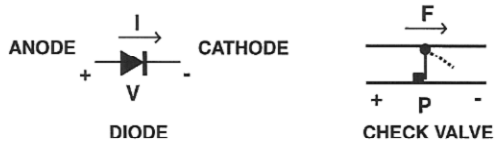
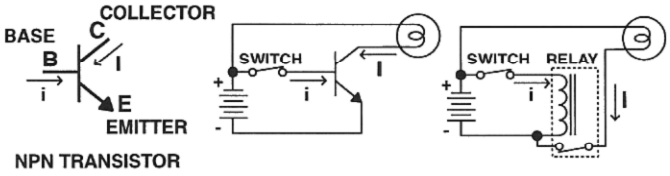
DIODE AND TRANSISTOR BASICS BY JOE BARBETTA REV. A 02/10/97

A CHECK VALVE FOR CURRENT



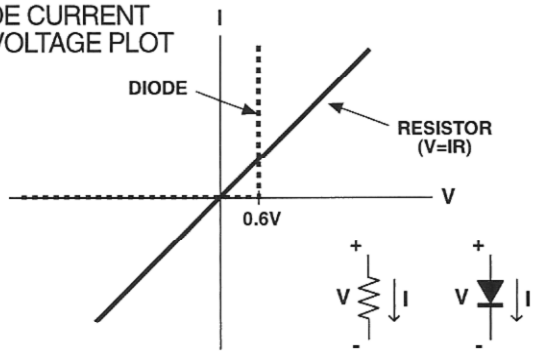
A **CHECK VALVE** IS A DEVICE THAT LIMITS THE FLOW OF A FLUID TO ONE DIRECTION. IF PRESSURE IS APPLIED ACCROSS A CHECK VALVE IN THE WRONG DIRECTION THE FLAP WILL BE PUSHED CLOSED AND THE FLOW WILL BE ZERO. CURRENT WILL ONLY FLOW THROUGH A DIODE IF A **FORWARD BIASED** VOLTAGE IS APPLIED ACROSS IT. THE VOLTAGE AT THE + SIDE (**ANODE**) SHOULD BE BE GREATER THAN AT THE - SIDE (**CATHODE**) FOR CURRENT TO FLOW.

THE TRANSISTOR IS AN ELECTRONIC SWITCH



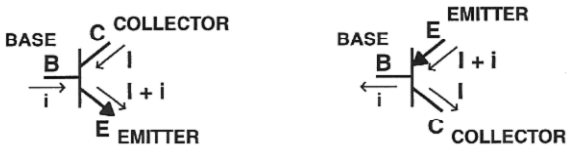
A **TRANSISTOR** CONTROLS A LARGE **CURRENT** (I) ENTERING ITS **COLLECTOR** WITH A SMALL CURRENT (i) ENTERING ITS **BASE** JUST AS A SMALL CURRENT IN A **RELAY'S COIL** CONTROLS A LARGE CURRENT THROUGH ITS **CONTACTS**. THE ABOVE 2 CIRCUITS DEMONSTRATE HOW EITHER A TRANSISTOR OR A RELAY CAN BE USED TO TURN ON A LAMP WHEN A SWITCH IS CLOSED.

DIODE CURRENT VS. VOLTAGE PLOT



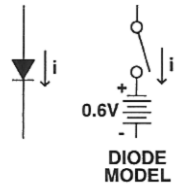
THE DIODE NEEDS A SMALL VOLTAGE FOR A CURRENT FLOW TO START. THINK OF THE PRESSURE NEEDED TO OPEN THE FLAP OF A CHECK VALVE. A **SILICON** DIODE NEEDS A **FORWARD VOLTAGE** OF AROUND **0.6V** FOR CURRENT TO FLOW. THE ABOVE GRAPH SHOWS THAT WHEN THE VOLTAGE ACROSS THE DIODE IS NEGATIVE OR LESS THAN 0.6V, NO CURRENT WILL FLOW. CONTRAST THIS OPERATION TO THAT OF A **LINEAR** DEVICE SUCH AS A RESISTOR. ITS CURRENT REVERSES AS ITS VOLTAGE DOES. THE DIODE IS A **NON-LINEAR** DEVICE BECAUSE OF THE ABRUPT CHANGE IN ITS CURVE.

NPN VS. PNP THE TWO TRANSISTOR STRUCTURES



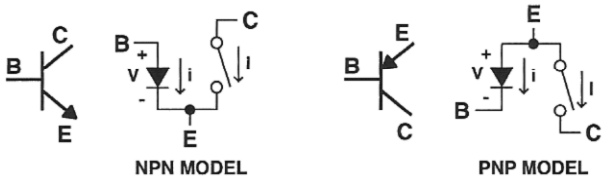
THE **PNP TRANSISTOR** OPERATES WITH CURRENTS THROUGH EACH OF ITS TERMINALS OPPOSITE TO THAT OF AN **NPN TRANSISTOR**. THE PNP **SCHEMATIC SYMBOL** HAS THE **EMITTER** ARROW OPPOSITE TO THAT OF THE NPN AND IS TYPICALLY DRAWN WITH THE EMITTER ON TOP. ON BOTH SYMBOLS, THE ARROW ON THE EMITTER SHOWS ITS CURRENT DIRECTION.

MODELING THE DIODE

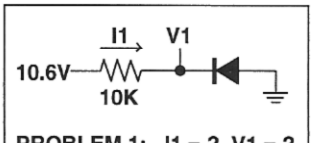


THE DIODE CAN BE MODELLED AS A SWITCH AND A BATTERY WITH A VOLTAGE EQUAL TO THAT OF THE FORWARD VOLTAGE. WHEN THE DIODE IS **FORWARD BIASED** (CONDUCTING CURRENT), THIS SWITCH IS CLOSED AND THE BATTERY'S VOLTAGE IS PRESENT FROM ANODE TO CATHODE. THIS SWITCH IS OPEN WHEN THE DIODE IS **REVERSED BIASED**, THUS NO CURRENT WILL FLOW AND THE BATTERY'S VOLTAGE WILL NOT BE SEEN.

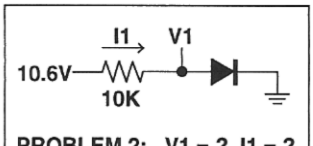
TRANSISTOR MODELS



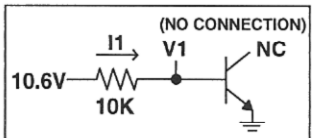
BOTH TRANSISTOR TYPES CAN BE SIMPLIFIED TO A MODEL COMPRISING A DIODE AND A SWITCH. WHEN CURRENT FLOWS THROUGH THE DIODE, THE SWITCH IS CLOSED. THIS IS CALLED **SATURATION**. IF NO CURRENT IS FLOWING THROUGH THE DIODE, THE SWITCH IS OPEN. THIS IS CALLED **CUTOFF**. REMEMBER THE DIODE'S CHARACTERISTICS. THIS DIODE NEEDS A VOLTAGE OF 0.6V FOR CURRENT TO FLOW, SO FOR THE NPN TRANSISTOR THE BASE VOLTAGE MUST BE > 0.6V RELATIVE TO THE EMITTER FOR THE SWITCH TO CLOSE.



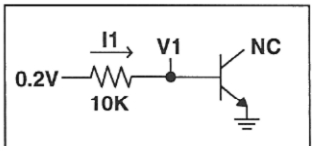
PROBLEM 1: I1 = ?, V1 = ?



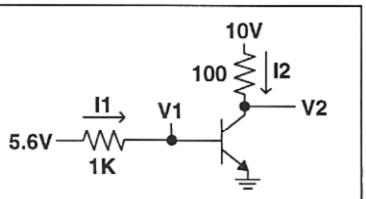
PROBLEM 2: V1 = ?, I1 = ?



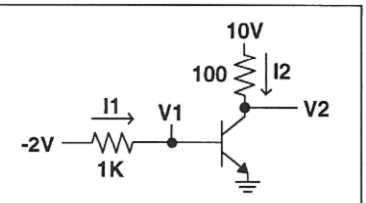
PROBLEM 3: V1 = ?, I1 = ?



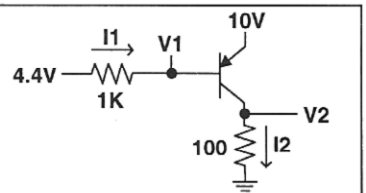
PROBLEM 4: I1 = ?, V1 = ?



PROBLEM 5: V1=?, I1=?, V2=?, I2=?

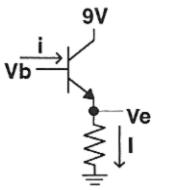


PROBLEM 6: I1=?, V1=?, V2=?, I2=?

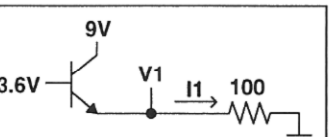


PROBLEM 7: V1=?, I1=?, V2=?, I2=?

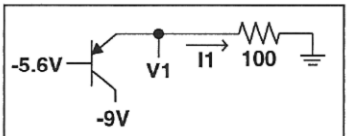
EMITTER FOLLOWER



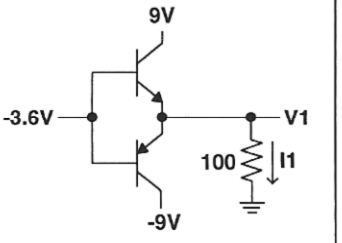
WHEN THE EMITTER OF A TRANSISTOR IS NOT CONNECTED DIRECTLY TO **GROUND** OR A VOLTAGE SOURCE, THE TRANSISTOR IS PROBABLY BEING USED AS AN **EMITTER FOLLOWER**. IN THIS CASE THE SWITCH USED IN THE MODEL MAY NOT BE FULLY OPEN OR CLOSED. THE TRANSISTOR MAY BE REACHING A STATE OF EQUILIBRIUM IN WHICH THE EMITTER VOLTAGE WILL FOLLOW THE BASE VOLTAGE MINUS THE 0.6V. Ve = Vb - 0.6V



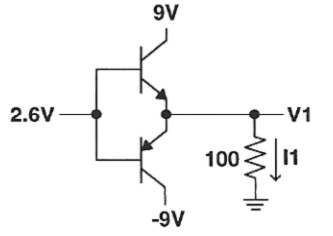
PROBLEM 8: V1 = ?, I1 = ?



PROBLEM 9: V1 = ?, I1 = ?



PROBLEM 10: V1 = ?, I1 = ?



PROBLEM 11: V1 = ?, I1 = ?

1: I1=0A, V1=10.6V 2: V1=0.6V, I1=1mA 3: V1=0.6V, I1=1mA 4: I1=0A, V1=0.2V 5: V1=0.6V, I1=5mA, V2=0V, I2=100mA 6: I1=0A, V1=-2V, I2=0A, V2=10V
7: V1=9.4V, I1=-5mA, V2=10V, I2=100mA 8: V1=3V, I1=30mA 9: V1=-5V, I1=-50mA 10: V1=-3V, I1=-30mA 11: V1=2V, I1=20mA