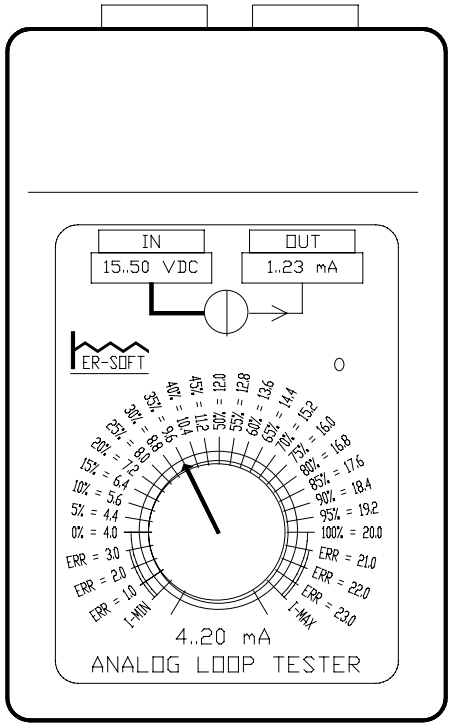
ER-Soft

Industrial Systems Design & Implementation



ANALOG LOOP TESTER

* THE ANALOG LOOP TESTER is a stabilized precision instrument which generates current in the range 4 to 20 mA, and is intended for testing analog control loops.

* It has been developed as a "2 Wire Transmitter", and is extremely simple to use. A LED lights up proportional to the loop current.

* Operating voltage 15 to 50 VDC stabilized or unstabilized.

* Overvoltage protection, overcurrent protection, and reverse polarity protection. These characteristics protect the analog input which is being tested.

* Allows simulation of the behavior of equipment which is out of range (i.e. values less than 4 mA or greater than 20 mA).

* Developed by engineers with many years of experience in the field of instrumentation.

* An exceptionally useful tool for the industrial engineer, and for all professionals working with instrumentation.

* Is no larger than a packet of cigarettes, and **does not need batteries**. Comes with two test cables, and extensive documentation with instructions and examples of use.

CONTENTS OF THE PACKAGE:

+ ANALOG LOOP TESTER unit

+ Two test cables

+ Replacement 100 mA rapid fuse
ø 5 x 20 mm

+ Instruction document.

ANALOG LOOPS

A current loop using 4 to 20 mA is a type of communication which is generally used in industry to transmit the value of a physical magnitude between two (or more) points. Current transmission is used because it is much less sensitive to electrical and magnetic noise than voltage transmission.

Power supplies normally operate with constant voltage. A current source (like the ANALOG LOOP TESTER) requires voltage in order to generate constant current.

CONVERSION BETWEEN
4 to 20 mA & 0 to 100 %

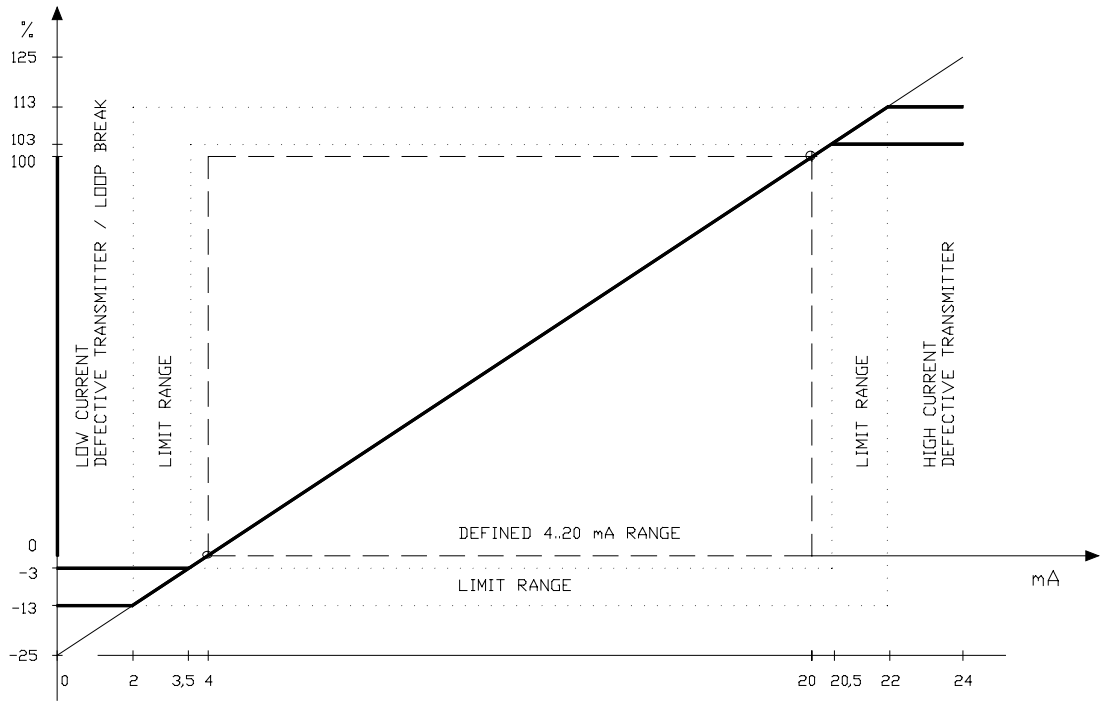
- CONVERSION FORMULAS

There are two formulas for conversion between a current of 4 to 20 mA and 0 to 100%, which may be very useful:

$$X\ mA\ \text{to:}\ Y\ \% = \frac{X\ mA - 4\ mA}{16\ mA} * 100\%$$

$$X\ \%\ \text{to:}\ Y\ mA = \frac{X\ \%}{100\%} * 16\ mA + 4\ mA$$

16 mA = (20 - 4) mA is the current range.



Conversión % - mA

- RANGE DEFINITION
The defined range is the linear conversion between the 4 a 20 mA range and the range 0 a 100 %. The range extends as far as the limit range, which allows a tolerance in the defined range.

- LIMIT RANGE
The limit range contains the low and high limits of the conversion. If the signal is outside of this range, whose normal limit values are 2 to 3,5 mA and 20,5 to 22 mA, the conversion unit must indicate an error and limit the signal.

- LOW CURRENT
An important characteristic of a 4 to 20 mA loop is the possibility of detecting a break in the loop. This will give a current of 0 mA which is not allowed. A low current can also be caused by a badly adjusted or defective transmitter.

- HIGH CURRENT
This may be caused by a badly adjusted or defective transmitter.

ANALOG-DIGITAL CONVERSION

- DIGITAL RANGE
The conversion of an analog signal to a digital signal is carried out in an A/D-converter. There are various types of converter:

1: FLASH: Ultra rapid.
2: SUCCESSIVE APPROXIMATION: Rapid.
3: DUAL SLOPE: Relatively slow.
4: Others.

Types 2 and 3 are the most commonly used, and type 2 more than type 3. The converter is normally 12 Bits, resulting in a digital range of 0 to 4095.

Many manufacturers make a conversion in the range of -25 to 125 % (equivalent to 0 to 24 mA). This range is 150% (= 125-(-25))%

The range which is used is only 100% Thus causing a reduction of the digital range to 0 to 2730.
2731 = 4096*100%/150%.

- RESOLUTION
The resolution is: 0.037% (= 100%/2731). A general rule is that physical measurements are considered acceptable in a range of 3 figures i.e., with a resolution of 0.1%, which is more than satisfactory.

DEFINITION OF THE PHYSICAL RANGE

The physical magnitude to be transmitted must be defined as a range, which could be:

1: from AA to BB: General
2: from 0 to 100 % Position of a valve
3: from 0 to 200 % Load of an electric motor
4: from 0 to 100 ºC Temperature
5: from -60 to 200 ºC Temperature
6: from 0 to 2.5 Bar Pressure
7: from 0 to 14 pH PH value

All of these ranges can be treated as a range of 0 to 100% or 4 to 20 mA.

- CONVERSION FORMULAS

There are two formulas for conversion between Physical Units (PU) and %, using the range in Physical Units from AA to BB:

$$PU \text{ to: } Y\ \% = \frac{(PU-AA)}{(BB-AA)} * 100\%$$

$$X\ \% \text{ to: } PU = \frac{X\ \%}{100\%} * (BB-AA) + AA$$

- RANGE versus RESOLUTION

It is important that the physical range is sufficiently covered by the measuring range. If this is not the case, the limitation of the signal may cause problems in control systems. If the range is too large, resolution will be lost.

PRESENTATION OF THE VALUE

All ranges may be represented as RELATIVE or ABSOLUTE. Relative means that the signal is x% in the range 0 to 100%, but in certain situations it is not relevant to speak of a relative measurement. For instance if we consider the case of a temperature in the absolute range -60 to 200 C, or, especially if the observer has a good idea of the absolute unit. A control valve opens to x% of its range of 0 to 100%. The load of a motor can be expressed equally well as a relative value, x% of 0 to 200% of its nominal value in kW. A relative representation generally contains more information than an absolute representation if the observer does not know the physical units of the measurement.

THE MODEL OF A LOOP

A typical analog loop consists of a power supply, a current generator and a resistor to measure the current, converted to a voltage.
(See the figure Analog Loop Model below).

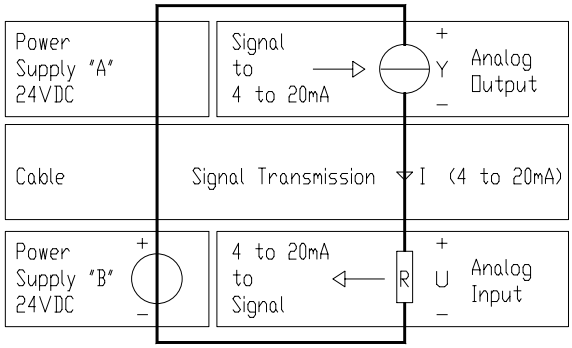
The figure has three levels:

1: The Transmitter (Current generator)
2: The Transmission Cable (Twisted Pair)
3: The Analog Input (A precision resistor)

1,3: A 24 VDC power supply is generally located together with the Process Control System (ie. the Analog Input).

A: In the case of 4-Wire transmitters, the transmitter itself contains a 24 VDC power supply (Power Supply "A" in the figure).

B: In the cases of 2- or 3-Wire transmitters, the central 24 VDC supply is used (Power Supply "B" in the figure).



Analog Loop Model

The resistor is normally a precision resistor of 100 ohm or 250 ohm, thus creating a respective voltage range of:

100 ohm: 0,40 a 2,00 V (with precision)
250 ohm: 1,00 a 5,00 V (with precision)

These values are obtained with a current of 4,00 to 20,00 mA, using Ohm's law:

$$U = R * I$$

The current generator has to operate in the voltage range: Y = 24 V - U:

100 ohm: 23,6 a 22 V
250 ohm: 23 a 19 V.

The ANALOG LOOP TESTER is able to operate in the range 15 to 50 VDC.

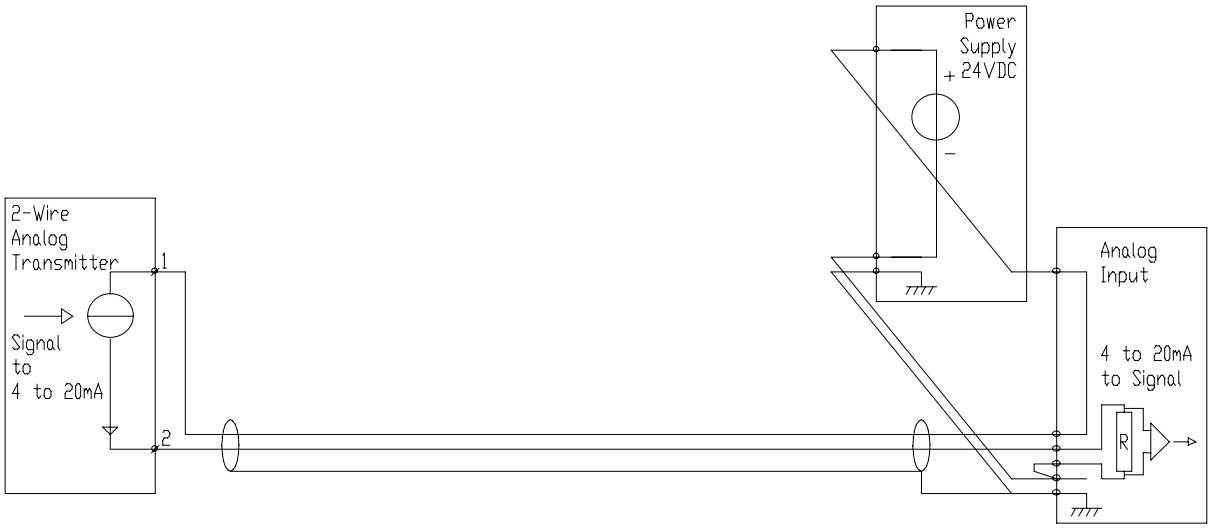
Use of the ANALOG LOOP TESTER

In the following analog loop diagrams, the loop can be tested with the ANALOG LOOP TESTER by only connecting the RED terminal to terminal "1" (+24 VDC), remove the wire from terminal "2" (The signal) and connect it to the BLACK terminal on the ANALOG LOOP TESTER, and ready to test.

NOTE: If you are sure that the terminals and wires you are touching are low power (or carry less than 50 Volt), you can not harm any equipment by connecting the ANALOG LOOP TESTER, - "Just try until it works".

The "2-Wire" ANALOG LOOP

The two wire configuration is used when the transmitter can be supplied from same voltage as is used for the analog input and its consumption is <= 4 mA. This is the case for many transmitters such as the ANALOG LOOP TESTER and temperature transmitters, position transmitters etc.



"2-Wire" ANALOG LOOP

The "3-Wire" ANALOG LOOP

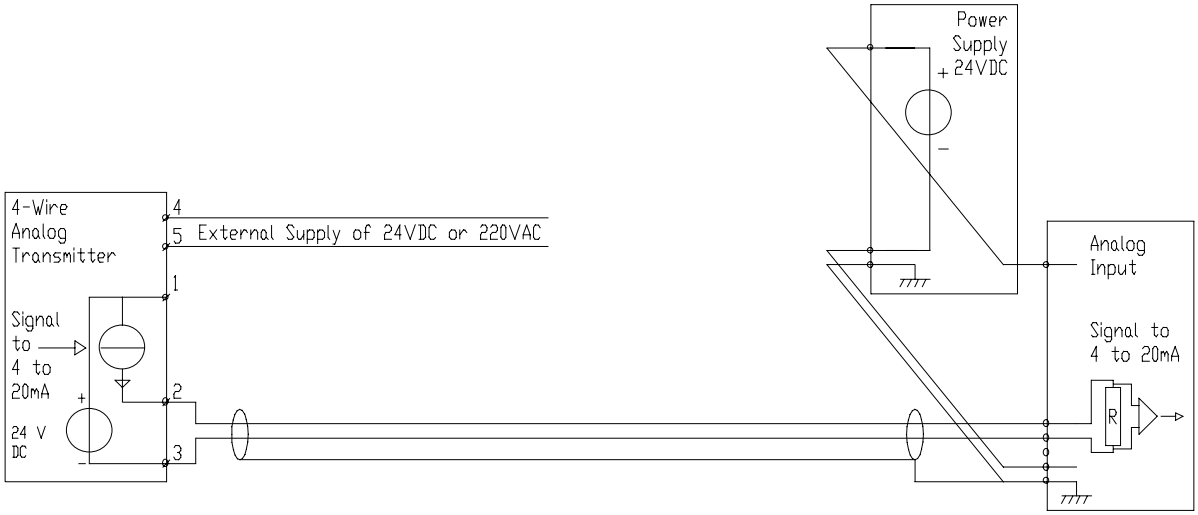
The three wire configuration is used when the transmitter is supplied with 24 VDC and consumes more than 4 mA. This is the case for many complex transmitters such as pH, level, pressure etc.

"3-Wire" ANALOG LOOP

The "4-Wire" ANALOG LOOP

The four wire configuration is used in a similar way to the three wire configuration, but generally has its own built-in 24 VDC power supply.

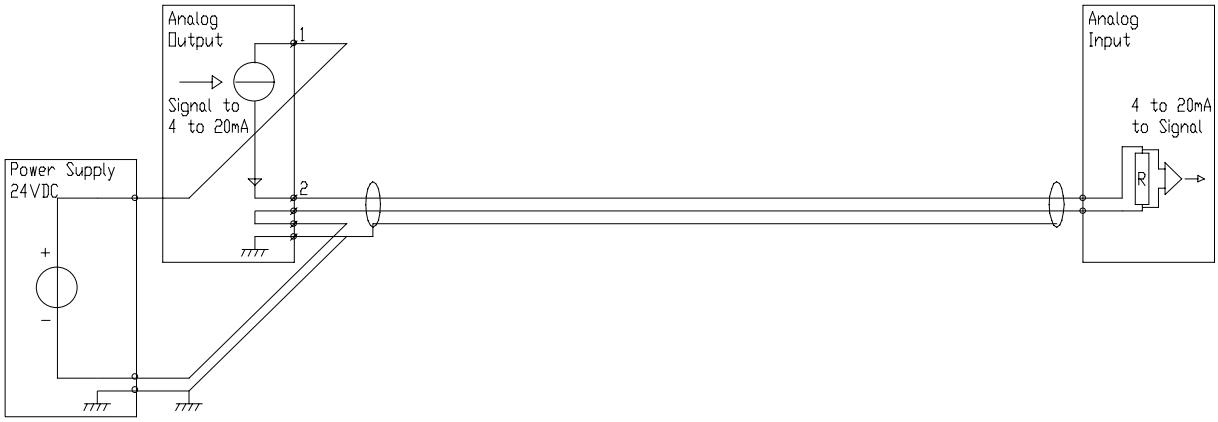
Note: Before testing with the ANALOG LOOP TESTER: Assure that terminal "1" exist and has +24 VDC with respect to terminal "3". If this is not the case: Insert an external 24 VDC supply from terminal "3" to the RED ANALOG LOOP TESTER terminal.



"4-Wire" ANALOG LOOP

ANALOG OUTPUT LOOP

The analog output loop configurations are similar to the 2, 3 and 4 wire analog input configurations.



ANALOG OUTPUT LOOP

TRANSMISSION CABLES

The cables used for the loop must be screened twisted wires (pair), with the screen connected only at one end of the cable. This point will normally be the central controller of the control system. The loop and the transmitter must be completely electrically isolated from the rest of the system.

TECHNICAL SPECIFICATION OF THE ANALOG LOOP TESTER:

PROTECTION
The ANALOG LOOP TESTER is protected against reverse polarity, overcurrent and overvoltage. The overvoltage protection will blow the 100 mA rapid fuse. The protection enters at 60 V. The fuse must be of the rapid type so as not to cause damage to the analog inputs in the event of an overvoltage.

STABILITY
The stability of the ANALOG LOOP TESTER's current generator is better than 1% for temperatures between 0 and 40 C. The stability is not dependent upon voltage variations.

DYNAMICS
The generator has a very high suppression of harmonics and electrical noise. The high frequency coupling is 100 pF in parallel with the current generator.

LINEARITY
The potentiometer and the scale have a typical tolerance of 2 %. The precision can be improved by using a multimeter in the loop.(scale 20 mA).

ADJUSTMENTS
THE ANALOG LOOP TESTER is adjusted from the factory. If a re-adjustment should be necessary, proceed as follows:

The adjustment of the ANALOG LOOP TESTER is iterative. There are two trimpots inside the case, one for the adjustment of 4 mA and the other for 20 mA. A multimeter with a range of 0 a 20 mA and a small screwdriver will also be needed. A circuit should be constructed as in the model of a loop, but replacing the resistor with the ammeter.

A: Turn the potentiometer to 0% = 4 mA, adjust until the ammeter shows 4 mA.

B: Turn the potentiometer to 100% = 20 mA, adjust until the ammeter shows 20 mA.

Repeat A, B, A, B, ... until the precision is not improved.

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