

Physics 3e

Assessable Practical

Number 2

“LED Chaser”

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ONE.

- a) The dual d-type flip flops count in binary to provide changing inputs to the NAND gates that ensure that only one of the outputs of the NAND's is low at any given time. This therefore activates its PnP transistor, making the LED's flash on and off in sequence and appear that they are chasing each other around in a circle.
- b) The first flip-flop receives the frequency input from the clock and because the Q-bar is connected to the Data input, the flip-flop toggles and therefore acts as a frequency divider, Q-bar only changing when the clock changes from low to high, therefore halving the frequency. The Q-bar output is the passed along to the next flip flop which also has it's Q-bar connected to its data input and so it divides the frequency further. This produces a two bit binary counter and therefore a unique combination of outputs is sent to the NAND's at all times.

TWO.

- a) The NAND gates receive the unique combinations of inputs from the d-type flip-flops. Because of the way that the inputs are wired from the outputs of the flip-flops, only one of the outputs of the nands is low at any given time, activating its transistor and therefor the LED.
- b) The NANDs receive the unique cycling outputs of the flip-flops and because NAND gates only go low when both its inputs are high the NAND's inputs accommodate for all the possible 2 bit combinations. Both inputs HIGH is a condition which is only possible for one NAND at a time, because of the way they are wired. When the NANDs are organized in the right order, the outputs appear to "chase". When the Q-bar outputs of the flip flops are HIGH, HIGH the inputs to the first NAND are both high and the output is low, causing the PnP transistor to be activated. When the Q-bar outputs are LOW, HIGH the second NAND is activated. When the outputs are HIGH, LOW, the third NAND gate is activated and when the flip-flop outputs are both LOW, the fourth NAND gate is activated.

THREE.

- a) The PnP transistors are turned on when the output from their respective NAND gates goes to LOW. When the transistors are activated they allow current to flow to the LED's, turning them on. The resistor protects the transistor from any harm from higher amperage and voltage from the former parts of the circuit.
- b) Because the transistors in this circuit are PnP transistors and not NpN, they are activated by a negative current or comparatively negative current being applied to their base rather than a positive one. When both the inputs of a NAND are high, a LOW is transmitted to the base of one of the transistors and it activates allowing the current to flow from the +9v to ground, through the 470 ohm resistor and then the LED's turning them on. The PnP transistors act effectively as an inverter, turning the LOW output from the NAND gates into a HIGH voltage, which can power the

LED's. The transistors are needed because if you try and power four LED's off the output of a logic gate, it will pull too much current through it and it will blow the IC. The resistors before the transistors are there to protect the transistors from damage when the NAND is not activated and the output is HIGH. If the resistor was not there, when the high voltages were applied to the base of the PnP transistor it would blow.

FOUR.

- a) When the NANDs activate the transistors and the current is allowed to flow through the LED's, they turn on and provide the light chasing effect. The resistors reduce the current that flows through the LED's to protect them from damage.
- b) When the LED's are arranged in the order of one of the LED's of set 1, then one of the LED's of set 2, then 3, then 4 then repeat as in the diagram. When they are in this order and the circuit is activated it will appear that there are four LED's chasing each other around the circle. The resistors impede the current going to the LED's to stop too much voltage going to them and causing them to burn out.

