DESIGN NOTES

Measuring 18 2-Wire RTDs with the LTC2983

Design Note 1035

Tom Domanski

Introduction

A single LTC®2983 temperature measurement device can support up to 18 2-wire RTD probes, as shown in Figure 1. Each RTD measurement involves simultaneous sensing of two voltages developed across R_{SENSE} and the RTD probe RTDx due to the current I_S. Each voltage is sensed differentially, and given the LTC2983's high common mode rejection ratio, the number of RTDs in the stack does not adversely affect the individual measurements.

The choice of the RTD probe depends on the system accuracy and sensitivity requirements. For example, given that 2-wire probes are used, the PT-1000 may prove more robust in the presence of wiring's parasitic resistance.

Once the RTDs are selected, I_S and R_{SENSE} should be chosen so that voltage at the top of the resistor stack (V at the CH1 input) does not exceed the input common mode limit of the LTC2983 over the operating temperature range of the system. This requirement is expressed as:

$$V_{DD} - 0.3 \ge \left(R_{SENSE} + \sum_{i=1}^{N} RTD_i \right) I_S,\ N = 1,2\ldots18$$

Consider the system shown in Figure 1 and assume the following constraints: 5V supply rail, all RTD probes are PT-100, and the maximum expected temperature measurement is at 150°C. Table 1 shows the channel assignment word for each one of the PT-100 probes. Consult the "Channel Assignment Memory Map" in the LTC2983 data sheet. Note that in this example CH3 senses the RTD1 probe, CH4 senses RTD2, etc.

Table 1. CH2 Through CH20 RTD Channel Assignment Word

FUNCTION		BIT FIELD	VALUE	DESCRIPTION
Sensor Type		31:27	01100	PT-100
Sense Resistor Channel Pointer		26:22	00010	CH2
Sensor Configuration		21:18	0001	2-Wire
Excitation Current		17:14	1000	1mA
RTD Curve		13:12	01	American Curve
Custom RTD Data Pointer	Address	11:6	000000	NA
	Length	5:0	000000	NA

The sense resistor, connected to CH2, is configured as shown in Table 2.

Table 2. Sense Resistor Channel Assignment Word

FUNCTION		BIT FIELD	VALUE	DESCRIPTION
Sensor Type		31:27	11101	Sense Resistor (29)
Sense Resistor Value	Integer	26:10	000000 1111101000	1kΩ
	Fraction	9:0	0000000000	

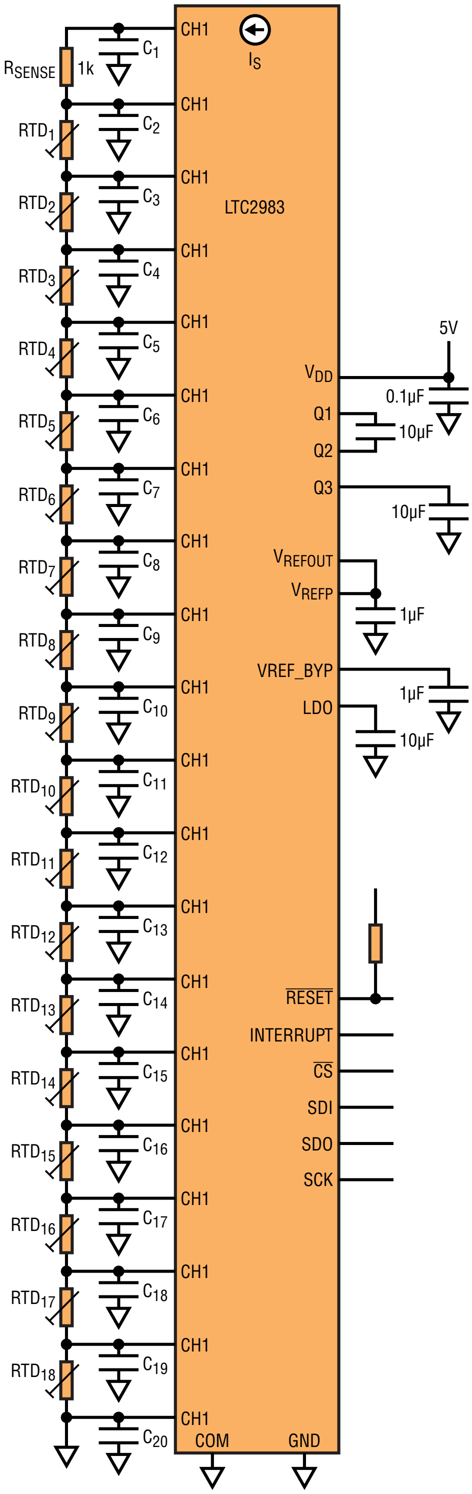

Figure 1. LTC2983 with 18 RTD Sensors

RTD Stack Settling Time

Once the excitation current source is enabled, it takes a finite amount of time for the R and C chain to settle. That is, the settling time, t_S. t_S is dependent on the number and value of the individual resistors (R_{SENSE} and RTDs) and capacitors at each input node. The upper bound on t_S can be estimated by lumping the total RC, but that yields an overly pessimistic result. Another method to obtain t_S is to simply simulate a circuit as shown in Figure 2:

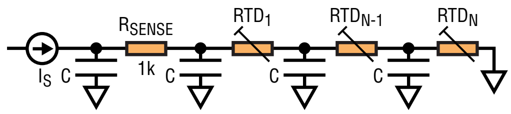

Figure 2. Delay Line Model of the RTD Stack

The results of simulation are shown in Figure 3. Here all capacitors are chosen to be 100nF, and R_{SENSE} is 1k. Each line represents settling time t_S to within 0.1% of the final value of the voltage across last RTD in the stack. For each graph, all RTDs are of the same type.

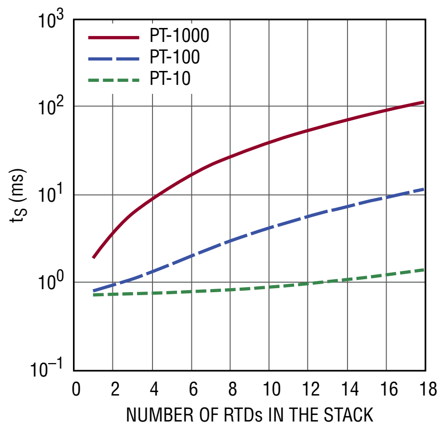

Figure 3. Simulated Settling Time of the RTD Stack

The LTC2983, by default, inserts a delay time t_{DELAY} = 1ms between enabling the excitation source and the beginning of the ADC conversion. This, however, is insufficient for any more than two PT-100 probes in the RTD stack (see Figure 3).

The t_{DELAY} may be increased by setting the value in the MUX configuration register, 0x0FF. By default the register is cleared. Each LSB added to the register value represents 100µs added to default t_{DELAY}. Consult the "Supplemental Information" section in the data sheet for more detail on the MUX delay. For example, writing 0x10 into 0x0FF results in:

$$t_{DELAY} = 1\text{ms} + 0\text{x}10 \bullet 100\mu\text{s} = 2.6\text{ms}$$

Note that the maximum value of programmable delay is 26.5ms, which is sufficient for settling of at most six PT-1000 devices, given the C = 100nF. See Figures 3 and 4.

The t_{DELAY} is inserted prior to each individual ADC cycle. Each RTD measurement consists of two ADC cycles. Therefore the total conversion time of the stack of RTDs is approximately:

$$t_{TOTAL} = (2t_{DELAY} + t_{CONV})N$$

Where t_{DELAY} is programmable by the user, t_{CONV} is given in the "Complete System Electrical Characteristics" table in the data sheet, typically 164ms including the default MUX delay, and N is the number of RTDs to be measured. t_{TOTAL} is summarized in Figure 4.

Conclusion

The LTC2983 can interface to as many as 18 2-wire RTD probes, but be sure to take into account the settling delay incurred by RC systems. The issue may be exacerbated by the number and type of RTD probes used. The delay issues can be examined using the model and simulation presented here.

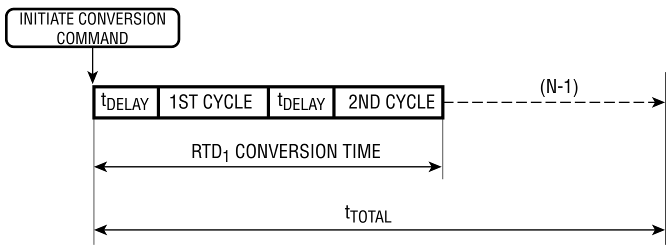

Figure 4. Total Conversion Time of the RTD Stack

Data Sheet Download

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Linear Technology Corporation
1630 McCarthy Blvd., Milpitas, CA 95035-7417
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