

Proprieties of transmitters in function of dynamic changes of operation point of two wires measurement line in 4-20mA standard

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Abstract-In the paper the author refers to a common opinion about high immunity of current loop measurement and control line to interferences. That opinion is only theoretical. The author presents of some experiments results which are pointed out on limitations concern immunity to interferences especially to the two wire measurement line in 4-20mA standard.

1. Introduction

Development of microelectronics has resulted in a rapid growth of quantity of two wires transmitters in 4-20 mA standards. Even though they operate in an analogue standard the modern computer technology supports them. Transmitters can be divided into some classes: analogue transmitters which input, output and all interior signals are classified as analogue ones and transmitters which input and output signals are classified as analogue ones, but interior is supported by computer technology. In the last case transmitters can be divided into other groups, as transmitters which can be locally programmable with a simple keyboard or programmable with an outer PC. In both cases it is necessary to have a direct access to the transmitter. That inconvenience is eliminated in the next class of transmitters which are programmable with access only to the connection wires in almost any place with a hand held communicator or with a PC equipped with a special interface. In such a situation digital communication with transmitter is performed by putting a high frequency signal on the analogue output signal. That way of digital communication has been introduced by Rosemount and it is named HART protocol.

An additional factor that contributes to popularity of two wires line in 4-20mA standard is its relatively easy application in hazardous areas as an intrinsically safe realization. [1,3]

In spite of such huge popularity of two wires 4-20mA standard there is lack of proper description of all aspects connected with designing at the beginning and finally with operation on such systems. [1,2,3,4,5]

In the paper the author would like to point out the aspect of immunity of the two wires measurement line in 4-20mA standard to interferences and verify common opinion about inherent immunity of the current loop systems [1,2].

2. Two wires measurement line in 4-20mA standard

Two wires measurement lines in 4-20mA standard gives possibilities to perform measurements in wide area systems used in industry. Characteristic parameter of such system is a relatively long distance between the measurement point and the place of indicating measurement value. In such a situation the interference has easier access to the measurement system. The principle of the two wires measurement line can be explained in the figure 1. The transmitter converts measurement value X_i into the current I . In case when the relation between output current I and input value X_i is linear (such situation is most often) it can be expressed by formula 1:

$$I=aX_i+b \quad (1)$$

where current changes between 4-20mA, but parameters a , b depend on a span of the measurement value. The current passing by milliammeter X_o indicates the value according to formula 2

$$X_o=cI+d \quad (2)$$

where parameters c , d depend on a span of the measurement value.

Both formulas represent static proprieties of the measurement line. Information is sent from transmitter to indicator, but electrical energy moves in the opposite direction. Measurement line is powered from DC source of voltage which frequently is placed near the indicating system or is a part of the indicator.

The indicator in the figure 1 is symbolically presented as a milliammeter but actually it can be sophisticated and controlled by a computer system.

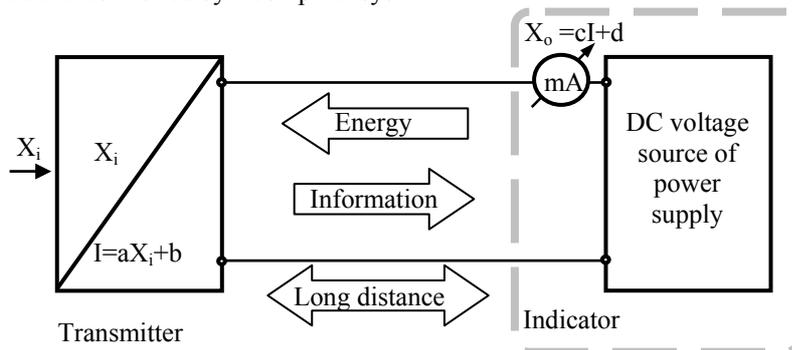


Figure 1. Functional block diagram of two wires measurement line in the standard 4-20 mA.

The electrical model of the measurement line is presented in the figure 2 as a loop of three series connected elements. The transmitter is presented by a source of current controlled by measurement value $I=f(X_i)$, power supply is presented by a DC source voltage U_{ps} and sum of all resistances between transmitter and DC source of voltage (interior resistance of indicator, wire resistance etc) is presented as a load resistance R_o [3,4,5].

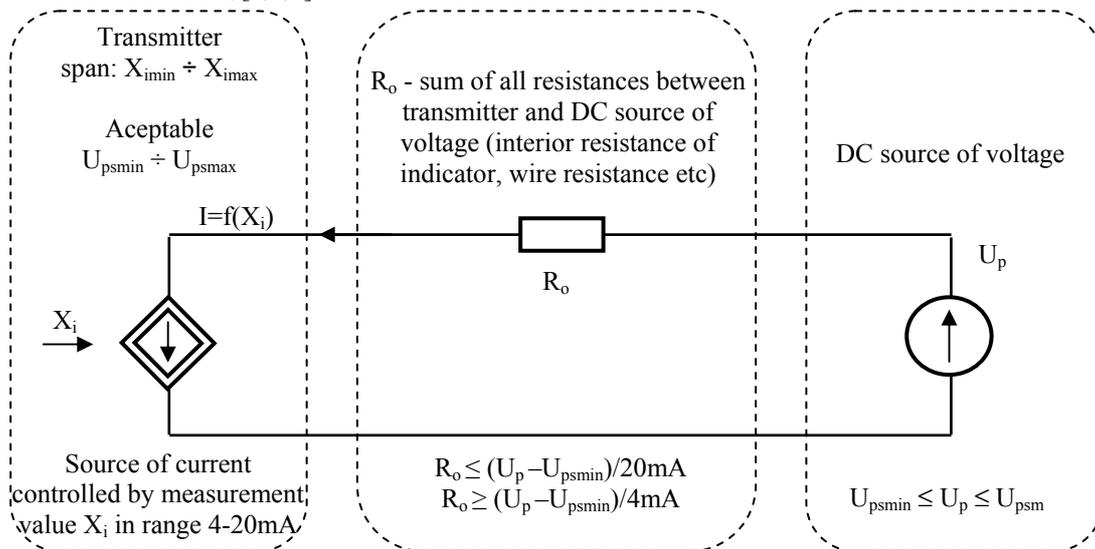
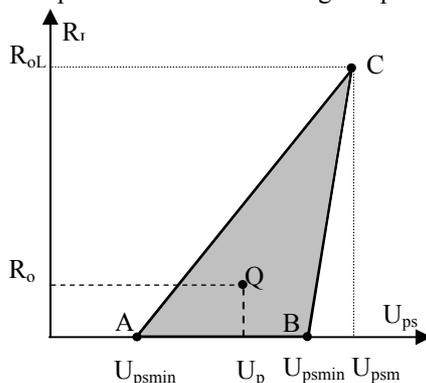


Figure 2. Electrical model of two wires measurement line in the standard 4-20 mA.

Such a simple electrical model in the figure 2 can be used to describe all the measurement lines, even in the most sophisticated systems. The measurement line under consideration can be also described by admissible area of operation in form of a diagram presented on Figure 3 [3].



Example values of parameters for transmitter with:
 $U_{psmin}=10V$ and $U_{psmax}=30V$
 are:
 $U_{psm}=35V$; $R_{oL}=1250\Omega$

Figure 3. Admissible area of operation of two wires measurement line in the standard 4-20 mA.

The admissible area of operation is specified by triangle ABC. Each practically accomplished measurement line can be described by two parameters: load resistance R_o and value of voltage from the source of power supply U_p . These two parameters point out point Q on the admissible area of operation. It is called a working point of the of two wires measurement line in the standard 4-20mA. For the measurement line correctly designed the working point Q has to be inside the admissible area of operation. Theoretically, the working point Q can change its position inside the admissible area of operation during measurement without any influence on the value of the loop current. It can be even stated that current controlled by transmitter (loop current) depends only on the input measurement value while the working point Q is inside the admissible area of operation.

Changing of the working point Q can be a result of changing load resistance R_o or value of voltage supply U_p or both. Actually, changing of load resistance R_o as interference phenomenon ought to be excluded. However, changing of the working point Q as a result of changing value of voltage in the loop is very probable. It can occur as a result of interference. These phenomena have been observed on wide area ships installation. Theoretically, following the above mentioned, the current loop should be invariable. In practice, some alterations of current have been noticed. The above observed phenomena inspired cycle of examinations of different transmitters to check their immunity influenced by outer interferences.

3. Test of the transmitters

Some examinations of different types of transmitters were done in order to determine an inherent immunity of a transmitter to outer interferences described as changing of the working point of the measurement line under consideration which is caused by influence of additional voltage in the loop. The examination system is presented in the figure 4.

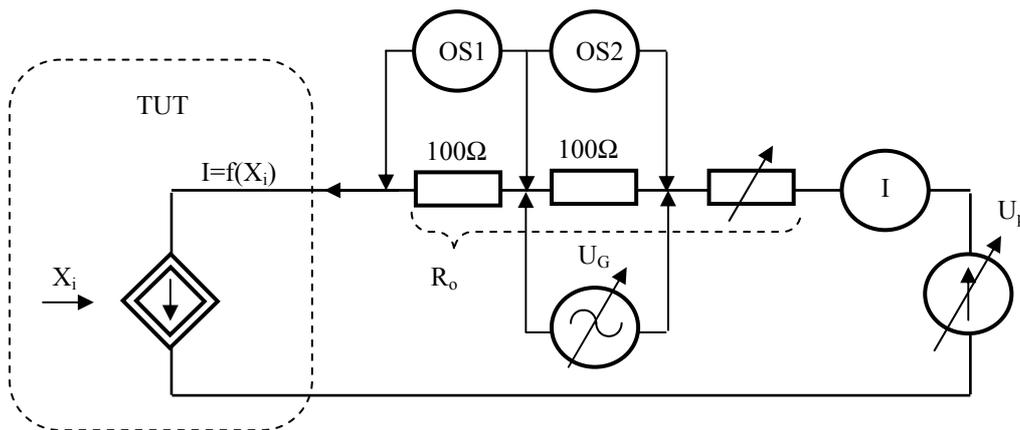


Figure 4. Measurement system for the examination of immunity of transmitters to interferences, TUT-transmitter under test, R_o - load resistance, U_G -generator of HF, U_p - voltage of power supply, I-dc current meter.

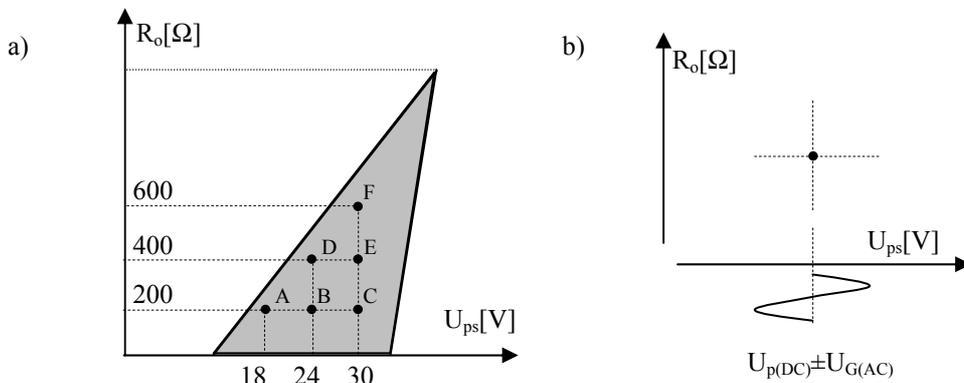


Figure 5. Testing points on the admissible area of operation; a) static positions, b) presentation of dynamic changes of working point around of the static position.

The programme of research included checking behaviour of transmitters by simulating dynamic changes of the working point in different parts of admissible area of operation of the two wire measurement line. The changes were forced by introducing additional alternating voltage from an outer generator U_G . The voltage was stable at the level of $2V_{pp}$. From one side the value of $2V_{pp}$ was chosen to assure sufficient dynamic changes of working point, and from the other side it continuously occurs into the admissible area of operation independently of type of transmitter under test. The frequency of the interference signal was regulated. Static testing points (A, B, C, D, E, F) are presented in the figure 5a. Dynamic changes of the working point around the static points are presented in the figure 5b. Estimating of the influence on interference was being done by measure of an ac current by scope.

3.1 Testing of transmitters for selected working points of the measurement line

Influence of the interference signal depending on the working point of measurement line was checked for some transmitters. Sample results are presented in the figure 6. All the examined transmitters are susceptible to influence of interference signal. The susceptibility depends strongly on the frequency of the interference signal. For relatively low frequency the interference signal does not depend on the place of the working point in the admissible area of operation. However, the dependence on the place of the working point was observed for relatively higher frequency.

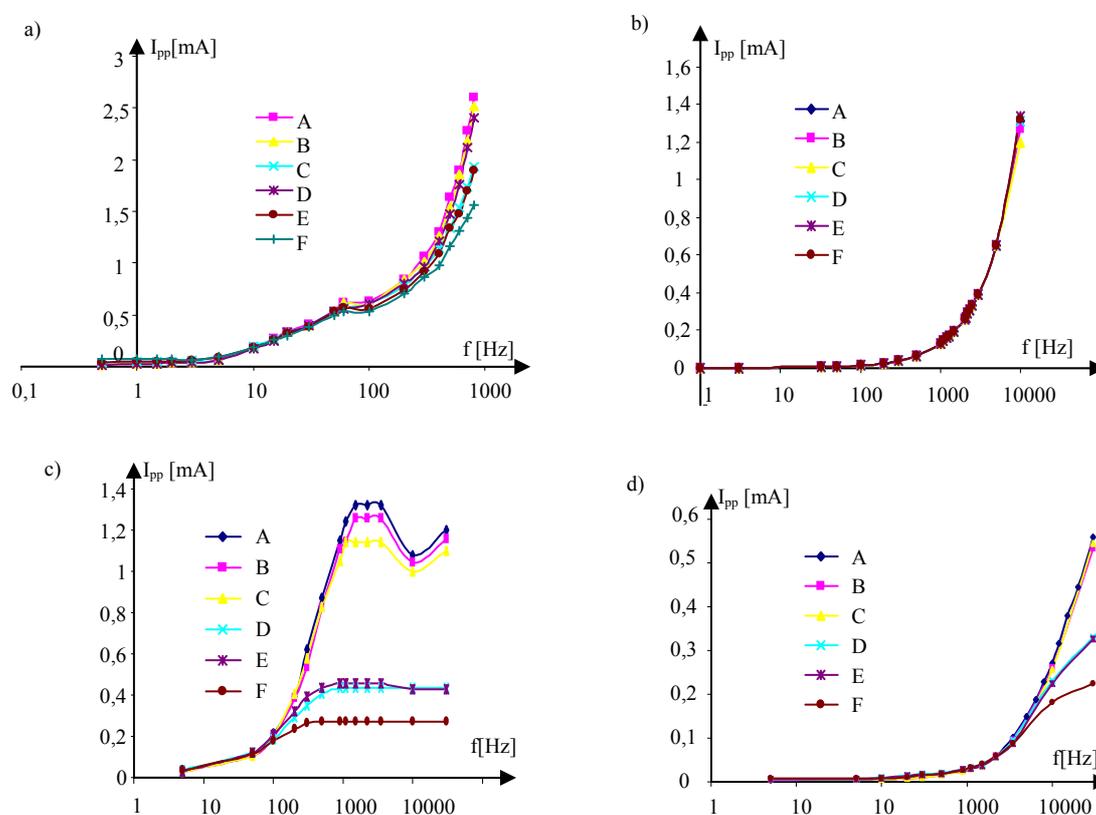


Figure 6. Influence of interference of $2V_{pp}$ on different types of transmitters for selected working points; a) Trafag 8106.01, b) Rosemount 3244MV, c) Rosemount 244PR, d) Autronika GT300.

In case of the programmable transmitter Rosemount 3244MV dependence on the place of working point was not observed, even for higher frequency. It is worth to notice that in case where dependence on the place of the working point was observed there was lower influence for a higher value of load resistance.

In order to compare the proprieties of the example results for the same static working point B for different types of transmitters are presented in figure 7. The level of 1% of span (16mA) was marked to make the comparison easier of the properties of different transmitters.

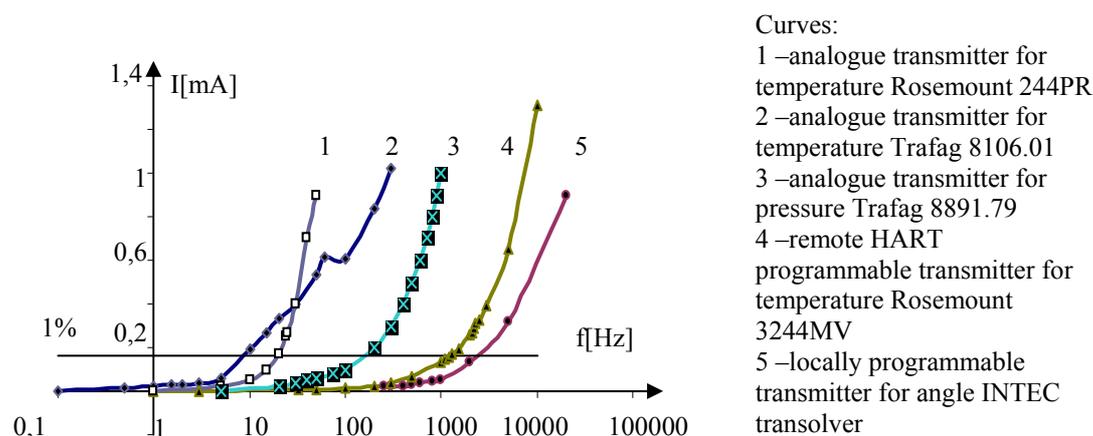


Figure 7. Influence of interference of $2V_{pp}$ on different types of transmitters.

As already mentioned above for all the tested transmitters a serious influence of the interference voltage has been observed. Generally analogue transmitters are more susceptible to influence of the interference then programmable ones. In most of cases the influence of the interference voltage was not registered by an indicator of the direct current, because the mean value of the current signal was equal to zero. However, in the case of the transmitter nr 2 a serious deformation of measured current was observed. The phenomenon introduces an additional measurement error because the mean value of disturbance current is different from the zero.

4. Conclusions

The common opinion about high immunity of current loop measurement and control line on interferences is too universal and only theoretical. Some test carried out on different transmitters of the two wire 4-20mA standard pointed out that the level of immunity depends mainly on the properties of the transmitters. Even though the transmitter works as source of current, it is thru only for relatively low frequency of interferences. For the analogue transmitters, which were tested, in case of frequency of interferences higher then 1-100Hz the influence on measurement loop current was noticed. The programmable transmitters are much more immune on the influence of disturbances then the analogue ones.

References

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