**Transistor Relay Driver Demo**

The basic transistor relay driver circuit is shown in fig. A. In fig. B we've added ammeters to measure the base and collector currents as well as voltmeters to measure the voltage across the transistor and the relay coil.

The following lists the input condition (i.e. the battery voltage) and all other voltages and currents. Note: The relay coil voltage and the transistor voltage must add up to the power supply voltage (10V in this case). We'll assume the relay coil has a DC resistance of 50Ω, the transistor has a gain ($h_{fe}$) of 100, and $V_{be} = 0.7V$ when forward biased.

- **Vbat = 0:** $I_{base} = 0$ so $I_{colletor} = 0$ so $V_{coil} = 0$ and $V_{transistor} = 10V$
- **Vbat = 1V:** $I_b = 30uA$ so $I_c = 30mA$ so $V_{coil} = 1.5V$ and $V_{trans} = 8.5V$
- **Vbat = 2V:** $I_b = 130uA$ so $I_c = 130mA$ so $V_{coil} = 6.5V$ and $V_{trans} = 3.5V$
- **Vbat = 3V:** $I_b = 230uA$, $I_c$ wants to be 230mA which would make $V_{coil} = 11.5V$

(Note: The coil voltage can't be larger than the power supply voltage so the transistor is saturated)

- **Vbat = 3V:** $I_b = 230uA$, $V_{trans} = 0.2V$ leaving $V_{coil} = 9.8V$ & $I_c = 196mA$.

Any further increase in $I_b$ won't put any more current through the relay coil.

In reality the DC gain ($h_{fe}$) can vary a lot as the collector current changes and won't be 100 for all collector currents. According to the datasheet the gain drops off substantially at high currents (Ex: $h_{fe} = 30$ when $I_c = 100mA$).

**Ex:** Trans is fully on (i.e. saturated), $V_{trans} = 0.2V$ and $V_{coil} = 9.8V$

- $I_c = 196mA$ (9.8V/50Ω)
- $I_b = 6.5mA$ ($I_c/30$)
- $V_{bat} = 65V$ ($V_{bat}/10KΩ$) (neglect 0.7V $V_{be}$)

Since 65V is much higher than needed the base resistor should be reduced to say 1KΩ where $V_{bat}=6.5V$ would be enough to saturate the transistor.