bridge resistance can be any value down to 100Ω minimum (e.g. three 350Ω load cells in parallel)

Bridge / Strain Gauge Connection



Measurement of Temperature with Thermocouples

A thermocouple converts thermal energy directly into an electrical voltage. The principal is based on the fact that if a temperature gradient is present in an electrical conductor, the heat flow will create a movement of electrons and an electromotive force (e.m.f.) will be generated in the region. There are two different materials in the circuit, each one generating a different voltage per degree temperature difference between its ends, and then a measurable voltage will be produced.

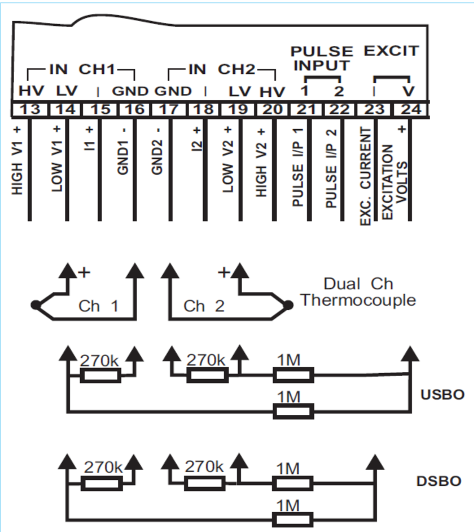
USC Thermocouple Range Chart

Type	°C Range	mV Input	USC Range
B	0...1820°C	0…13.8mV	30mV
E	-250...1000°C	-9.7…76.4mV	100mV(30mV if Tmax <425°C)
J	-210...1200°C	-8.1…69.5mV	100mV(30mV if Tmax <550°C)
K	-200...1372°C	-5.9…54.9mV	100mV(30mV if Tmax <750°C)
N	-200...1300°C	-4.0…47.5mV	100mV(30mV if Tmax <850°C)
R	-20...1760°C	-0.1…21.0mV	Range: 30mV
S	-20...1760°C	-0.1…18.6mV	Range: 30mV
T	-250...400°C	-6.2…20.9mV	Range: 30mV

Tmax is the maximum input temperature value selected in the setup software. Temperatures can be measured in °C, °F or °K.

In a practical thermocouple circuit there are two junctions of the dissimilar metal conductors - one at the "hot" end (where we want to measure the temperature) and the other at the "cold" end the terminals of the USC701. The USC701 measures the cold temperature and makes the necessary correction to the readings obtained.

Thermocouple Connection



Linearisation

The relationship between the thermocouple generated mV and the actual temperature is not completely linear. The linearity error depends on the type of thermocouple and the temperature range. The USC offers the user the option of linearising the readings (to ±0.1°C).

If standard linearisation is selected the mV readings are corrected to the true temperature equivalents according to the International Temperature Scale ITS-90.

Burnout

The USC can be set to indicate up or down scale burnout by the connection of an external 1M/270k resistor network per channel. For up scale burnout connect the network to terminal 24 or down scale burnout connect the network to terminal 23.

Temperature with RTD sensors

A practical industrial method for temperature measurement is to use resistance temperature detectors (RTDs). These sensors change their resistance with temperature. The most common of these uses a Pt100 sensor. This has the characteristics of high stability and repeatability.

Types & Ranges

The relationship between the resistance and the actual temperature is not completely linear. The linearity error depends on the type of RTD and the temperature range standard linearisation is in accordance with the IEC 751 (DIN 43760). The USC can support the following RTDs:

RTD Connection

These sensors change their resistance with temperature and can be measured the same as “resistance” measurement using 2, 3 or 4-wire connection.

Two sensors can be measured if 2-wire measurement is used.

RTD Range Chart

Type	°C Range	Resistance Input	mV Input max	USC Range
Pt100	210...+800°C	14.1...375.5Ω	37.5	100mV(30mV if Tmax <600°C)
Pt1000	-210...+800°C	141...3755Ω	375	1000mV(300mV if Tmax <600°C)
Cu10	-190...+250°C	1.47...18.73Ω	1.9	30mV
Ni120	-100...+300°C	63.7...339.5Ω	34	100mV(30mV if Tmax <250°C)

Where Tmax is the maximum input temperature value selected in the setup software. Temperatures can be measured in °C, °F or °K.

Non standard or less popular measurement curves can be entered using the 101-point linearisation tables manually. Finished programs can be saved for recal.

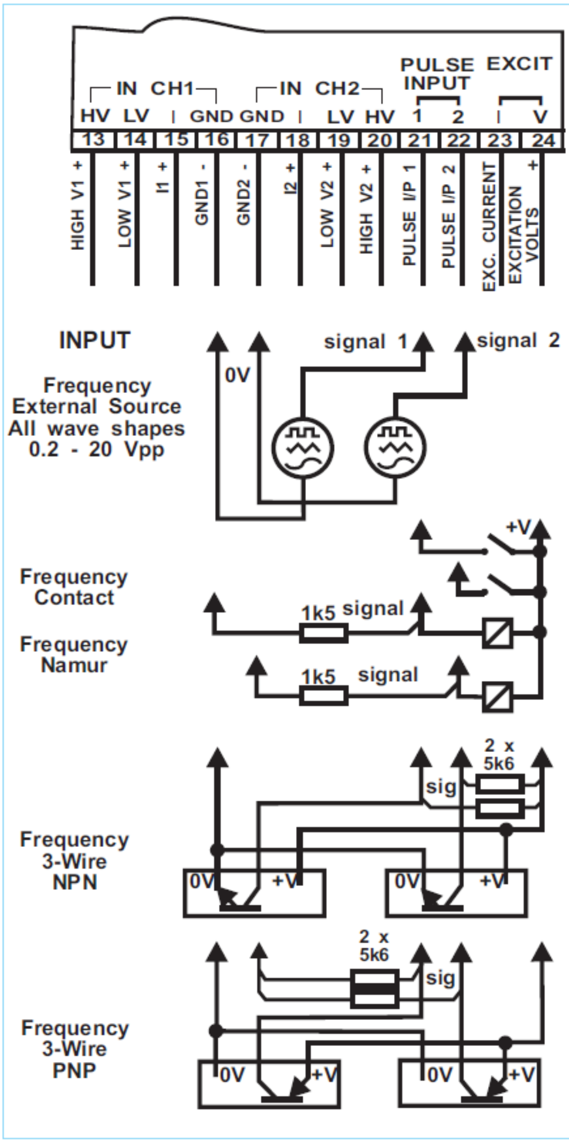
Two Pulse Inputs

There are two digital input channels.

- The USC can use these channels for the following
- Measurement of Frequency
- Measurement of Phase
- Measurement of Counts or Displacement
- Control functions such as Hold, Reset, Enable

The input impedance is 20kΩ. The excitation level and the input trigger level must be set to suit the input sensor or signal level to be used. Please note that when configuring two pulse inputs that there is only one excitation voltage output (3 to 18 volts) and the pulse input trigger level (0 to 28 volts) when set is the same level for both pulse inputs.

Pulse Input Probe and Sensor Connections



Pulse Input: Probes, Signals and Connections

Regardless of the measurement function the pulse input must be configured for the signal or probe type. The configuration software will configure the input as required however some probes or signal types require external resistors to be wired across the input terminals.

Control Inputs

The pulse inputs can be configured as control inputs. These control inputs are then assigned to control variables that are used in input and general equations.

Control Variables:

- **Hold:** when triggered, then the measured parameter will be held at the last value until the hold is removed.
- **Reset:** when triggered, then the measured parameter (which is either the maximum (peak) or minimum of the previous set of measurements) will be reset to the next measured value.
- **Enable:** this control is used to disable the relays for a set time (programmable).

Measurement of Frequency

The USC to measure frequency on either pulse input, the frequency range can be as small as 1 pulse/hour or as large as 5kHz and can be zero based or offset (e.g. 45-55Hz). The trigger edge is programmable. The measurement method is a reciprocal counting technique. The update time is approximately 70msec plus the period of the measured signal for frequencies above 14 Hz, or the period of the measured signal for lower frequencies. If the frequency is measured with a **Quadrature Sensor**, then only one sensor can be measured with both P1 & P2 input channels connected to the one sensor. The input frequency is measured and the phasing of these two inputs is also detected to give a direction output – relay 2 is closed for forward direction and open for reverse direction. When measuring frequency the input is positive or negative edge triggered.

Pulse Input Type and trigger Level Chart

Signal type	HIGH trigger	LOW trigger	Trigger level
Pulse	Voltage > trigger level	Voltage < trigger level	0.5*(Vmax+Vmin)
Contact	Contact closed	Contact open	0.5*Vexcit
NAMUR prox	Target absent (1kΩ, >3mA)	Target present (8kΩ, <1mA)	2.5V
NPN prox	Transistor off	Transistor on	0.5*Vexcit
PNP prox	Transistor on	Transistor off	0.5*Vexcit

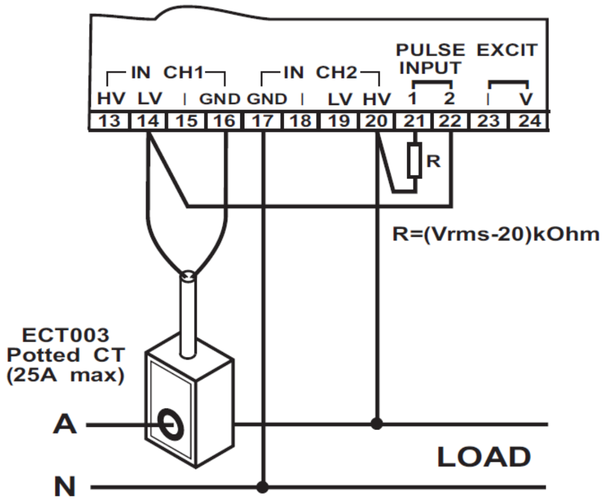
Measurement of Phase

To measure phase pulse input P1 is configured to measure frequency and pulse input P2 is configured to measure the phase difference between the P1 and P2 inputs.

The phase range can be as large as ±180 degrees.

The trigger edge is programmable.

Watts, VAR, Phase Angle, Power Factor I <25A Connection.



Output 1

The USC has one 14 bit resolution isolated output that can be configured as an **Analogue** output connected to terminals 11 (+ve) and 12 (-ve) **or** a **Pulse** output connected to terminals 10 open-collector and 12 common emitter.

Analogue Output

The analogue output is set as a current (22mA range with a 20V drive potential) or a voltage (20V range with a 20mA drive) proportional to one of the measured input variables or a user defined equation.

Pulse Output

This output is an open collector transistor with a voltage rating of 50V and a current rating of 100mA. The user can configure the pulse output as:

- Pulse width modulated output pulse width a PWM period adjustable from 0.1 to 70mS. The “on” period is proportional to the relative level of the output signal.
- A low frequency output range that can produce a linear change in frequency from 0.0028Hz to 1kHz.
- A high frequency output range that can produce a linear change in frequency from 0Hz to 92kHz. If the required output is below 15Hz then the output will drop to 0Hz. The output increases in 1uSec steps as the required output frequency rises. Output frequencies above 5kHz will have noticeable steps.

Relay Outputs

The USC has two relay outputs, with a normally open contact.

The operation of each relay can be either ON-OFF or PWM.

Relay 1 has the N/O contact at terminals 6 & 7.

Relay 2 has the N/O contact at terminals 8 & 9.

On-Off Relay

The user can select a High set point and a Low set point for each relay.

There are six operational modes:

- Direct: The relay is energised when the measured variable exceeds the High set-point and is de-energised when the measured variable drops below the Low set-point.
- Reverse: The relay is energised when the measured variable drops below the Low set point and is de-energised when the measured variable. exceeds the High set point.
- Window: The relay is energised when the measured variable less than the High set-point but also greater than the Low set-point; and is de-energised when outside this window.
- Reverse Window: The relay is energised when the measured variable greater than the High set point or less than the Low set point; and is de-energised when between the two set-points.
- Latch: The relay is energised when the measured variable exceeds the set point, and is de-energised when the Reset signal is activated on the Digital Input channel.
- Reverse Latch: The relay is energised when the measured variable drops below the set point, and is de-energised when the Reset signal is activated on the Digital Input channel.

There are 3 delay **timers** relating to the relays (each has its own user selectable time period before the operation is enabled):

- ON delay (a timer to delay relay energising after being triggered);
- OFF delay (a timer to delay relay de-energising after being triggered);
- Enable delay (a timer to delay relay operation after being triggered by a signal on the Digital input channel).

PWM Relay

The relay contact can be used for Pulse Duration Control where a fixed time interval (1 to 160 seconds) is divided into an ON/OFF ratio dependent upon the input signal level.

The user can set the pulse interval.

The user can also select if the action is to be Direct (the ON period increases for increasing signal), or Reverse (the ON period decreases for increasing signal).

Excitation Outputs

Excitation Voltage

The USC provides a regulated dc voltage output at terminal 24 (referenced to the GND terminal 16 or 17). This voltage is generally used to support analogue inputs that require an excitation voltage to function correctly.

The excitation level can be set from 3 to 18Vdc and support loads of up to 50mA.

Excitation Current

The USC provides a matched pair of precision 100µA dc current outputs.

- These current sources are used to measure resistance input.
- One is accessible to the user at terminal 23 (referenced to the GND terminal 16 or 17).
- The second is connected internally to terminal 19 via internal switches when required for the measurement of resistance on the second analogue channel (IN CH2) or when utilising 3-wire resistance measurement (refer to “Measurement of resistance).

Change Settings Using a Screwdriver

A “Select” switch and “ADJ” control are accessible on the top of the USC. These allow the user to select a calibration parameter and then trim this parameter using a small screwdriver.

The selector switch is labelled 0 to 7 and these switch positions are as labelled below:

Function Selector

0. Configure
1. Output offset
2. Output span
3. Relay 1 upper trip point
4. Relay 1 lower trip point
5. Relay 2 upper trip point
6. Relay 2 lower trip point
7. Pulse 1, Pulse 2 Trigger level

For example, with the switch in position 2, the output span calibration can be trimmed.

The amount of adjustment depends on the rate of change of the encoder. Fast adjustment of the encoder results in coarse trim, whilst slow adjustment results in a finer trim.