

Oct. 21, 1969

R. S. HUGHES

3,474,264

CIRCUIT FOR VARYING THE HYSTERESIS OF A SCHMITT TRIGGER

Filed June 16, 1966

2 Sheets-Sheet 1

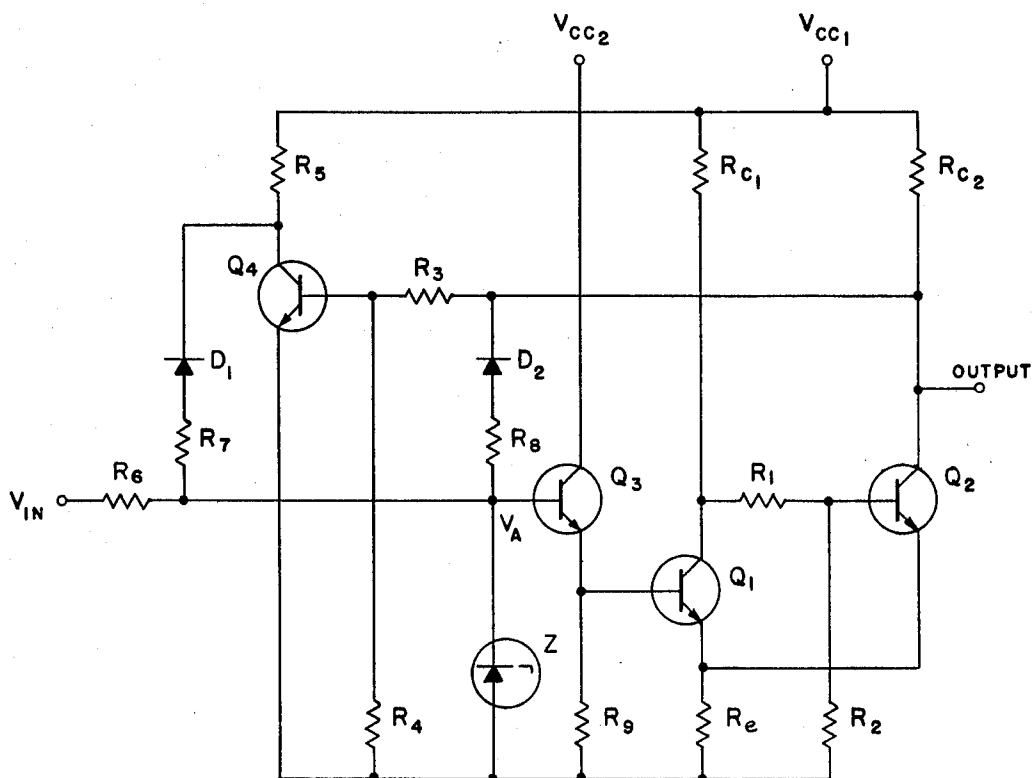


FIG. 1.

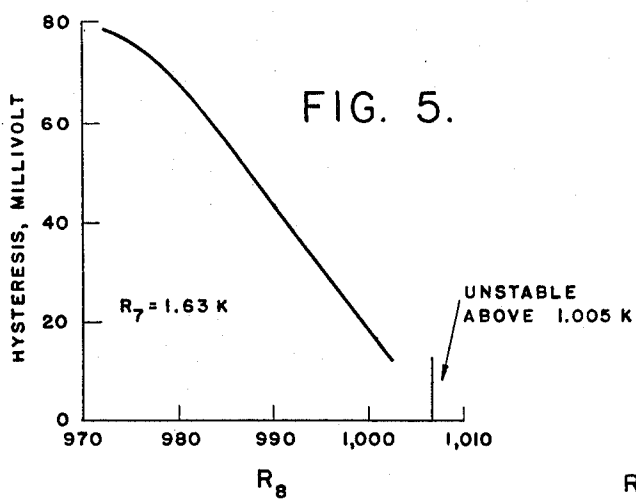


FIG. 5.

INVENTOR.
RICHARD S. HUGHES
BY
JOHN M. KOCH
ROY MILLER
ATTORNEYS.

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R. S. HUGHES

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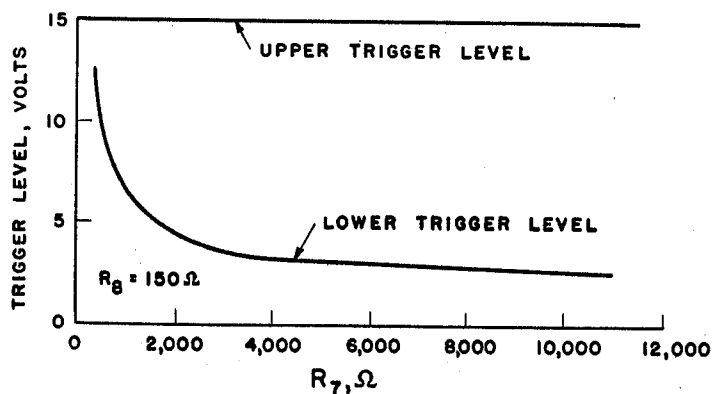


FIG. 2.

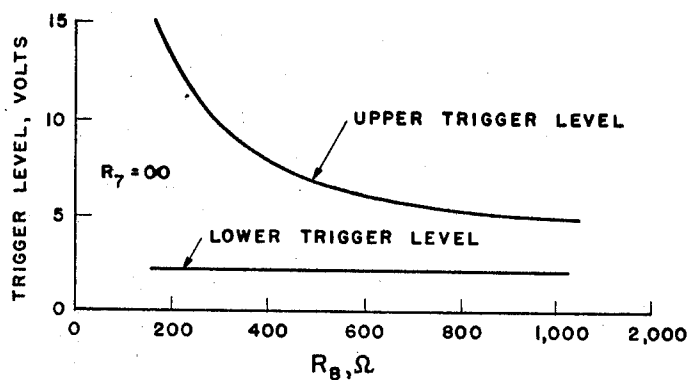


FIG. 3.

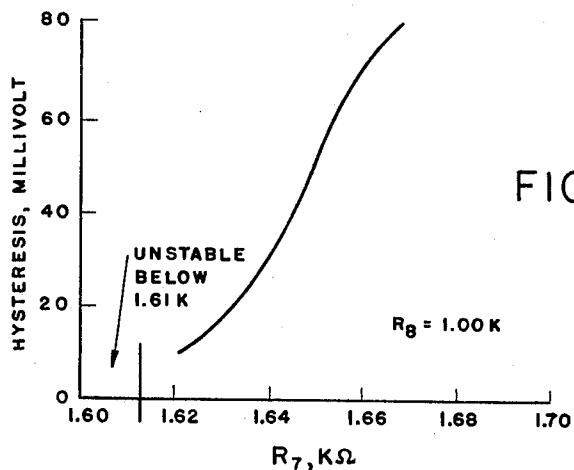


FIG. 4.

INVENTOR.

RICHARD S. HUGHES

BY

JOHN M. KOCH
ROY MILLER
ATTORNEYS.

1

3,474,264

CIRCUIT FOR VARYING THE HYSTERESIS OF A SCHMITT TRIGGER

Richard S. Hughes, China Lake, Calif., assignor to the United States of America as represented by the Secretary of the Navy

Filed June 16, 1966, Ser. No. 559,053

Int. Cl. H03k 3/26, 17/00

U.S. Cl. 307-290

1 Claim

ABSTRACT OF THE DISCLOSURE

A circuit for externally varying the hysteresis of a Schmitt trigger without changing the operating characteristics of the Schmitt trigger by alternately introducing and withdrawing resistance from the input circuit to vary the level of the input as seen by the Schmitt trigger.

The invention described herein may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

It is generally known that the conventional Schmitt trigger circuit exhibits hysteresis in that to effect a transition in one direction it is necessary to first pass beyond the voltage at which the reverse transition takes place.

There are many situations, such as in ramp and other function generators, where the hysteresis offered by the Schmitt trigger circuit could be utilized if the range of the hysteresis could be suitably widened in an efficient straight-forward manner and without degradation of the trigger operation relative to the output rise time of the circuit, the output pulse amplitudes of the circuit, etc.

Accordingly, it is a principal object of this invention to provide a modified Schmitt trigger circuit wherein the range of the hysteresis is suitably widened for useful applications of the circuit, in an efficient manner, and without degradation of the desired trigger operation properties or qualities of the circuit.

Additional objects of the invention will become apparent from the following description, which is given primarily for purposes of illustration, and not limitation.

Stated in general terms, the objects of the invention are attained by providing circuit means externally of the Schmitt trigger circuit configuration for controlling the pulse amplitude of the input to the Schmitt trigger circuit, preferably predetermined resistance means that are alternately introduced into, and withdrawn from the circuit of either the upper trigger level, the lower trigger level, or at both trigger levels to widen the range of the hysteresis of the Schmitt trigger circuit in a desired manner without detrimentally affecting desired circuit operation characteristics.

A more detailed description of a specific embodiment of the invention is given below with reference to the drawings, wherein:

FIG. 1 is a schematic circuit diagram showing a modified Schmitt trigger circuit of the invention;

FIG. 2 is a graph showing the changes in the upper and lower trigger levels as a function of the resistor R_7 ;

FIG. 3 is a similar graph showing the effect of resistor R_8 ;

FIG. 4 is a graph showing the hysteresis as a function of small changes in the value of resistor R_7 ; and

2

FIG. 5 is a similar graph showing the effect of resistor R_8 .

As shown in FIG. 1, transistors Q_1 and Q_2 are connected in the customary Schmitt trigger circuit configuration. Externally of this configuration, transistor Q_3 is connected to transistor Q_1 , the supply voltage V_{CC2} and the input terminal V_{in} to act as a buffer to avoid loading the driving circuitry. The Zener diode Z is connected to transistor Q_3 to protect the transistor against over-voltage effects. Transistor Q_3 also is connected to resistor R_8 and diode D_2 to further modify the Schmitt trigger circuit externally thereof. A resistor R_7 , diode D_1 and transistor Q_4 are connected in series in a line leading from the input terminal V_{in} to ground in a manner to control the pulse amplitude of the input to the Schmitt trigger circuit, along with resistor R_8 , diode D_2 and transistor Q_3 , as described below.

In operation, in the normal state, transistor Q_1 is off and transistor Q_2 is on and assumed to be saturated. The voltage V_A at the base of transistor Q_3 is given approximately by the equation:

$$V_A = \frac{R_8 V_{in}}{R_6 + R_8} \quad (1)$$

This assumes no loading on resistance R_8 by Zener diode Z or transistor Q_3 and that transistor Q_2 is at ground potential. Resistor R_7 is not in the circuit. Transistor Q_4 is off, thus back-biasing diode D_1 and removing resistor R_7 from the circuit, which includes R_6 , R_8 , D_2 and Q_2 .

When the voltage V_A nears the inherent upper trigger level of the circuit, transistor Q_1 starts conducting. Transistor Q_1 continues to conduct until transistor Q_2 turns off. This action turns on transistor Q_4 . At this point, diode D_2 is back-biased and resistor R_8 is removed from the circuit. Diode D_1 becomes forward-biased thus placing resistor R_7 into operation in a circuit including R_6 , R_7 , D_1 and Q_4 . At this stage, the voltage V_A is given by the following equation:

$$V_A = \frac{V_{in} R_7}{R_6 + R_7} \quad (2)$$

The lower trigger point of the circuit can be controlled by resistor R_7 . Zener diode Z is used to limit the maximum voltage across resistor R_8 and to prevent forward biasing of the base-collector circuit of transistor Q_1 .

During a cursory examination of the circuit of FIG. 1, it would appear that transistor Q_1 can be used in the place of Q_4 because the states of both transistors are essentially the same during the circuit operation. However, the problem resides in the fact that transistor Q_1 functions as a linear amplifier for a short time before transistor Q_2 switches on. Also, it is a difficult problem to arrange to have the collector voltage of transistor Q_1 to approach the value of the ground potential.

The inherent upper trigger point for the Schmitt trigger circuit, including transistor Q_3 in the circuit, is designated voltage X in the following equation, and the lower trigger voltage point is designated Y . From Equation 1, one obtains the following equation for V_{in} , at the upper trigger point:

$$V_{in} = \frac{X(R_6 + R_8)}{R_8} \quad (3)$$

and at the lower trigger point, one obtains for V_{in} :

$$V_{in} = \frac{Y(R_6 + R_7)}{R_7} \quad (4)$$

3

The difference between the values of V_{in} at the upper trigger point and at the lower trigger point is the hysteresis H :

$$H = \frac{X(R_6 + R_8)}{R_8} - \frac{Y(R_6 + R_7)}{R_7} \quad (5)$$

In a specific embodiment of the circuit of the invention shown in FIG. 1, the circuit values were as follows:

$V_{CC1} = +24$ v. $R_{C1} = R_{C2} = 3K$
 $I_{+24} = 20$ ma. $R_e = 39\Omega$
 $V_{CC2} = +12$ v. $R_1 = R_7 = 10K$
 $I_{+12} = 5$ ma. $R_2 = 2K$
 $Q_1, Q_2, Q_3, Q_4 = 2N916$ $R_3 = 7.5K$
 $D_1, D_2 = FD-200$ $R_4 = 1K$
 $Z = 1N748$ $R_5 = R_6 = 5.1K$

FIGS. 2 and 3 show the effects of R_7 and R_8 , respectively, on the upper and lower trigger levels of the modified Schmitt trigger circuit of the invention shown in FIG. 1. It will be seen that the hysteresis can be controlled and widened by the use of the variable hysteresis Schmitt trigger circuit of the invention. FIGS. 4 and 5 show the hysteresis of the circuit as a function of small changes in the values of resistors R_7 and R_8 , respectively.

It will be seen that the variable hysteresis Schmitt trigger circuit of the invention can be used with only a low trigger point controlling resistor, such as R_7 , only a high trigger point controlling resistor, such as R_8 , or two resistors, such as R_7 and R_8 for controlling both the upper and lower trigger levels of a Schmitt trigger circuit. Also, it will be understood that vacuum tube amplifiers, as well as transistor amplifiers, can be used in the modified Schmitt trigger circuit of the invention.

Obviously, many other modifications and variations of the variable hysteresis Schmitt trigger circuit of the invention are possible in the light of the teachings given hereinabove. It is therefore to be understood that the invention may be practiced otherwise than as specifically described and illustrated hereinabove.

What is claimed is:

4

1. A circuit for varying the hysteresis of a Schmitt trigger comprising:

an input;

a transistor having emitter, collector and base electrodes;

a first resistance coupled between said input and the input to a Schmitt trigger;

a series combination of a second resistance and a first diode operatively connected between the input to the Schmitt trigger and the collector of the transistor wherein,

the cathode of the first diode is connected to the collector of the transistor;

a third resistor operatively connected between the collector of the transistor and a biasing voltage;

means for grounding the emitter of the transistor;

a fourth resistor coupled between the base of the transistor and the output from the Schmitt trigger;

a series combination of a fifth resistor and a second diode operatively connected between the input to the Schmitt trigger and the output from the Schmitt trigger wherein,

the cathode of the second diode is connected to the output of the Schmitt trigger; and

a sixth resistor operatively connected between the base of the transistor and ground.

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DONALD D. FORRER, Primary Examiner

H. A. DIXON, Assistant Examiner

U.S. Cl. X.R.

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