Commodity IC Data: 555

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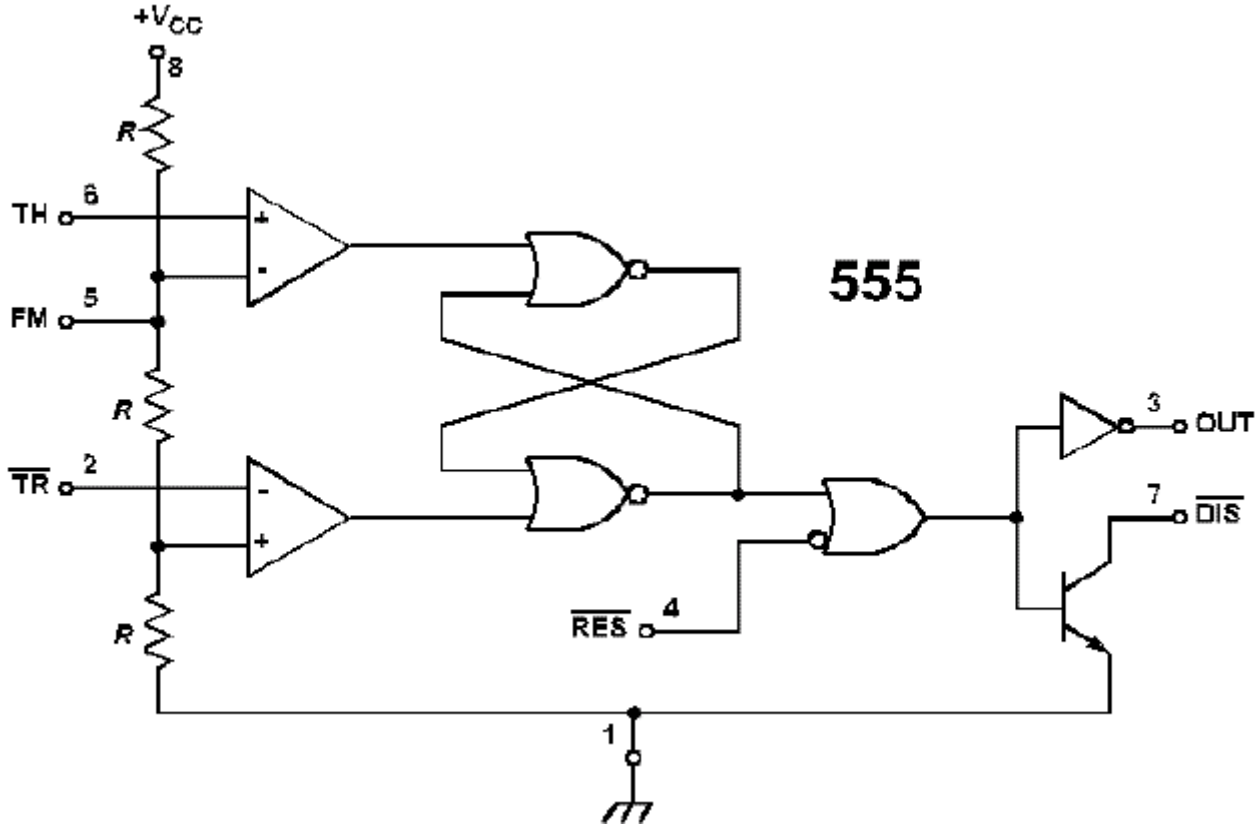
Q: I am having trouble doing detailed design of analog circuits for low-cost products using commonly-available integrated circuits. In particular, parts specifications for the 555 timer and single-supply op-amps and comparators fail to give their full functional diagrams or models of their output or input characteristics. The SG3525A PWM controller, popular for push-pull converter designs, lacks some useful design data too. Can you provide some of this information?

A: Commonly-used *commodity* ICs are described in the commercial literature but these specifications sometimes do not include important design parameters. Here are some of those parameters from my investigations from using these parts in designs. In this part of a multi-part response, we look at the versatile and venerable 555 timer.

NE555

The 555 timer (originally the Signetics NE555 bipolar IC) data-sheets often show a block diagram, but it is usually incomplete. The following diagram (suitable for printing and hanging on your workbench) is intended to give a fuller functional specification of the part.



The value of *R* depends on whether the part is bipolar or CMOS, with CMOS having a much higher value. They are nominally 5 kΩ in the BJT version. /DIS and OUT have the same logic state, in voltage. That is, when OUT is low, the /DIS open-collector BJT is on. Most data-

sheets fail to include the polarities on the comparator inputs, yet they are needed to determine circuit behavior.

One of the often-omitted descriptions for the 555 is that of the FM input (pin 5). It can be used to frequency-modulate the output when used as an oscillator, but what are the parameters? This will be covered more fully in a future TechNote (with derivations). The 555 output frequency (used as a VFC) and duty ratio (used as a PWM) are nonlinear. The output off-time (0 V out), t_L, does not change with the oscillator threshold voltage, V_H, on pin 5 (the FM pin). The on-time, t_H, varies with V_H and consequently, the switching period, T_s, varies with it also, so that the change in t_H and T_s are the same. For $V_H \approx (2/3)\cdot V_{CC}$, then the fractional change in t_H with fractional change in V_H (that is, the sensitivity) is:

$$S_{V_H}^{t_H} = \frac{3}{2\cdot\ln(2)} \cong 2.16$$

The incremental change in T_s with V_H is:

$$\frac{dT_s}{dV_H} = R\cdot C\cdot\frac{V_{CC}}{2\cdot(V_{CC}-V_H)\cdot(V_{CC}-V_H/2)} = \frac{9}{4}\cdot\frac{R\cdot C}{V_{CC}},\ V_H = \tfrac{2}{3}\cdot V_{CC}$$

For duty ratio:

$$\frac{dD}{dV_H} = \frac{9}{4}\cdot\frac{D\cdot(1-D)}{V_{CC}\cdot\ln(2)} \cong 3.25\cdot\frac{D\cdot(1-D)}{V_{CC}},\quad V_H = \tfrac{2}{3}\cdot V_{CC}$$

The 555 is not well-suited for use as either a VFC or PWM because of both nonlinearity and limited range, though if neither of these is an obstacle, this versatile component can do either.