1. Introduction

Silicon Labs’ TS9002 low-power dual comparator incorporates an internal reference that, when used with a simple feedback network, can adjust the hysteresis. Since only two resistors are needed for the feedback network, only one resistor needs to be adjusted to alter the hysteresis band.

For this walk-through, only the A-comparator of the TS9002 will be considered. For the A-comparator, the output will go high once the input to the A-comparator rises from below to above the upper threshold, while the output of the A-comparator will go low once the input to the A-comparator goes from above to below the low threshold.

First, the hysteresis for the TS9002 comparator will be set to 30 mV. The voltage supplied by the internal reference, or the REF pin, is 1.182 V. The voltage applied to the Hysteresis pin, HYST, should be half the hysteresis band voltage, \( V_{HB} \), below the reference voltage. Equation 1 defines the required voltage at the HYST pin in terms of the reference voltage and the desired hysteresis band. For an internal reference voltage of 1.182 V and a hysteresis band of 30 mV, the required voltage at HYST results in 1.167 V.

\[
HYST = REF - 0.5 \times V_{HB}
\]

Equation 1.

Before selecting the feedback network resistor values of \( R_1 \) and \( R_2 \), it is important to note that the current sourced by the internal reference must be maintained below 20 µA and significantly greater than 20 pA. The current sourced by the internal reference can be approximated by Equation 2. Therefore, to satisfy both conditions, the value of 2 is selected to be 1 MΩ. This results in a reference current of 1.16 µA.

\[
I_{REF} = \frac{HYST}{R_2}
\]

Equation 2.

To calculate the required \( R_1 \) value for the corresponding hysteresis band and internal reference current, Equation 3 is provided on page 9 of the TS9002 data sheet. A 30 mV hysteresis band, with a reference current of 1.167 µA, results in a \( R_1 \) value of 12.85 kΩ.

\[
R_1 = \frac{0.5 \times HYST}{I_{REF}}
\]

Equation 3.

This feedback network consisting of \( R_2 \) as 1 MΩ and \( R_1 \) as 12.85 kΩ, results in a 30 mV hysteresis band with the lower threshold occurring at 1.168 V while the high threshold occurs at 1.198 V.

To easily adjust the hysteresis band to 40 mV, only the \( R_1 \) value needs to be changed. Using a 40 mV hysteresis band, the new voltage at the HYST pin should be equal to 1.162 V, or 20 mV below the reference voltage as defined by Equation 1. Since \( R_2 \) remains equal to 1MΩ, the new reference current is now equal to 1.162 µA. Inserting the 40 mV hysteresis band and the corresponding reference current into Equation 3, the appropriate \( R_1 \) value of 17.2 kΩ can be calculated.
The new feedback network consisting of R2 as 1 MΩ and R1 as 17.2 kΩ, the resulting hysteresis band is equal to 40 mV with an upper threshold occurring at 1.202 V and a low threshold occurring at 1.202 V.

As shown in this application note, the hysteresis band for Silicon Labs' TS9002 low-power dual comparator can be easily adjusted by only changing the value of one resistor within the feedback network.

For additional information, see the following:

- TS9002 dual comparator
- TS9002 data sheet
- Silicon Labs' family of comparators
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