Schmitt trigger using PLS153 AN018

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INTRODUCTION

One of the many features of the PLS153 is the availability of individually controlled 3-State I/O pins. Taking advantage of this feature, a Schmitt trigger may be constructed using one input pin, two bidirectional I/O pins and additional components of three resistors. The two threshold voltages, as well as the hysterisis, are determined by the values of the three resistors and the parameters of the PLS153 device, which are 1) input threshold voltage, V_{TH}, 2) High output voltage, V_{OH}, and 3) Low output voltage, V_{OL}. The circuit may be simplified if Schmitt function is needed only on Low going High or High going Low, and if the hysterisis and threshold voltages are not important.

DESCRIPTION

A simplified block diagram of a non-inverting Schmitt trigger is shown in 1 where R_1, R_2, and R_1, R_3, form two pairs of voltage dividers one of which get into action at input voltage direction of High going Low and the other Low going High. Assuming that input voltage starts at zero volt, the output voltage is therefore at V_{OL} which causes Q_2 to pull R_3 towards ground. As the input voltage increases, only a fraction of the voltage is impressed upon the input buffer due to the dividing network R_1 and R_3. As soon as the input voltage reaches a point where $V_1=V_{TH}$ (V_{TH}=1.38V typical), the output switches to V_{OH} which, in turn, turns off Q_2 and turns on Q_1. V_1 will jump to a value greater than V_{TH} and Q_1 then pulls the input pin, through R_2, towards V_{OH}, which in turn locks the output to a High state even if the input voltage fluctuates, as long as it does not fluctuate outside of the designed hysterisis. When the input voltage goes from a High to a Low, the Schmitt function repeats itself except that Q_1 and Q_2 reverse their roles.

The triggering voltages, V_H (Low going High) and V_L (High going Low) are:

$V_H=V_{TH}\,[(R_1+R_3)/R_3] - V_{OL}\,(R_1/R_3)$;

$V_L=V_{TH}\,[(R_1+R_2)/R_2] - V_{OH}\,(R_1/R_2)$;

where, at room temperature, V_{CC} = 5.0V, I_{OH}/I_{OL}<1mA. V_{TH} is the threshold voltage of the device, typically 1.38V; V_{OL} is the output Low voltage of the device, typically 0.36V at $|I_{OL}|$ <1mA; V_{OH} is the output High voltage of the device, typically 3.8V at $|I_{OH}|$ <1mA.

The implementation of 1 using PLS153/153A is as shown in Figures 2a and 2b. A scope photo of the operation of the circuit is shown in Figure 6.

An inverting Schmitt triggered buffer may be constructed using the same principle. A simple block diagram of such inverter is shown in Figure 3a. The circuit is implemented as shown in Figures 3b and c.

If the voltage levels (V_L and V_H) and the hysterisis are not critical, one I/O pin may be used to pull the input pin High and Low. Therefore one I/O pin and a resistor may be saved. The drawback is that the range of V_H and V_L is quite limited. The circuit is as shown in Figure 4.

If Schmitt function is needed only in one direction, one of the resistor/output circuit may be eliminated. The circuit is as shown in Figure 5.

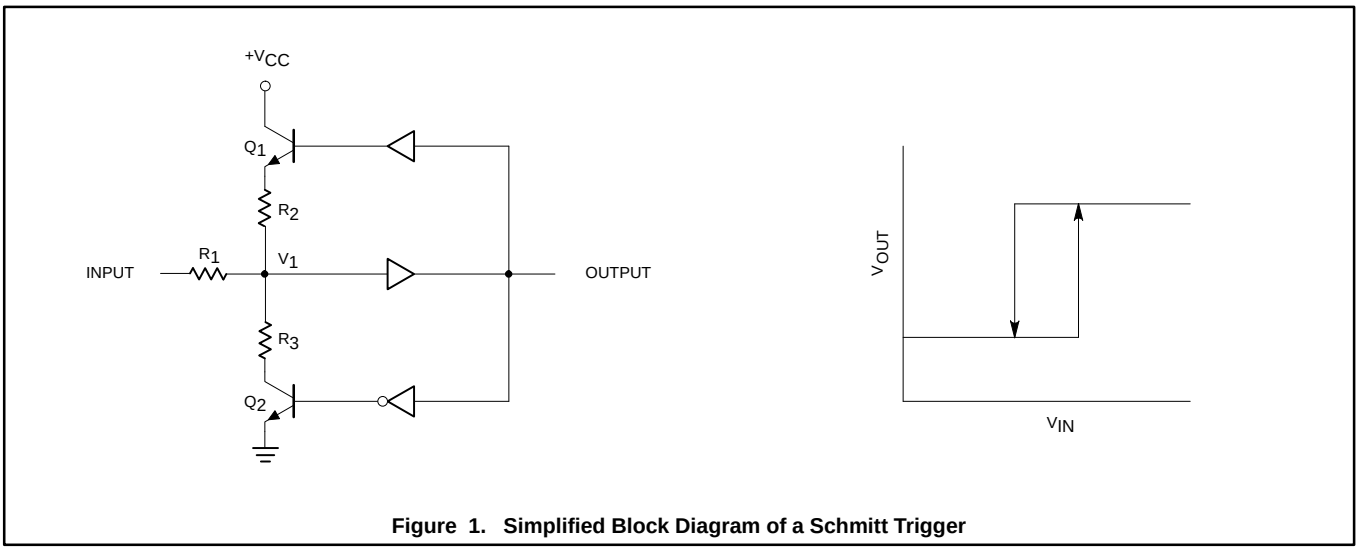
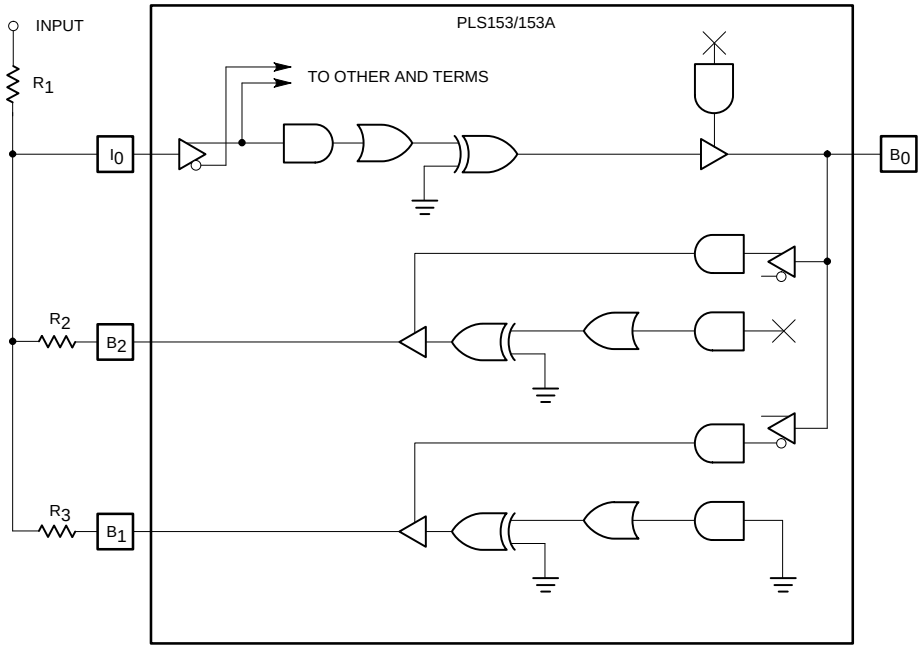


Figure 1. Simplified Block Diagram of a Schmitt Trigger



a. Using PLS153/153A

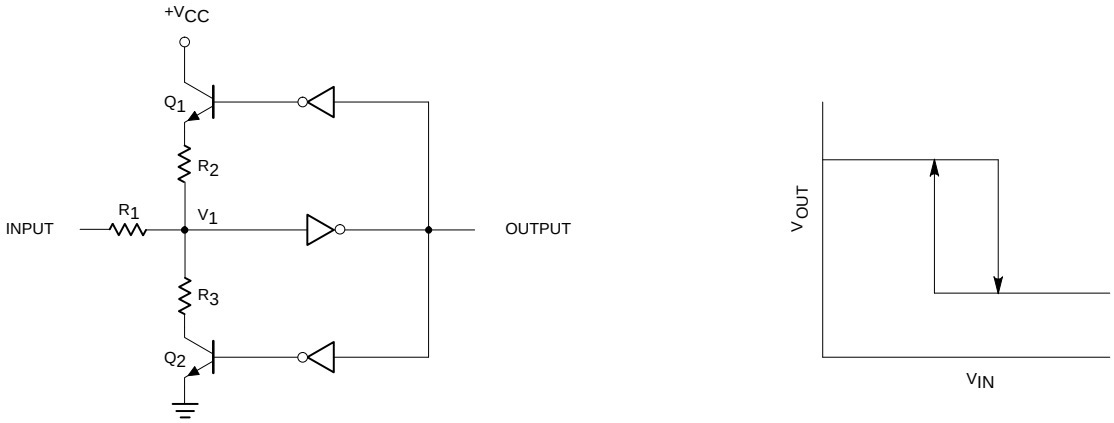
NOTE: Schmitt trigger output may be obtained from both I_0 and $B(I)_0$ to drive the AND-ARRAY.

SNAP LISTING FOR A SCHMITT TRIGGER FUNCTION. EXTERNAL RESISTORS ARE REQUIRED AS SHOWN ABOVE.

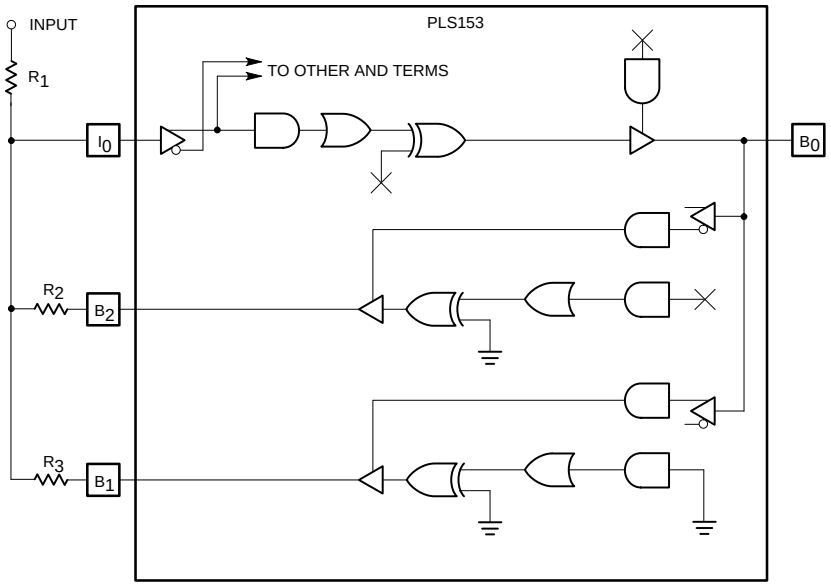
```
@pinlist
input       i;
output      b
B1          o;
B2          o;

@logic equations
output      =       input;
output.oe   =       1

B1.oe       =       / output;
B1          =       0;

B2.oe       =       output
B2          =       1;
```

b. SNAP Equations

Figure 2. Schmitt Trigger



a. Simplified Block Diagram



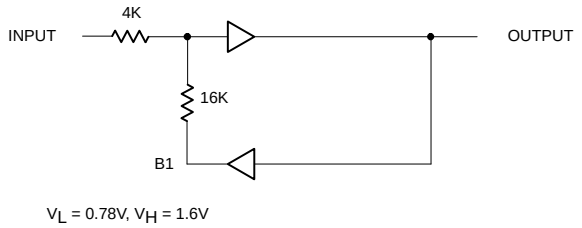
b. Using PLS153

SNAP LISTING SHOWING INVERTING SCHMITT TRIGGER FUNCTION.

```
@pinlist
input       i;
output      b
B1          o;
B2          o;

@logic equations
output      =       / input;
output.oe   =       1

B1.oe       =       output;
B1          =       0;

B2.oe       =       output
B2          =       1;
```

c. SNAP Equations

Figure 3. Inverting Schmitt Trigger



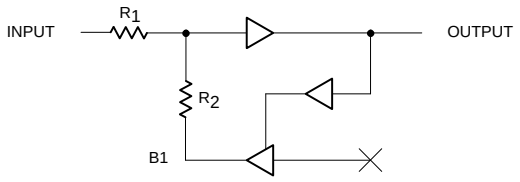
a.

SNAP LISTING SHOWING SCHMITT TRIGGER USING ONE I/O PIN TO PULL INPUT HIGH OR LOW.

```
@pinlist
input       i;
output      b
B1          o;

@logic equations
output      =       input;
output.oe   =       1

B1          =       output;
B1.oe       =       1;
```

b.

Figure 4. Schmitt Trigger Using One I/O Pin

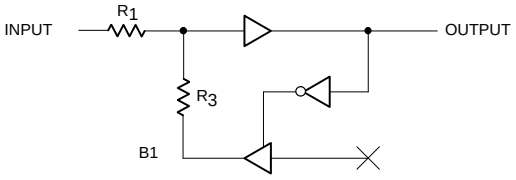


a. High Going Low Direction

SNAP LISTING FOR SCHMITT TRIGGER FUNCTION IN THE HIGH TO LOW DIRECTION ONLY.

```
@pinlist
input       i;
output      b
B1          o;

@logic equations
output      =       input;
output.oe   =       1

B.oe        =       output;
B1          =       1;
```

c.



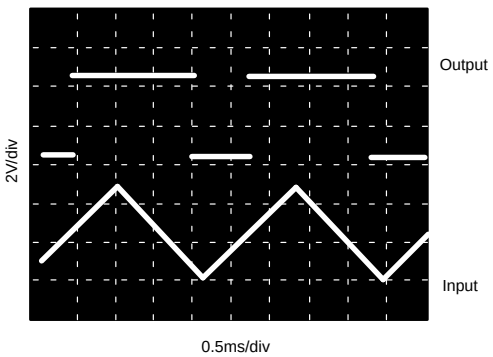
b. Low Going High Direction

SNAP LISTING FOR SCHMITT TRIGGER FUNCTION IN THE LOW TO HIGH DIRECTION ONLY.

```
@pinlist
input       i;
output      b
B1          o;

@logic equations
output      =       input;
output.oe   =       1

B1.oe       =       /output;
B1          =       1;
```

d.

Figure 5. Schmitt Trigger



NOTE:
R_1 = 3.9kΩ, R_2 = 10.8k..kΩ, R_3 = 2.0kΩ,
V_{CC} = 5.0V, Ambient temperature ≈ 25ºC

Figure 6. A Non-Inverting Schmitt Triggered Buffer