Protections of embededded system inputs

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Abstract: The paper reveals the solution for the protection of inputs and outputs of embedded systems and their mathematical description. These are the problems of galvanic separation, restrictions disturbing voltage, limit reduction of signals and signal verification of loaded value. They dealt galvanic isolators and limiters limit on another principle. The work compares different methods of input and output. Another part is a summary of methods for operations related to the evaluation of the accuracy of the capture inputs before further processing. Other parts of the thesis is a mathematical description of the behavior of protection of inputs and outputs. to find the causes of nonlinearity limit limiters and analog galvanic isolators. The linear optocouplers are designed to the partial non-linearity caused by the method used and participation components.

The research work was performed to financial support of grant reg. No IGA/32/FAI/11/D.

Key-Words: - inputs protections, linear optocoupler, protection of analog signals, Strejc identification method, embedded system

1 Introduction

Digital and analog inputs of embeded systems are very sensitive to power surges. The normal maximum repeatable value of the input voltage is 1.1 times the microprocessor supply voltage max. Both because of interference, so the possibility of error when connecting, for example, affixing a higher level of voltage, these inputs must protect against this surge.

Problem of the protection of analog signals is maintaining the linearity and stability of the surge when time-varying signals are used. Three types of circuits were selected. Linear optocoupler IL300 is used in the first circuit, programmable voltage reference LM431 is used in the second circuit with behaving as an ideal zener diode and the third circuit is using the typical Zener diode for comparison. For these purposes test module was created on which all three above mentioned circuits were placed. This paper describe find the causes of static and dynamic nonlinearity limit limiters, analog galvanic isolators and their mathematical description.

2 Problem Formulation

2.1 Static input / output characteristics measurement

Static input / output characteristics measurement is a helpful method for find static characteristics like a gain and saturation voltage these three circuits. Next reason is a verification linearity and circuits behaviours. Measurements were carried out using the following equipment and software using VEE Pro 9.0, which established a program for this measurement. The input voltage was chosen in the range of 0 to 5.1V. Step input voltage was 10mV. Waiting time between samples was chosen as 0.2 s were sufficient to fully stabilize the input voltage. Supply voltage of both the power supply circuit IL300 was 5.01 V. Measurements were repeated 10 times for each input voltage from 0 to 5V. Circuit with the TL431 was set to limit voltage 2.95V. Zener diode according to the manufacturer for voltage 3V.

2.1.1 Used equipment

Multimeters Agilent 34410A were connected to a computer via USB. Agilent E3632A Programmable source was connected to a computer via GPIB and GPIB converter / USB.

• Programmable input voltage source Agilent 3632E
• Voltmeter "D" Agilent 34410A to measure the input voltage
• Voltmeter "A" Agilent 34410A to measure the circuit with IL300 output voltage
• Voltmeter "B" Agilent 34410A to measure the circuit TL431 output voltage
• Voltmeter "C" Agilent 34410A voltmeter to measure the input circuit with Zener diode voltage circuit

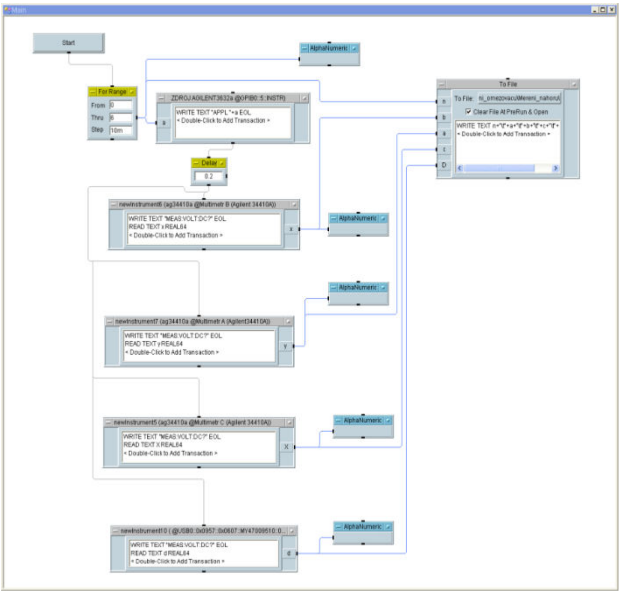

Fig. 1 Program in VEE Pro 9.0 for the automatic measurement

2.1 Dynamic input / output characteristics measurement

Dynamic input / output characteristics measurement is a method for find dynamic characteristics. Circuit inputs are connected to known time-varying DC signal. Signal from the generator was plugged to one oscilloscope channel input and tested circuits outputs were connected to next tree oscilloscope inputs and circuits outputs signals are compared with signal from generator. The maximum voltage was set lover than saturation voltages of these circuits. Testing signal was used the square wave signal. Measurements were carried out using the following equipment. The testing signal frequency was 20 kHz. This frequency is sufficiently for this measurement.

2.1.2 Used equipment

• Agilent 33220A Function / Arbitrary Waveform Generator, 20 MHz as source of signal
• Agilent DSO6104A Oscilloscope: 1 GHz, 4 channels
• 3x N2862A Passive Probe, 10:1, 150 MHz, 1.2 m

Probes were compared and set to same gain.

2.2 Strejc identification method

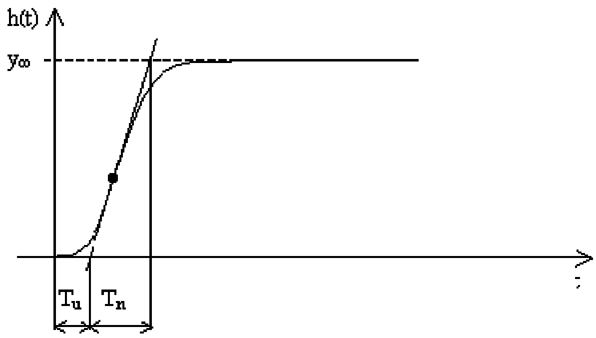

Fig. 2 The aperiodic step response with displayed a rise time and a delay time

If the step response of the controlled system has an aperiodic train, we can approach it by a second order proportional plant with a different time constants or by a nth order proportional plant with a same-time constants. The choice of the type of the

model's plant is dependent on a parameter τ, which is computed as:

$$\tau = \frac{T_u}{T_n}$$

where: T_u – delay time, T_n – rise time

If the parameter τ is smaller than 0.1, we choice the proportional plant with a different time constants, else we choice the proportional plant with same-time constants

ISBN: 978-1-61804-004-6

$\tau<0.1$ => aproximujeme přenosem ve tvaru: $G(s)=\frac{K}{(T_1s+1)\cdot(T_2s+1)}$

$\tau\geq0.1$ => aproximujeme přenosem ve tvaru: $G(s)=\frac{K}{(Ts+1)^n}$

3 Problem Solution

Test module was created on which all three above mentioned circuits were placed. For circuit with linear optocoupler IL300 connection was used same schematic as in datasheet for IL300. Circuit with programmable voltage reference LM431 is used in the second circuit with behaving as an ideal zener diode. Saturation voltage was set to 2.9V. Circuit with common zener diode is used only for comparison.

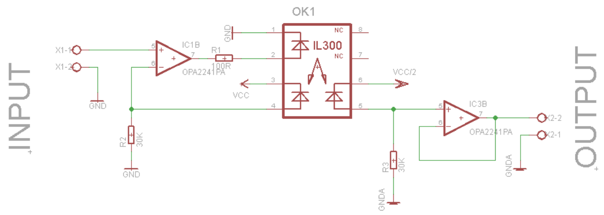

Fig. 3 The circuit schematic used: a) with IL300 linear optocoupler

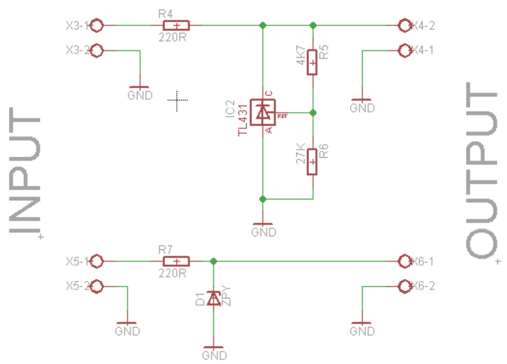

Fig. 4 Circuit schematics used: b) with the voltage reference LM431 circuit, c) with the common Zener diode

3.1 Static input / output characteristics measurement

The first step it was measured input/output characteristic. It was used the DC voltage on all inputs of these three circuits which were tested. The input voltage was chosen in the range of 0 to 6 V. The step input voltage was 10mV and measures were repeated ten times.

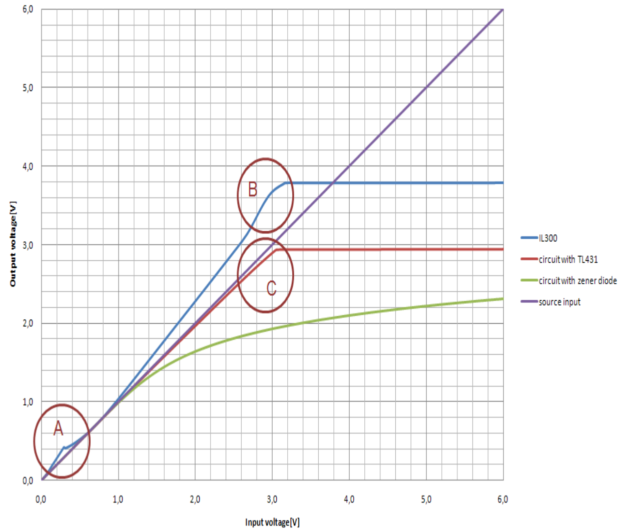

Fig.5 Static Input / Output characteristics of measured circuit

Circuit with a linear optocoupler IL300:
The resulting characteristics show several nonlinearities (area "A", "B") and the resulting deviation from the input voltage is determined by the increased gain of operational amplifiers, which can remove the appropriate circuit connection. R_3 was set from 30kΩ to 21.8kΩ
Circuit to circuit TL431:
The resulting highly linear characteristic and the resulting deviation from the input voltage
(Area 'C') are caused by from their consumption of the circuit and current through resistors R5 and R6.
Zener diode circuit:
As evident from the chart below, the Zener diode circuit has poor properties and it is listed here only for a comparison.

3.2 Dynamic input / output characteristics measurement

The second step it was measured input / output dynamic characteristics. The testing input signal was used the square wave signal. The testing signal frequency was 20 kHz and the duty cycle was 50%.

ISBN: 978-1-61804-004-6

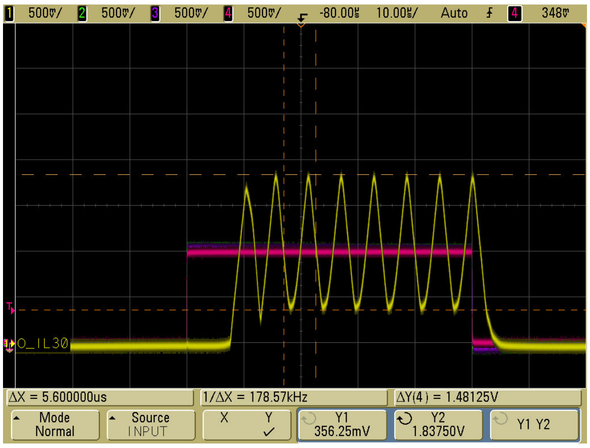

Fig. 6 The input / output dynamic characteristic

As can be seen in Fig. 6, there was a very high oscillation. It doesn't make any differences if amplitude or frequency of the input signal was changed. Same oscillation on the same amplitude and frequency is also when the DC invariable input was used. The oscillation frequency was 178.6 kHz and the amplitude was 1.49 V. When 1 nF capacitor was added to the input operational amplifier negative feedback, the oscillation was removed.

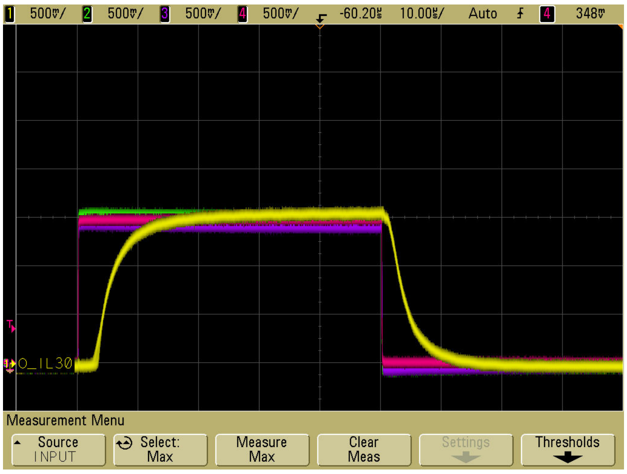

Fig. 7 The input / output dynamic characteristic after the intervention to circuit

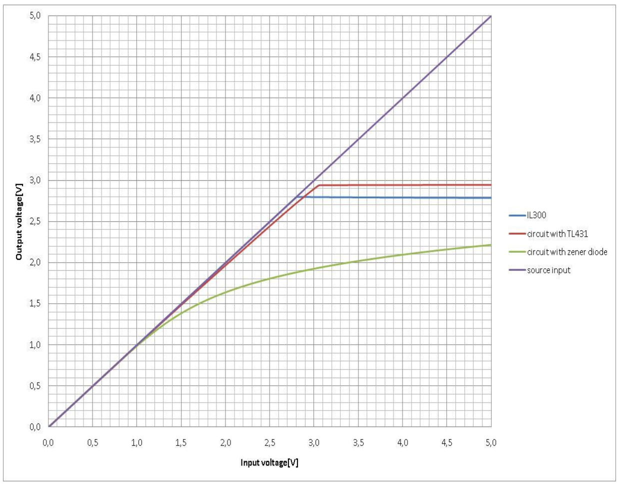

Fig. 8 The static input / output characteristic after the intervention to circuit

Figure 8 shows the static input / output characteristic after the intervention to circuit. It is evident from figure hereinbefore output signal from circuit with IL300 strictly imitates that of input signal from generator.

3.3 Circuit with IL300 identification

As is evident on figure 8 output from the circuit with I300 has the aperiodic train, therefore it would be used the Strejcs identification method. In this case after the step change of the signal follow a insensitivity zone which has a duration 2.35 µs. It stands to reason the insensitivity zone does not depend on input frequency. It was used the Strejcs identification method for identification. $\tau<0.1$thereby It was chosen the transfer function with different time constants. Resulting transfer function of the circuit with IL300 is in the form

$$G(s) = \frac{K}{(0.8698s + 1) \cdot (1.615s + 1)}$$

Simulation in the Matlab was done and hereinbefore curves strictly imitates that of the output signal from circuit with IL300.

4 Conclusion

For measure static input/ output characteristics was created the program in the VEE 9.0 PRO. Principles for find dynamic characteristics another protections of inputs and outputs were described and

ISBN: 978-1-61804-004-6

demonstrated on found circuit with IL300 behavior and mathematical description.

Another part of the work in the next period is a mathematical description of the behavior of another protections of inputs and outputs.

5 Acknowledgements

This work was supported in part by the Ministry of Education of the Czech Republic under grant MSM 7088352101 and in part by Tomas Bata University in Zlin under grant IGA/32/FAI/11/D.

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