Using Smart transmitters in IS systems

TP1101
August 1991

R W Squires BSc, CEng, FIEE, MInstMC
(Technical Director, Measurement Technology Ltd)

Based on an article published in the September 1991 issue of 'Control and Instrumentation'

Introduction
The 4 to 20mA 2-wire transmitter has become a universal standard in the process industries, providing a solution which most have learned to apply without too many problems. Intrinsically safe (IS) versions, allowing use in hazardous areas, are available from a number of suppliers and the principles of applying these are also understood by most users. However, the development of 'Smart' transmitters which increase the amount of information available with improved operating flexibility has changed the situation as there is much less understanding of how to apply these devices. This is particularly true when hazardous-area use is involved. This article reviews the application of traditional 4 to 20mA transmitters, the characteristics of some of the 'Smart' transmitters now available, and discusses the solutions available from one manufacturer to allow them to be safely and easily used in IS applications.

Traditional 'analogue' transmitters
Interfacing to analogue transmitters in general purpose (non-IS) applications is well established and understood, as shown in figure 1. This provides a dc supply to power the transmitter and a series resistor to monitor the current flowing in the transmitter loop. The value of this resistor is now almost universally adopted as 250Ω, giving a 1 to 5V signal for receiving instruments. The signal level is high enough for the system to be relatively immune from interference and the loop is unaffected by changes in line resistance.

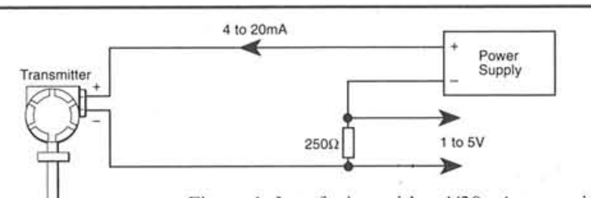

Figure 1. Interfacing with a 4/20mA transmitter (non–IS)

Only a few factors need to be considered for correct functioning of the 4 to 20mA loop:–

(i) Minimum transmitter operating voltage
(ii) Maximum transmitter rated voltage
(iii) Loop resistance (250Ω load resistor plus line resistance)

A simple application of Ohms Law will will establish whether the loop is correctly designed – although it is surprising how often this is overlooked! For example, a loop using a 24V power supply and with 50Ω line resistance will give a minimum voltage (at 20mA) of 18V across the transmitter. Therefore any transmitter with a minimum operating voltage up to this value (in practice this includes almost all transmitters) should operate satisfactorily.

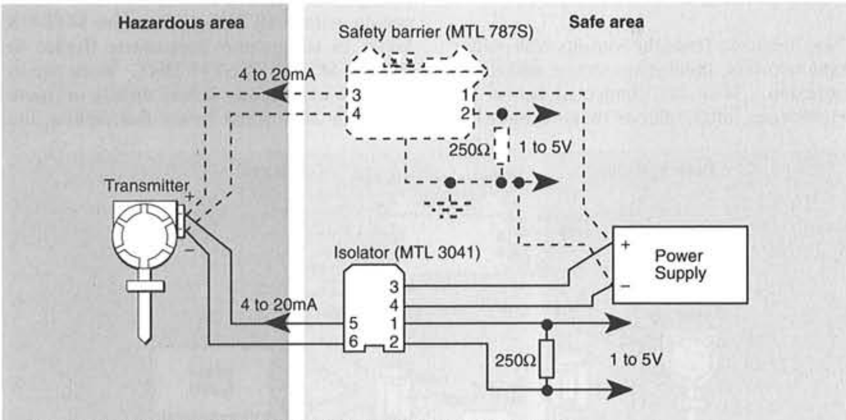

Figure 2. IS interfacing with a 4/20mA analogue transmitter

To use these transmitters in IS applications, some additional factors need to be considered (reference 1). A safety barrier or isolating interface unit must be included in the loop – as shown in figure 2. This device, together with the transmitter itself, must be suitably certified for the area classification and gas group appropriate for the application. Additional factors that must be considered are:–

(i) Compatibility of loop supply voltage with barrier working voltage.
(ii) Certified transmitter maximum voltage, current and power levels equal to or greater than those of the barrier or isolator.
(iii) Transmitter insulation voltage rating from earth needs to be ≥500V if a safety barrier is used.

Ohms Law must still be satisfied for the correct functioning of the loop. For example, in figure 2 the selected safety barrier operates acceptably with a supply voltage up to 26V, the voltage drop (outgoing and return channels combined) being 8.1V at 20mA. Hence, with a 25V supply and 50Ω of line resistance (equivalent to about 1200m of 18AWG cable for both channels) the system works adequately with transmitters with a minimum operating voltage of ≤11.9V. The barrier is BASEEFA certified to EN 50 020 as suitable for powering devices in Zones 0, 1, or 2 and IIC, IIB or IIA gas groups. It has a safety description of 28V 300Ω and a matched power of 0.65W. Therefore any transmitter used will need certification parameters at least equal to these of the barrier and must achieve the required insulation from earth.

The system in figure 2 using an isolator is similar in principle. One significant difference is that the isolator provides a guaranteed 17.5V minimum output to the loop at 20mA. Therefore the voltage available for the transmitter, with the same 50Ω line resistance, is increased to 16.5V at this current. This additional voltage allows users to add a certified local loop-powered display without any additional certification problems. For example, an MTL681 display drops less than 2V at 20mA. Since the hazardous-area terminals of the interface unit are isolated from earth, the transmitter is not required to meet specific insulation requirements for certification.

'Smart' transmitters
To those unused to applying intrinsic safety to transmitter loops the situation already described may seem complicated enough, but in practice it is relatively straightforward. However, the difficulties can become more formidable when the new generation of 'Smart' transmitters are used in IS applications. The benefits of these devices are well known and documented (references 2,3,4) and include easy reconfiguration, reduced maintenance cost and improved accuracy/repeatability through the use of digital technology. These benefits are achieved by the transmission of serial digital data using the 4 to 20mA signal loop, in many cases simultaneously with the analogue information. An increasing number of manufacturers now market such devices, but each uses proprietary signal levels, types and protocols, with little commonality. Any IS barrier or isolating interface unit must therefore be designed to accommodate the required digital signal levels and bandwidth in addition to the traditional analogue signal. Digital signals currently used to represent binary data include small amplitude frequency shift keyed (FSK) tones and current loop switching between 4 and 20mA.

The means by which users communicate digitally with a transmitter varies. Some generate and send the data to the transmitter from their distributed control system (DCS) which also decodes data received in return. Alternatively, a portable hand-held terminal (HHT) can be used to take advantage of the transmitter's facilities and flexibility with respect to reconfiguration, trouble-shooting and maintenance. An HHT can be used in the safe area, or directly attached to the hazardous-area loop wiring at the barrier/isolator, in field junction boxes, or at the transmitter itself, as shown in figure 3.

These devices, from the various transmitter manufacturers, themselves create additional confusion. Most are connected across the signal wires (although one manufacturer has chosen a series connection); some merely sink current from the loop whilst others source and sink currents. Many have no IS certification. A summary of signal types and levels adopted by some transmitter manufacturers, and the characteristics of their associated HHT, is given in Table 1. This information is by no means exhaustive but serves to illustrate the variety.

For users, it is obviously important to be able to integrate these transmitters into existing systems with as few interfacing problems as possible. Experience suggests that the most clearly defined and easiest to apply of all the proprietary signals is the HART (Highway Addressable Remote Transmitter) protocol introduced by Rosemount. This has now been adopted by a large number of equipment suppliers (currently more than 60 companies are registered users) and is co-ordinated through a HART User Group in which MTL is actively involved.

Newly announced IS certified devices which operate with HART protocol are the MTL418 Smart IS temperature transmitter (figure 4) and the MTL611/CNF41 HHT. Both the IS interface units shown schematically in figure 3 have a 28V 300Ω safety description and are designed to provide full analogue accuracy whilst transmitting digital data in either direction. These devices have been designed specifically to cater for Smart transmitters and will operate with any of the signals listed in Table 1, but suitability of the particular HHT units for hazardous-area use should be confirmed with the transmitter manufacturer. Both units offer the user the advantage of a wide range of power supply voltages (20 to 35V dc) whilst providing a guaranteed output voltage of 15V minimum to the transmitter loop. This ensures compatibility with a wide range of transmitters, together with suitable display devices when required.

The MTL611/CNF41 combination is certified as 'non-energy storing' at its loop connections, and can thus be added to almost any IS loop without needing further certification. A modified version of this combination is being developed for other HART compatible transmitter manufacturers to incorporate as an HHT for their particular devices.

Clearly, incorporating Smart transmitters in IS systems demands more thought than when more traditional versions are used. The variety of signal types and HHT units in existence means that the compatibility of these devices with the user's certification requirements and the intended IS interface unit must be more rigourously established. However, the solutions provided by one manufacturer make it possible to utilise the significant advantages of these transmitters while still keeping the application rules simple.

International fieldbus

The understandable desire to avoid the proliferation of numerous proprietary standards in the next generation of all-digital field devices is one of the driving forces behind continuing efforts by the IEC and the ISA to define an international standard fieldbus. This is proving a formidable task as the power and complexity of devices and systems increases. The author is involved in the standards activity at the Physical Layer level and MTL, through participation in the International Fieldbus Consortium (IFC), has provided IS interface units for the field trials, taking place in the USA, to prove the physical layer draft standard. However it would be optimistic in the author's view to expect commercial systems before 1995. In the meantime, the HART protocol would seem to provide a useful interim solution.

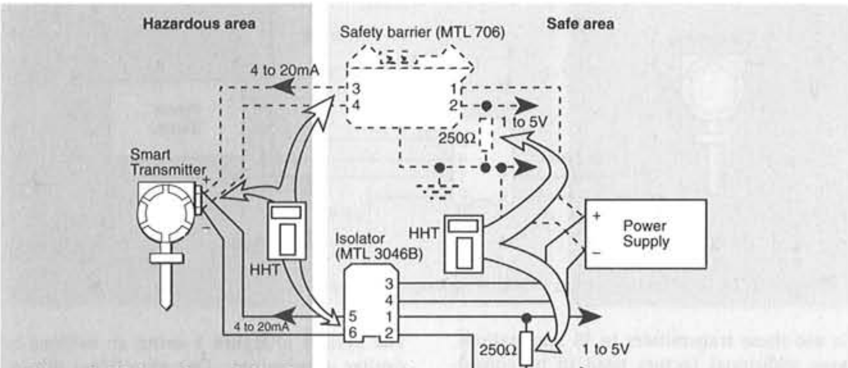

Figure 3. IS interface with a Smart transmitter

Figure 4. MTL418 IS Smart temperature transmitter

References:–

1. **Intrinsic Safety Rules OK for Process Instrumentation**, I C Hutcheon, *Measurement and Control*, May and June 1989
2. **The 'Hard Dollars' of Intelligent Transmitters**, *Control Engineering Supplement*, June 1990
3. **Smart Transmitters versus not so Smart**, Paul Sharrock, *Control and Instrumentation*, February 1991
4. **Transmitters wait on Fieldbus for next leap forward**, David Searle, *Process Industry Journal*, April 1990

Table 1: Typical Smart transmitter characteristics

Manufacturer/ transmitter type	Signal type	Signal levels Tx	HHT	Data rate (bits/s)	HHT IS certified	Simultaneous analogue and type digital transmission
Rosemount 3000 Series	FSK '0':2200Hz '1':1200Hz (HART protocol)	1mA pk-pk	0.5V pk-pk	1200	yes	yes
Honeywell ST 3000 Series	16mA digital pulse	4-20mA	0-16mA shunt current	218	yes	no
Foxboro 820 Series	FSK 5kHz/8kHz	1-2mA pk-pk	0.8V pk-pk	4800	no	yes
Chessell 3500 Series	Manchester encoded digital	0.8mA square wave	0-0.8mA shunt current	200	no	yes
MTL418	FSK ('HART' protocol')	1mA pk-pk	0.5V pk-pk	1200	yes	yes