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» Product: SMT100

» Interface: 4-20 mA

» Application Note AN006

SMT100 4-20 mA tutorial

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Introduction

The SMT100 4-20 mA is a soil moisture sensor with a current interface (two wire loop powered transmitter). An analog current loop is often used in industry for process control but also common in agricultural and horticultural irrigation control applications. The main advantage of the current loop is that the loop can power the sensor and provides the measurement data at the same time using just two wires. Furthermore cable lengths can be very long since voltage drop along the wires does not affect the measurement accuracy as it may be the case with analog voltage output sensors. As an additional benefit cable faults like a break can be detected since valid current values are only between 4 and 20 mA. With a cable break current will drop to zero. A current loop has also a very high noise immunity.

Current loop principle

A typical 4-20 mA current-loop circuit is made up of three individual elements: a sensor with built-in current output (transmitter), a loop power supply and a receiver with built-in resistor. In loop powered applications, all three elements are connected in a closed series circuit (see Figure 1). The transmitter controls the current like a throttle valve. According to Ohm's law this current generates a voltage along the resistor R in the receiver which can be easily measured by a voltage meter or an analog to digital converter.

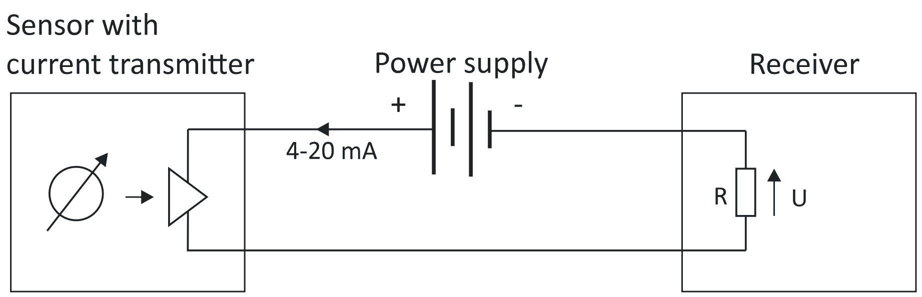

Figure 1

PLC (programmable logic controller) connection

In the simplest case the PLC already has a 4-20 mA input so that the SMT100 can be connected according to Figure 2 (please always consult the manual of your PLC). The brown wire of the SMT100 connects to the voltage output VDC and the white wire to the 4-20 mA input of the PLC. Please observe the supply voltage range of the SMT100 according to the datasheet. It is also required that at least 12 V are present at the sensor.

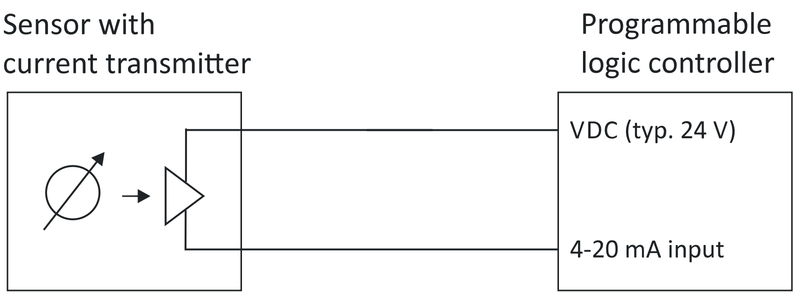

Figure 2: Current loop principle

In case the PLC is not equipped with a dedicated 4-20 mA input, standard analog voltage inputs can be used as shown in Figure 3. The brown wire of the SMT100 connects to the voltage output VDC and the white wire to the analog voltage input of the PLC (typically 0-10 V range).

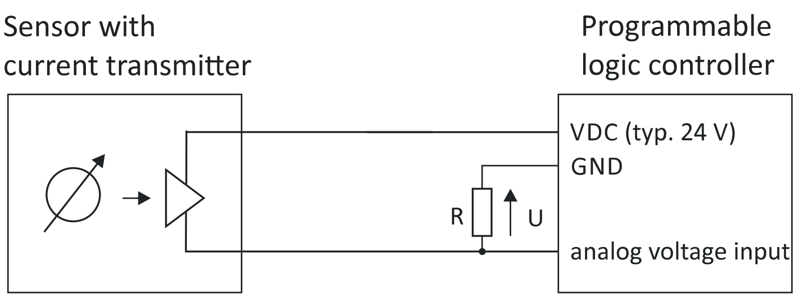

Figure 3: Current to voltage conversion

The external resistor R has to be selected carefully depending on VDC and the cable resistance. If the cable resistance can be negleced (for short cable lengths) then the maximum value of the resistor R can be calculated as follows (Table 1): Rmax = (VDC - 12 V) / 0.02 A

VDC	Rmax
13 V	50 Ohm
24 V	600 Ohm
30 V	900 Ohm

Table 1: Maximum resistor value vs. supply voltage

Of course the proper selection of the resistor R also depends on the input voltage range of the PLC. A typical example is a PLC with a 24 V DC power supply and an analog input voltage range of 0-10 V. The maximum current of 20 mA shall therefore convert into a voltage of U = 10 V. According to Ohm's law a 500 Ohm resistor is required. This leaves 2 V margin for voltage drop along the cable, respectively 100 Ohm at 20 mA current. The TRUEBNER TrueFlex cable has a copper wire cross section of 0.25 mm^2. This converts into a resistance of about of 0.15 Ohm per m (forth and back). So a maximum cable length of 100 m/ 0.15 = 667 m is achievable. Please always allow for some safety margin, since cable parameters have some tolerances. Using an input voltage range of 0-1 V (50 Ohm resistor) leaves 11 V for cable drop and therefore a maximum cable length of over 3 km in theory. Using a cable with larger copper diameter allows for even longer cable lengths. If the PLC has an analog input voltage range of 0 - 1 V then a resistor value of 50 Ohm is required and a 11 V margin for voltage drop along the cable is left.

The volumetric water content is related to the current as shown in Fig. 4.

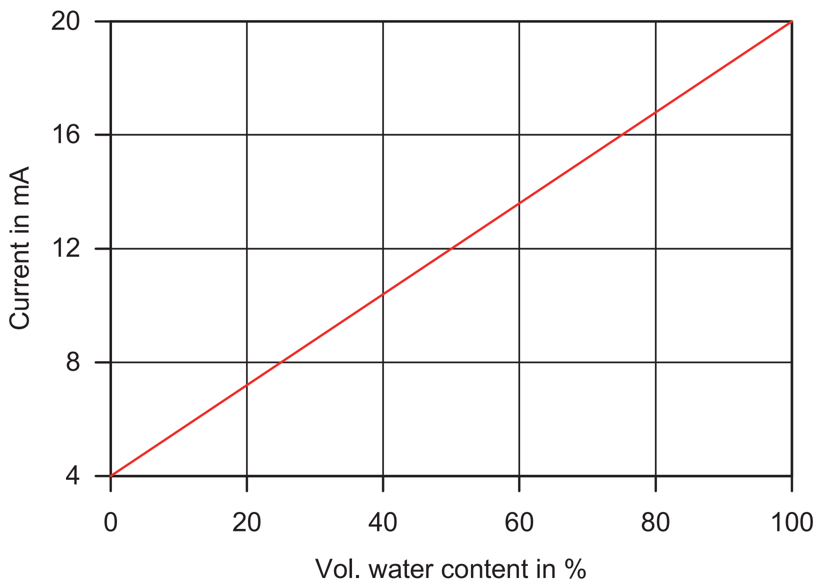

Figure 4: Relation between current and volumetric water content

The volumetric water content Vw can be calculated from the current I in mA as follows:

Vw = (I/mA x 6.25) - 25

E.g. I = 4 mA → Vw = 0%

I = 20 mA → Vw = 100%

If a 500 Ohm resistor is used then the volumetric water content Vw can be calculated from the measured voltage U in Volt as follows:

Vw = (U/V x 12.5) - 25

E.g. U= 2 V → Vw = 0%

U= 10 V → Vw = 100%