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DMS APPLICATION NOTE 21

4-20mA Current Loop Configurations and FAQ's

Introduction

As described in DMS Application Note 20, a current loop transmitter's primary function is to convert a sensor's output into a proportional 4-20mA current which can then be fed to a remote process monitor and/or controller. Transmitters are available with either floating outputs (typically used in loop-powered applications) or with single-ended outputs (typically used in locally-powered applications). This application note will describe the key differences between loop- and locally-powered configurations and depict some real-world schematics using DATEL's process monitors.

Selecting a Process Monitor

When upgrading existing applications, the choice of which process monitor type to use is normally dictated by the installed transmitter. For new installations, factors to be considered when deciding which type of transmitter and process monitor to select include the available supply voltage (usually +5V, +12V, or +24V), the desired display technology (LED or LCD), and the physical distance between the transmitter and process monitor (ranging from several inches to, at times, thousands of feet). Loop-powered devices, with their simple 2-wire hookup, usually require higher supply voltages but are preferred in applications involving a single supply and/or long wiring runs.

Process monitors which must be readable in direct sunlight should use LCD displays; whereas indoor applications can usually take advantage of an LED display's superior legibility. Outdoor applications that must also be viewable at night or in dimly lit areas should use locally-powered backlit LCD displays

Since loop-powered process monitors must function accurately with currents between 4 and 20mA, low-power liquid crystal displays (LCD's), similar to the type found in inexpensive hand-held calculators, have traditionally been the only type used in loop-powered process-monitors. However, the availability of super-efficient red LED displays, specially selected and driven by proprietary circuits, has allowed DATEL to offer the loop-powered DMS-20PC-4/20 Series, 3½ digit, LED-display process monitors. LED displays offer superior legibility, all-angle viewing, and can be viewed in either bright or dimly-lit environments.

If digit size is an important requirement, locally-powered LED-display process monitors—with their two individual power supply inputs—are the better choice. However, at the present time, large, super-bright LED's can not be adequately illuminated with currents much below 60mA. Because locally-powered process monitors' power consumption is not limited to the 4-20mA current circulating in the loop, they are readily available with large, 0.56 inch (14.2mm) high digits, super-bright LED displays.

Single-Ended, Locally-Powered Transmitters and Process Monitors

Figure 1 shows a 4-20mA transmitter driving DATEL's DMS-30PC-4/20S-24RL locally-powered, single-ended input, process monitor. As shown in the illustration, locally-powered process monitors have two power-supply input terminals and two current-loop input terminals. In most of these configurations, the supply (typically +24V) powers both the transmitter and the process monitor, with the low side of the

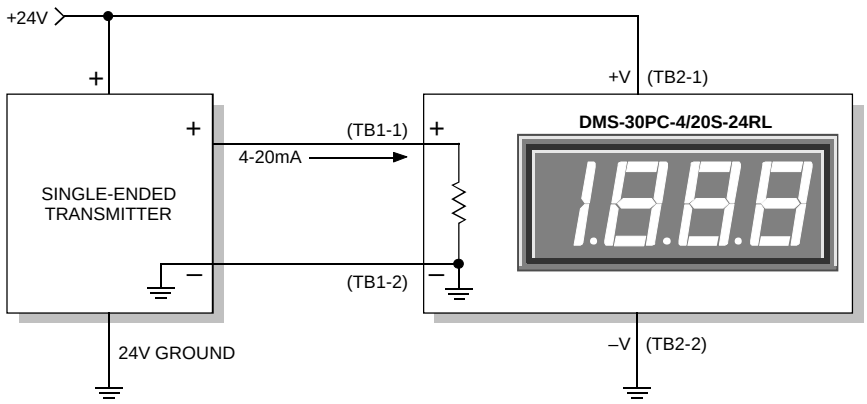

Figure 1. Typical Connections for Single-Ended Transmitters Driving Single-Ended +24V Powered Meters.

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transmitter's "–" terminal connected to the system ground inside the transmitter and process monitor. This type of ground-referenced transmitter and process monitor input/output configuration is commonly referred to as "single-ended".

Most single-ended input process monitors must be the first device in the loop, i.e., the device electrically closest to the transmitter's 4-20mA "–" output terminal since their "–" input terminal is internally tied to the system ground. Any additional devices in the loop must have their "–" 4-20mA input connection tied to the "+" terminal (TB1-1) of the DMS-30PC-4/20S-24RL.

The above requirement poses an important restriction on these additional loop devices in that they must either be powered from separate, transformer-isolated power supplies, or they must be floating loop-powered devices (described in next section). However, caution must be exercised when using a single-ended transmitter with a floating loop-powered process monitor. The transmitter must have enough output compliance to accommodate the additional voltage drop imposed by the loop-powered monitor.

Another option when using multiple series-connected process monitors and controllers is to use devices which provide built-in isolation between the loop current and the system ground. DATEL's DMS-30PC-4/20S-24RL-I and DMS-40PC-4/20S-24RL-I process monitors incorporate built-in dc/dc converters that effectively isolate the process monitors' loop-input circuitry from the +24V system supply. Figure 2 illustrates a typical wiring diagram for the DMS-30PC-4/20S-24RL-I.

Loop-Powered Process Monitors and Transmitters

Loop-powered 4-20mA input process monitors and transmitters, commonly referred to as "self-powered", obtain all of their operating power directly from the current circulating in the loop. These loop-powered devices are easily identified because they have only two input connections: a "+" input where the loop current enters, and a "–" input where the loop current exists. Loop-powered process monitors produce no drop in the magnitude of the 4-20mA current, but instead drop a voltage (or "loop drop") equal to their loop resistance (or "burden") multiplied by the instantaneous loop current. DMS Applicaton Note 20 covers the topic of loop drops in greater detail.

Series-connected loop-powered transmitters similar the one shown in Figure 3 modulate the two wires comprising their series loop with a 4-20mA signal which is directly proportional to the sensor's output. As is the case with single-ended transmitters, loop-powered transmitters also

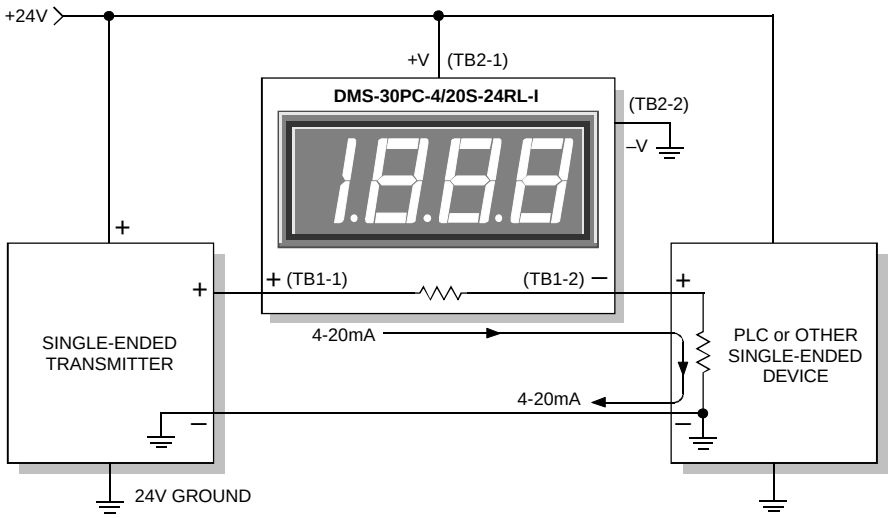

Figure 2. Typical Connection for Isolated-Supply Meters in Series with an Auxillary Device

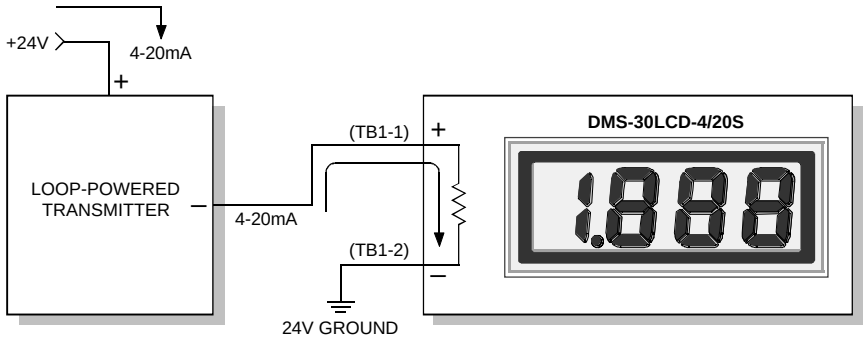

Figure 3. Typical Connection for Loop-Powered Transmitters Driving Loop-Powered Process Monitors

contain signal-conditioning electronics. However, unlike the single-ended types which could draw power from the full +24V supply, loop-powered transmitters must draw all of their operating power from currents as low as 4mA—a condition which limits their use to relatively low-power applications.

DATEL now offers loop-powered LCD-display process monitors which feature super-low loop drops: from the 2.9V drop of the DMS-40LCD-4/20 Series, to the 1.8V drop of the DMS-20LCD-4/20 Series. In most applications, these low loop-drops allow three or more process monitors to be used in a current loop that also uses a loop controller/PLC.

4-20mA FAQ's (Frequently Asked Questions)

Question: Why does my process monitor's display reading stay fixed at "000" as the 4-20mA signal is varied?

The most common cause for a process monitor not responding to changes in the loop current occurrs when a single-ended transmitter is driving two single-ended input process monitors (see Figure 4). The second process monitor's grounded negative (–) input effectively shunts the transmitter's output current around the first monitor, that is, no loop current passes through the DMS-30PC-4/20s-24RL's input circuit. The solution is to either power the second process monitor from an isolated dc power supply or use one of DATEL's "-I" isolated-power process monitors (see Figure 2).

Question: How do I hook up a +24V supply to a loop-powered DMS-20LCD-4/20S?

You don't! The two input terminals on DMS-20LCD/4/20S can only be connected to the modulated 4-20mA transmitter output current. The system power supply's two "+" and "–" output leads should never be connected directly to a loop-powered device's "+" and "–" input terminals; doing so will place the full supply voltage (sometimes in excess of 36Vdc!) across the monitor's input resistors. These input resistors typically measure less than 30 Ohms, and can easily be damaged by the resulting excessive power dissipation.

Question: What do the 'S', 'B', 'P' and 'I' 4/20 suffixes in DATEL's 4-20mA process monitor part numbers stand for?

The 'S', 'B', 'P', and 'I' suffixes in the 4/20 part number field are used to denote the monitor's display-readings capabilities. For example, the DMS-20PC-4/20S standard unipolar-reading model's gain and offset adjustments are optimized to display "000" with a 4mA input, and up to "1999" with a 20mA input. The DMS-20PC-4/2B bipolar reading model is designed to display a negative number with 4mA, "000" with 12mA, and a positive number with 20mA. The '4/20P' positive-reading model is optimized to display positive numbers with all inputs between 4 and 20mA.

The inverse-reading '4/20I' model is designed to display inverse readings, that is, a 4mA input will display a full-scale positive number, while a 20mA input will display "000". The '4/20I' model uses the same DIP-switch settings tables as its '4/20S' counterpart, the only difference is its full-scale and zero display-readings are reversed.

Question: How does ambient light affect the selection of a process monitor?

Process monitors which must be readable in direct sunlight should use LCD displays, while indoor applications can usually take advantage of an LED display's superior legibility. Outdoor applications that must also be viewable at night, or in dimly lit areas, should use locally-powered process monitors with backlit LCD displays.

At the present time, high-intensity LED's can not be illuminated adequately with currents much below 60mA. Therefore, if display legibility is an important requirement, locally-powered LED display process monitors are the better choice for indoor applications since their power consumption is not limited to the 4-20mA currents circulating in the loop.

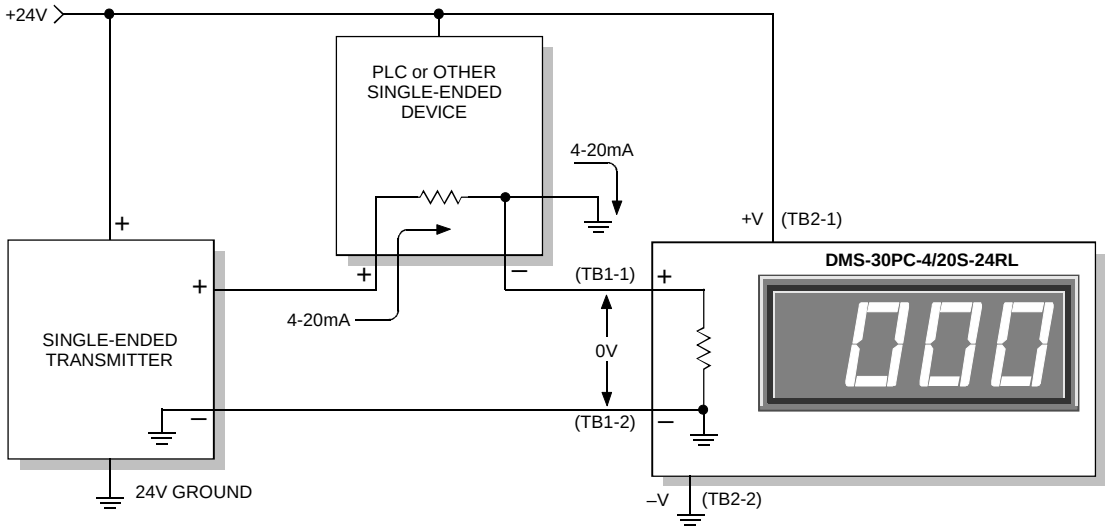

Figure 4. Where Did the Loop Current Go?

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