AND8426/D

Programming the Hysteresis Voltage Of Universal Voltage Monitors MC34161, MC33161 and NCV33161

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APPLICATION NOTE

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Device	Application	Input Voltage	Output Power	Topology	I/O Isolation
MC34161 MC33161 NCV33161	Universal Voltage Monitor	N/A	N/A	N/A	N/A

Circuit Description

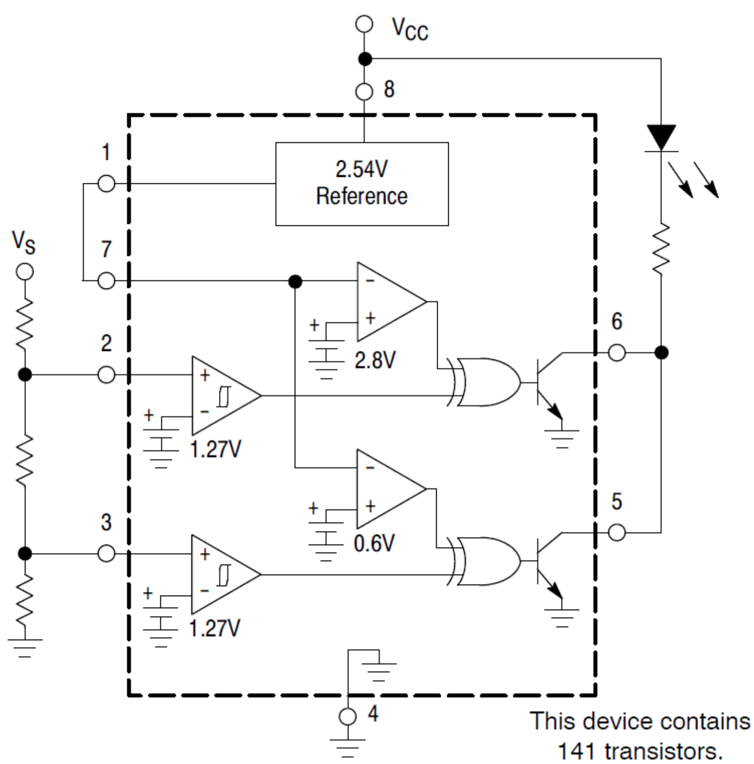

Figure 1. General Block Diagram of MC34161/MC33161

The Figure 1 shows the basic block diagram of MC34161/MC33161. It can be used for wide variety of voltage sensing application. They offer the circuit designer an economical solution for positive and negative voltage detection. The circuit consists of two comparators with hysteresis, a unique mode select input for channel programming, a output of 2.54 V reference, and two open collector outputs capable of sinking in excess of 10 mA.

Most of the comparators for the voltage monitoring provide hysteresis which is used for reducing the sensitivity to noise or a slowly moving input (low slew rate) signal. From the information of MC34161/MC33161 datasheet, the hysteresis is fixed to around 25 mV typically. However, this hysteresis value may not be enough for some applications for reducing the sensitivity to noise or comparator input voltage fluctuation. For example, at the automotive application, the noise level or voltage fluctuation (divided down to comparator input) may be as high as 300 mV − 400 mV during system operating. Therefore, a comprehensive and easy way to increase the hysteresis is definitely a need for the MC34161/MC33161 application under high noise level.

This document demonstrates the steps to show how to program the hysteresis voltage. And also, simulation results together with laboratory bench test verification will be shown.

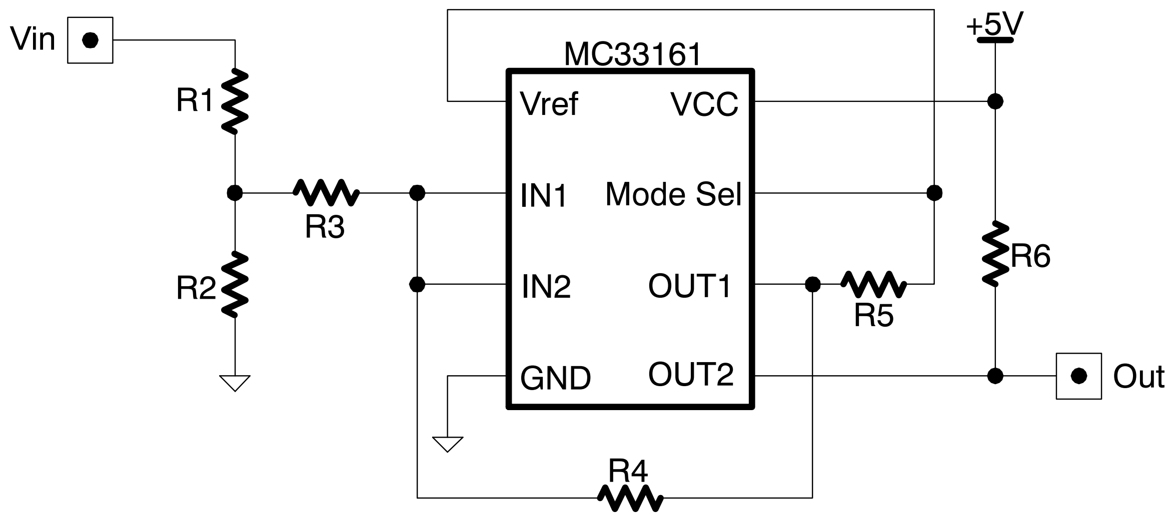

Figure 2. Schematic for Programming the Hysteresis Voltage

The configuration in the Figure 2 shows the circuit schematic for programming the hysteresis voltage. Basically, the hysteresis can be adjusted by varying R2, R3 and R4. Moreover, R1 and R2 are also used for the purpose of dividing down the external V_{IN} voltage. As mentioned before, R2, R3 and R4 can affect the amount of hysteresis voltage, it is necessary to find the easy way for the user to set the hysteresis voltage to fit for his own application. For R5 and R6, for typical application it sets as R5 = 200k and R6 = 10k.

From the circuit simulation result, it is found that R3 variation (fix R1, R2 and R4) can provide very good linear relationship with hysteresis voltage and Figure 3 depicts it:

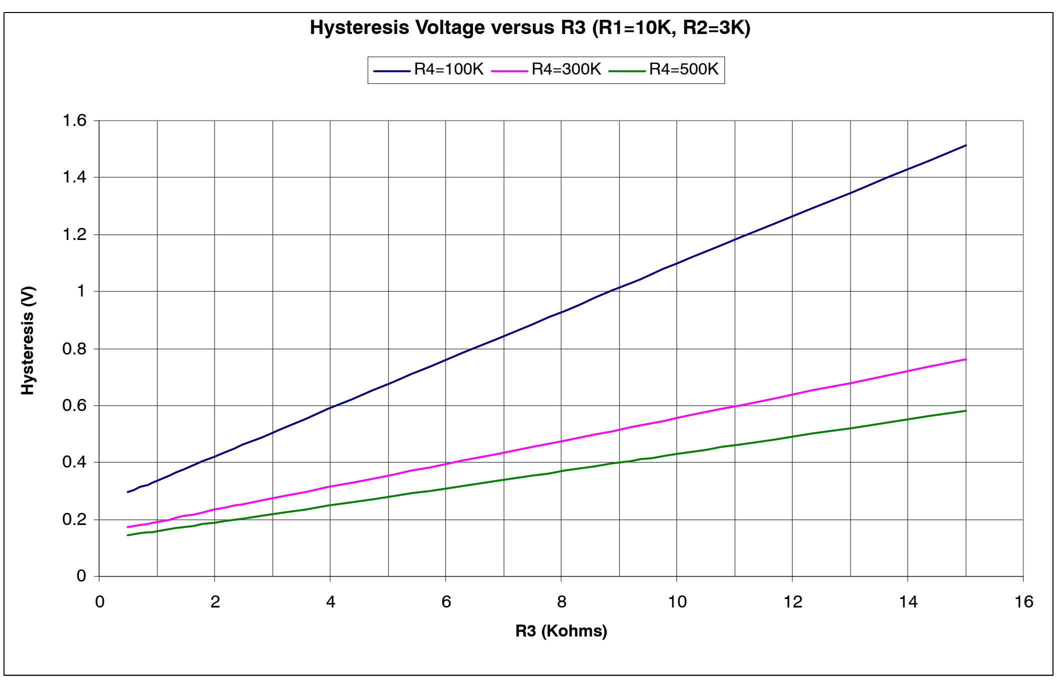

Figure 3. Chart to Show the Linear Relationship Between R3 and Hysteresis Voltage

For given V_{IN+} and ΔV_{IN} (i,e. Hysteresis Voltage) with fixed R2 and R4, we are required to evaluate R1 and R3 to complete the system configuration. The charts shown at next page will help us how to evaluate R1 and R3. All the equations attached at charts are formed by the method of linear regression using known values which are acquired from simulation results.

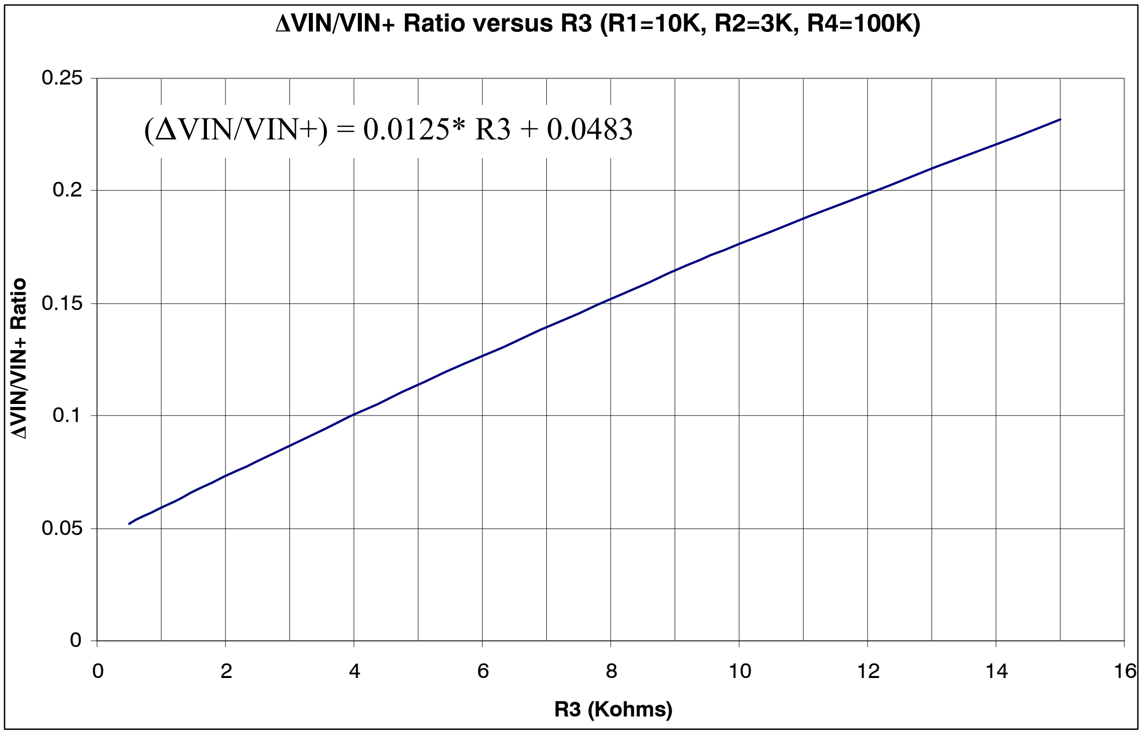

Figure 4. Chart for $\Delta V_{IN}/V_{IN+}$ Ratio versus R3

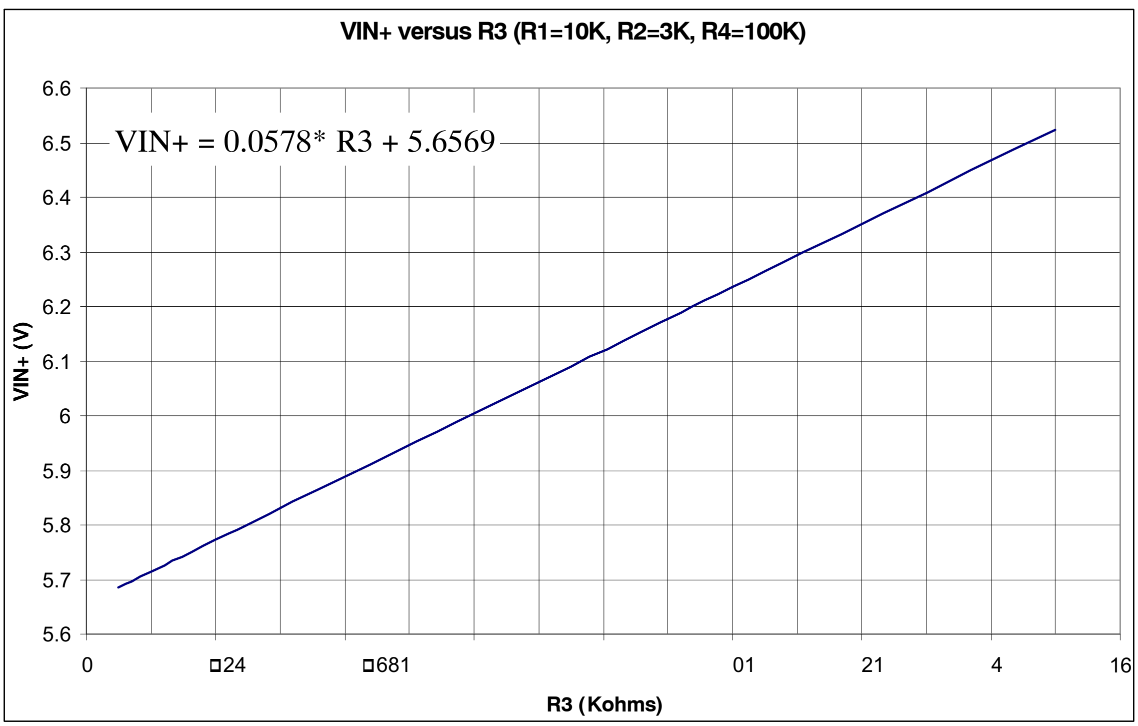

Figure 5. Chart for V_{IN+} versus R3

Steps to Evaluate R1 and R3 for Given V_{IN+} and ΔV_{IN}

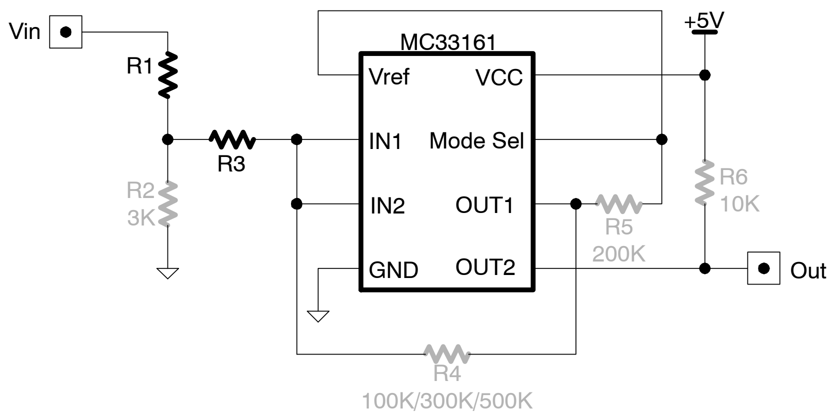

Figure 6. Circuit for Evaluation of R1 and R3

1. Fix R2 = 3k, R4 = 100k/300k/500k (see step 3 for detail)
2. For given V_{IN+} and ΔV_{IN}, calculate the ratio of $\Delta V_{IN}/V_{IN+}$.
3. From Figure 4 chart with make use of the equation provided, evaluate R3 based on the calculated $\Delta V_{IN}/V_{IN+}$. If R3 is found to be negative, try to use R4 = 300k (use Figure 10) or R4 = 500k (use Figure 12) and repeat R3 evaluation.
4. From Figure 5 (if R4 = 300k, use Figure 11. If R4 = 500k use Figure 13) chart with make use of the equation provided, evaluate V_{IN+} based on the R3 which is defined at step 3, say V_{IN+}' It should be noted that the V_{IN+}' value here is NOT the one that will be used, it is just for intermediate value to proceed the calculation.
5. Evaluate R1' based on the formula: (V_{IN+}')*(R1' + R2) = (V_{IN+})*(R1 + R2) where R1 = 10k, R3 = 3k.
6. So, R1 (notate as R1' at step 5), R2, R3 and R4 are evaluated.

Example

The customer wants to have the application of which Output is low when V_{IN} = 3 V and output is high when V_{IN} = 2.75 V.

Step 1: Fix R2 = 3K, R4 = 100k

Step 2: V_{IN+} = 3 V and required hysteresis ΔV_{IN}
= 3 – 2.75
= 0.25 V
So the ($\Delta V_{IN}/V_{IN+}$) ratio = 0.25 / 3
= 0.0833

Step 3: From the Figure 4 chart with make use of equation,
we have
0.08333 = 0.0125 * R3 + 0.0483
Therefore, R3 = (0.08333 – 0.0483)/0.0125
R3 = 2.803k

Step 4: From the Figure 5 chart with make use of equation,
we have
V_{IN+}' = 0.0578 * 2.803 + 5.6569
V_{IN+}' = 5.819 V

Step 5: Evaluate R1 by the formula mentioned at step 5,
5.819 * (R1 + 3) = 3 * (10 + 3)
R1 = 3.702k

So, the system will give V_{IN+} = 3 V with ΔV_{IN} = 0.25 V for R1 = 3.702k, R2 = 3k, R3 = 2.803k, R4 = 100k.

Validation by PSPICE Simulation

Now, we put those resistor values into PSPICE for functional validation.

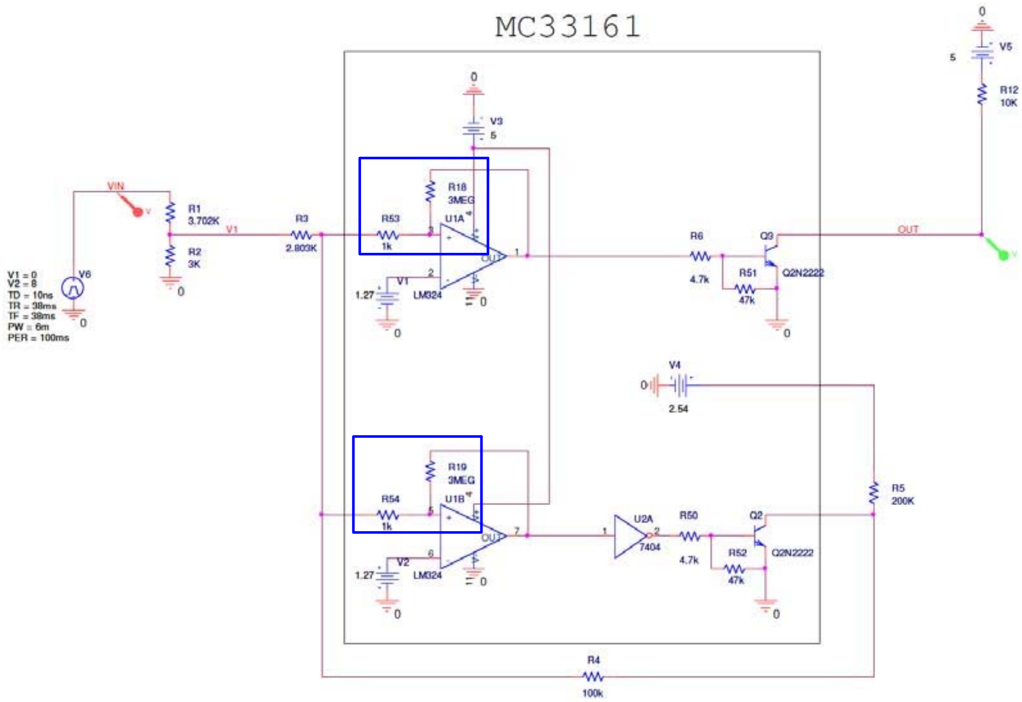

Figure 7. MC33161 PSPICE Schematic Model

Note: For the comparators portion, LM324 (U1A/U1B), R18(R19) and R53(R54) are used to provide 25 mV hysteresis which is the "intrinsic" amount per datasheet quoted. And input characteristics of LM324 is quite similar to those of real MC33161.

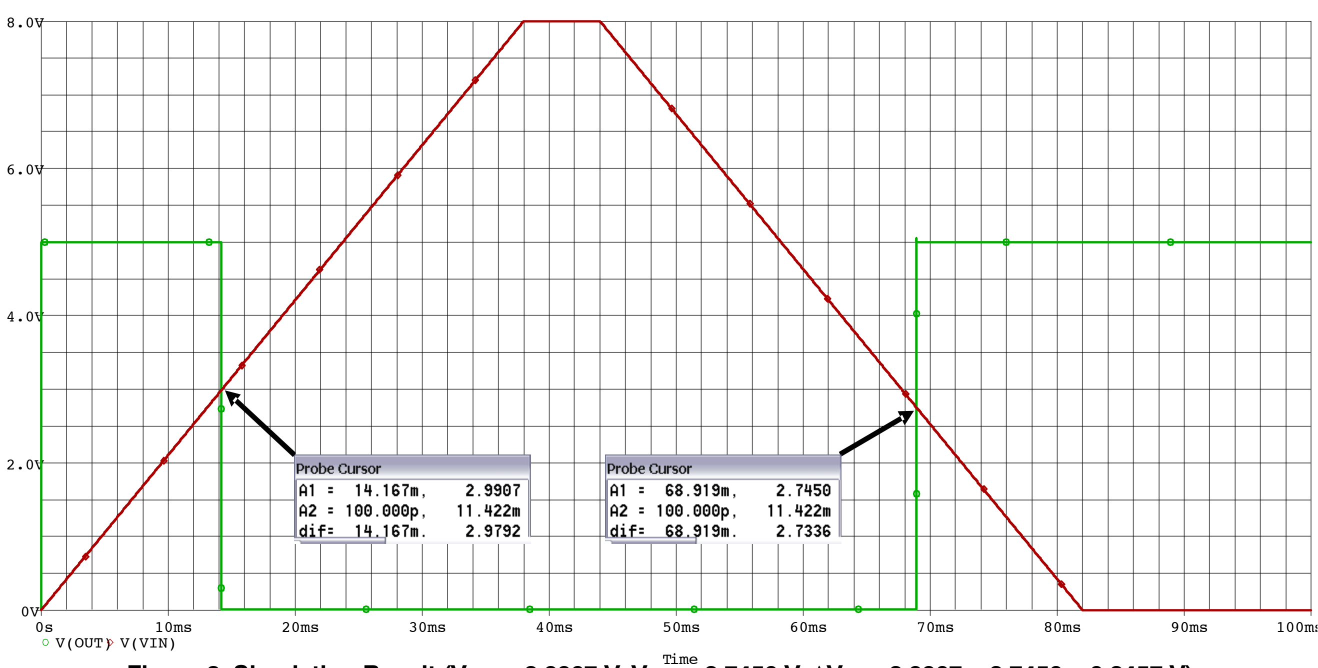

Figure 8. Simulation Result (V_{IN+} = 2.9907 V, V_{IN-} = 2.7450 V, ΔV_{IN} = 2.9907 − 2.7450 = 0.2457 V)

So, the simulation result is consistent with theoretical calculation.

Validation by Laboratory Evaluation

Recall the resistor sets R1 to R4
R1 = 3.702k
R2 = 3k
R3 = 2.803k
R4 = 100k
At laboratory, the following resistor values are used:
R1 = 3.6k + 100 Ω = 3.70k
R2 = 3k
R3 = 2.7k + 100 Ω = 2.80k
R4 = 100k
All resistors are tolerance 1%

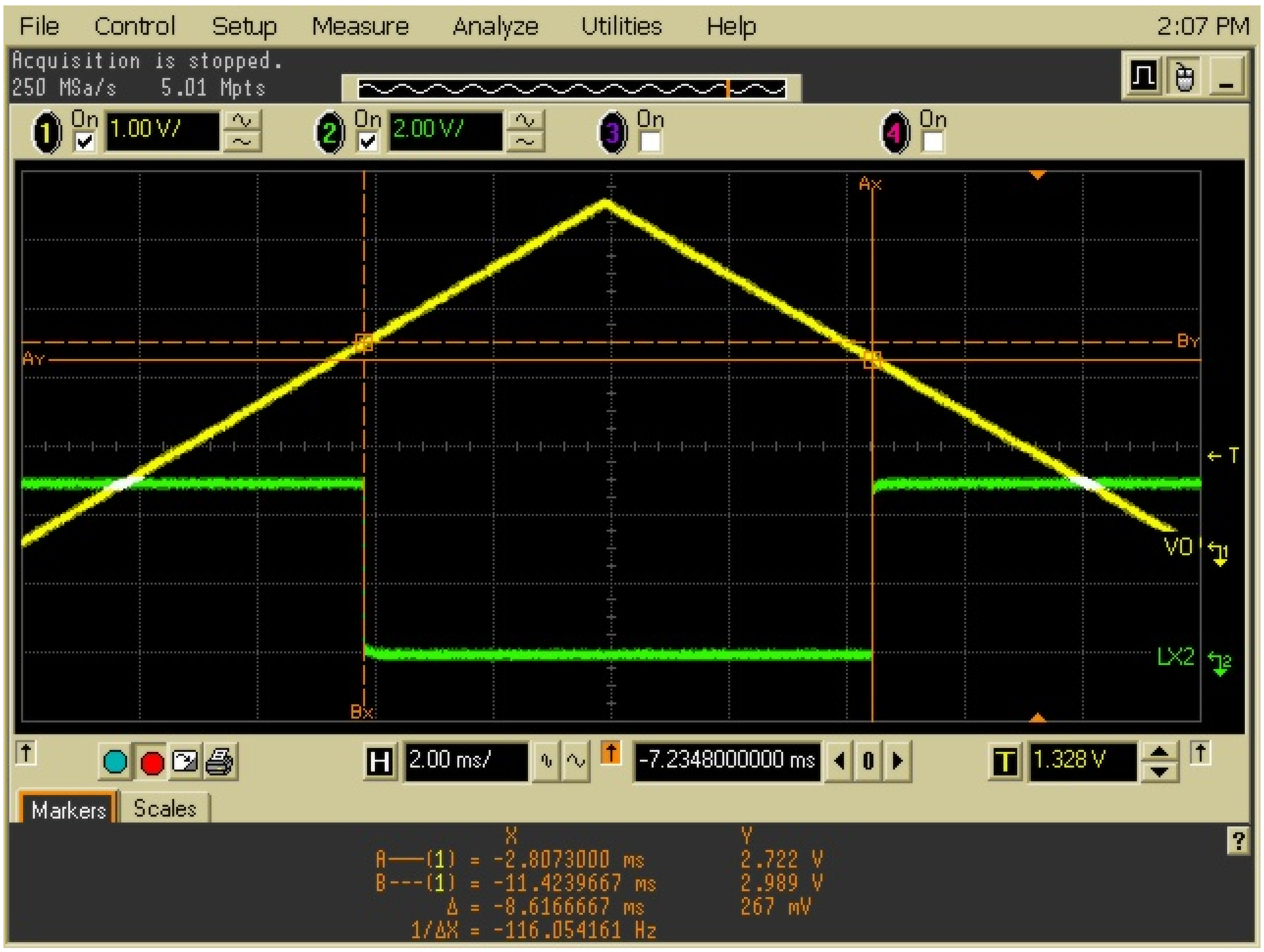

Figure 9. Scope Capture (V_{IN+} = 2.989 V, V_{IN-} = 2.722 V, ΔV_{IN} = 2.989 − 2.722 = 0.267 V)

So the evaluation result in laboratory bench is also consistent with theoretical calculation.

Cautions For Selection of Resistor R3 to R4

1. R3 should be used lower than 15k, otherwise there will have some non linear behavior with either V_{IN+} or $\Delta V_{IN}/V_{IN+}$
2. R4 should be used higher than 100k.

The following charts provide V_{IN+} and $\Delta V_{IN}/V_{IN+}$ versus R3 for R4 = 300k and R4 = 500k. Those may be used if $\Delta V_{IN}/V_{IN+}$ are too small for R4 = 100k configuration.

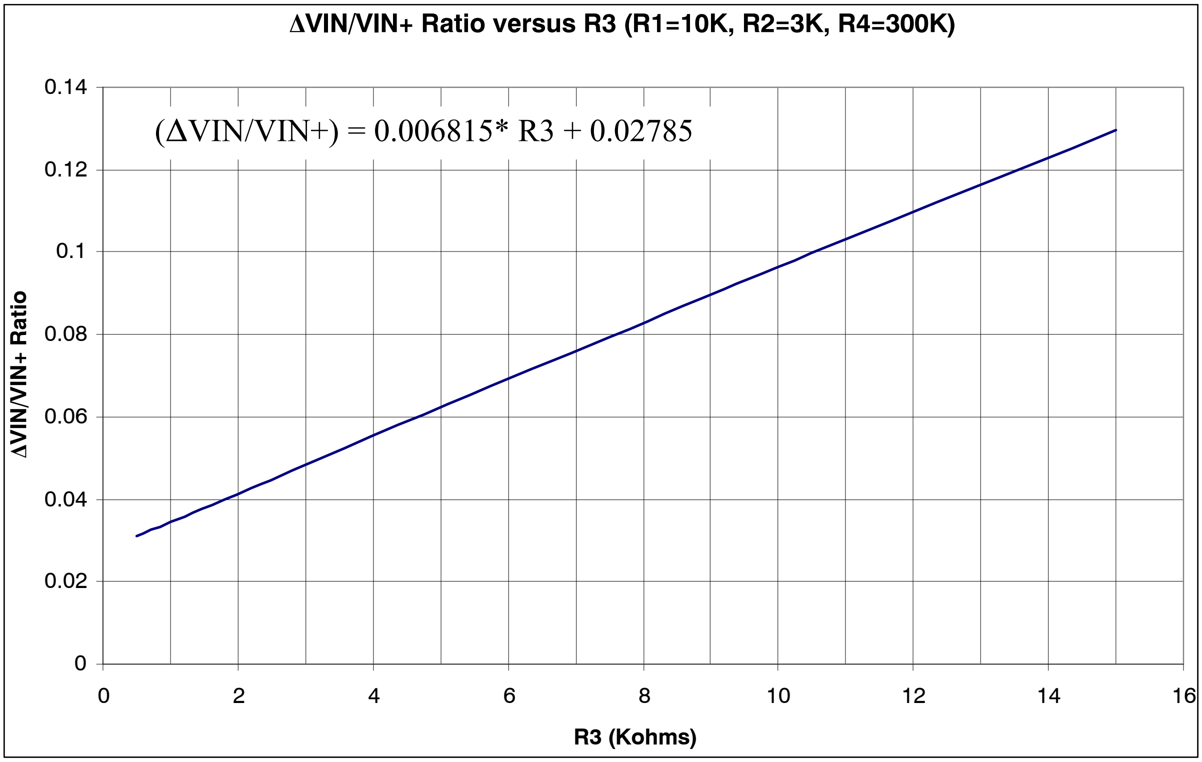

Figure 10. Chart for $\Delta V_{IN}/V_{IN+}$ Ratio versus R3 (R4 = 300k)

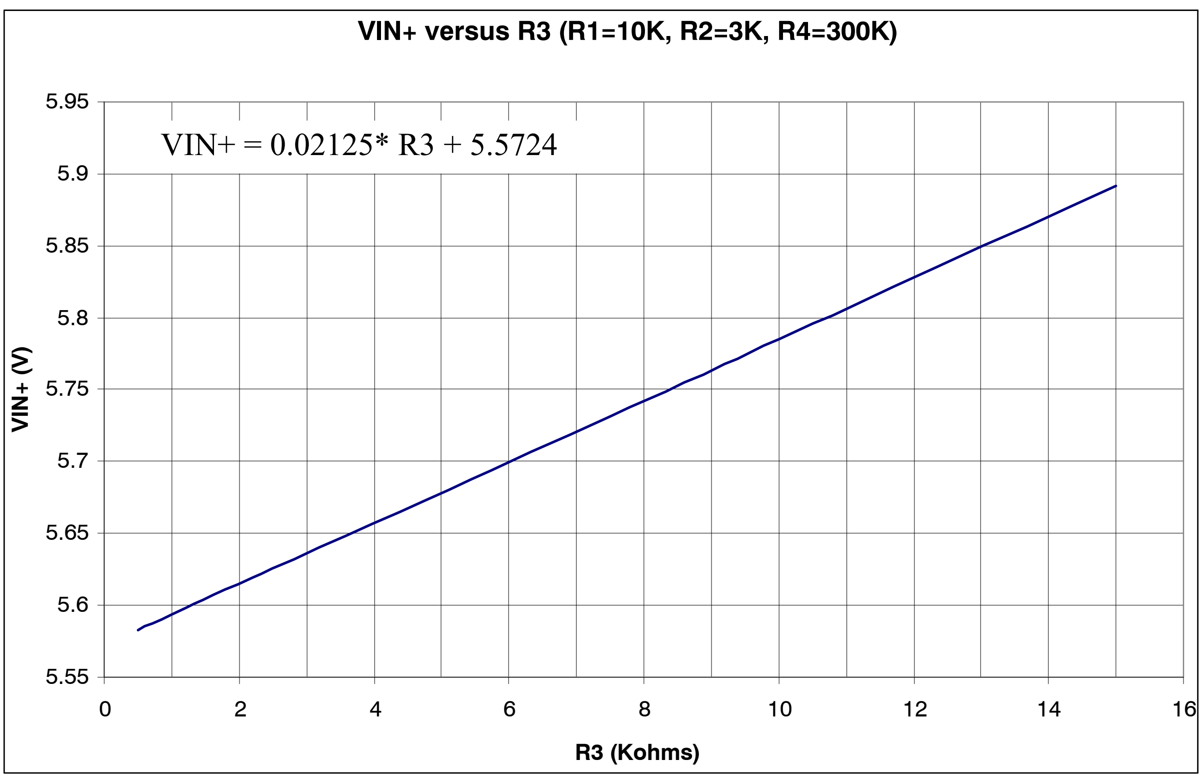

Figure 11. Chart for V_{IN+} versus R3 (R4 = 300k)

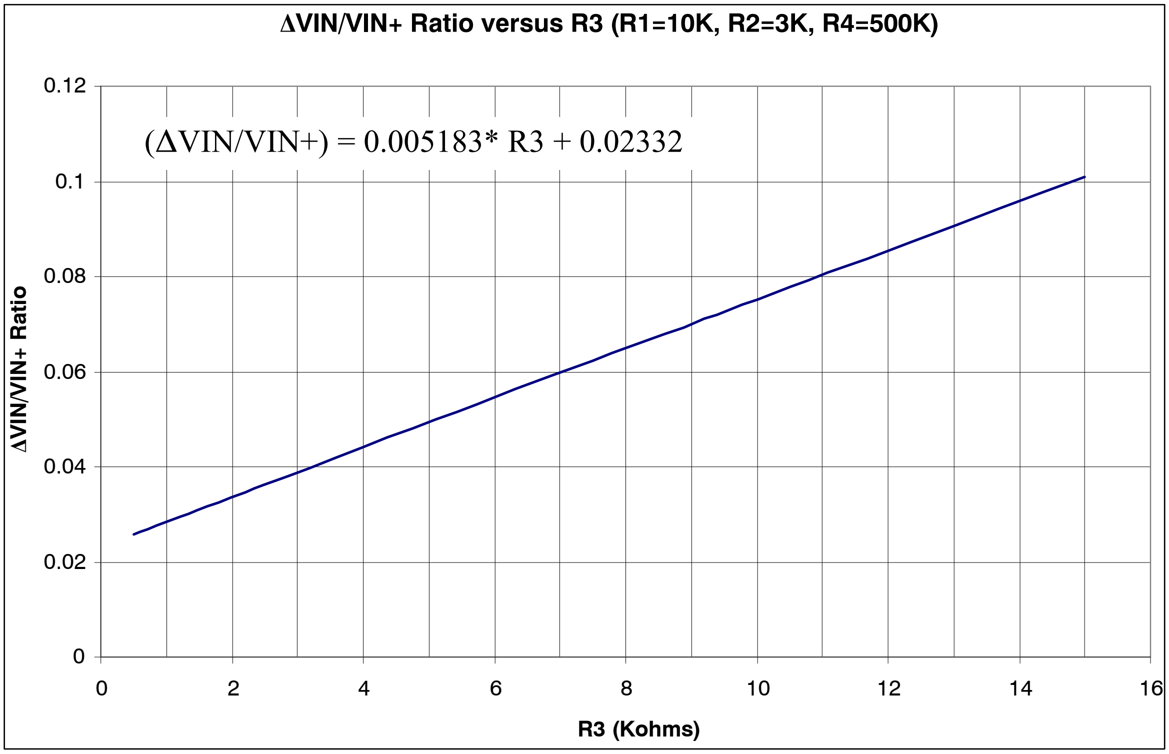

Figure 12. Chart for $\Delta V_{IN}/V_{IN+}$ Ratio versus R3 (R4 = 500k)

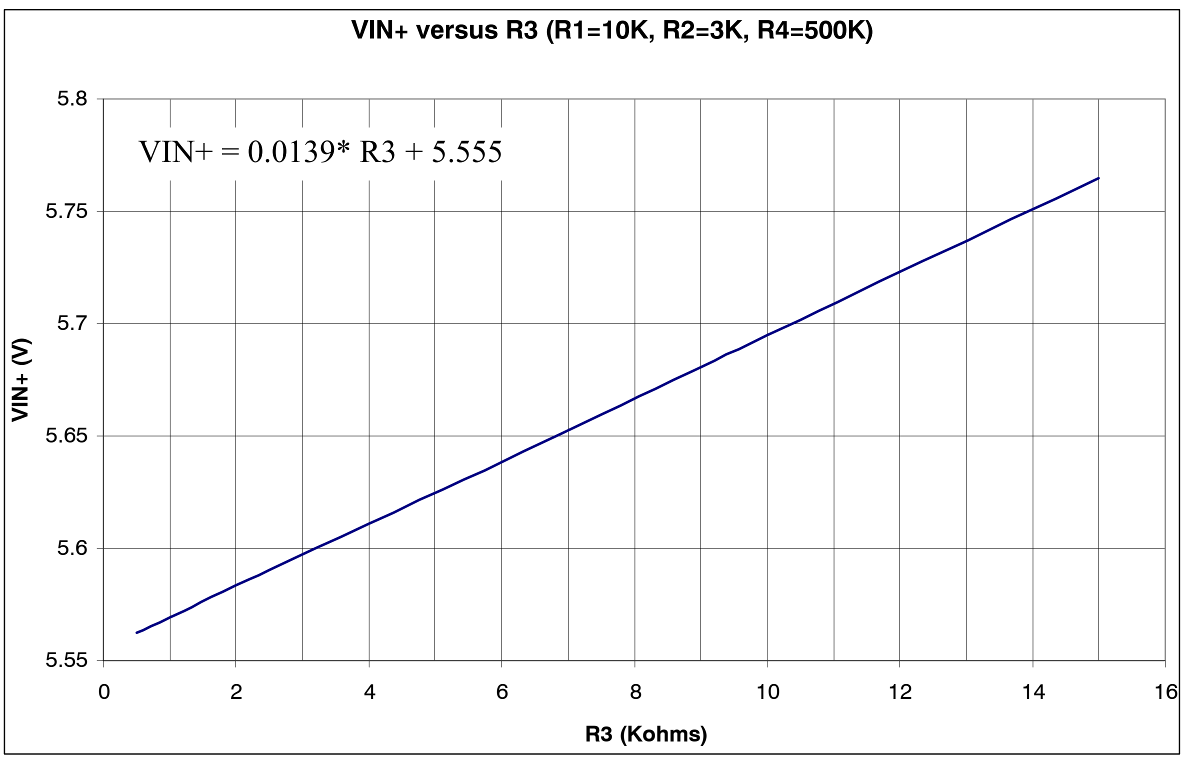

Figure 13. Chart for V_{IN+} versus R3 (R4 = 500k)

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