<u>ELEC1</u>: <u>Introductory Electronics</u> – Revision Notes (April 2016) **Milo Noblet**, milo.me.uk

Knowledge of subsystem division and voltage, current, resistance and power is assumed.

DIODES

Silicon Diode

- V_{FWD} = ~0.7V
- once conducting a very small increase in voltage allows a larger increase in current

Light-emitting diode

- V_{FWD} = ~1.8V, though dependent on other factors
- I_{FWD} = ~20mA
- If reverse bias voltage > ~5V, then the LED is likely to be damaged
- will often need a protective current-limiting resistor to allow it to be used with higher voltages. Calculate using V/I=R where V = V_S-V_F and I = 20mA
- maximum value for R should be next highest preferred value

Zener diodes

- V_{FWD} = ~ 0.7V
- $V_{BREAKDOWN}$ = 2.7V up to 200V – depends on the diode
- Zener diodes provide a cheap way of making a stabilised power supply. It behaves in such a way that as the reverse voltage reaches V_B the reverse current increases suddenly.
- After V_B the reverse current is limited by a series resistor so that V_Z (V across the Zener) remains constant over a wide range of currents
- Zeners can also be used to prevent the voltage difference in a system exceeding a chosen value, or to reduce a voltage by a certain amount irrespective of current flowing.

- To calculate min value of R we need:
  - max input V; max power dissipation; min current; max current (from power rating)

$$I_{Z(\text{max.})} = \frac{P_{max.}}{V_Z} \quad \text{thus} \quad I_{load} = I_Z - I_{min}, \quad R = \frac{V_{max} - V_Z}{I_Z}$$

If the output is short circuited, $\max current = \frac{V_{max.}}{R}$

Under <u>normal</u> conditions, $P_R = I_Z \times (V_{max} - V_Z)$

Under <u>short circuit</u>, $P_R = I_Z \times V_{max}$

RESISTIVE INPUT TRANSDUCERS

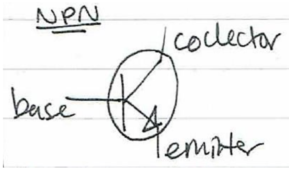
- LDR: as light level increases, LDR's resistance decreases
- NTC thermistor: as temperature increases, resistance decreases
- when used in a potential divider circuit, we can calibrate such that a certain output voltage occurs at a certain light level or temperature

$$V_R = V_S \times \frac{R}{R_{total}}$$

- Having the input transducer on the top of the potential divider gives a higher V_{OUT} as it's hotter/lighter, whereas having it on the bottom gives higher V_{OUT} as colder/darker.

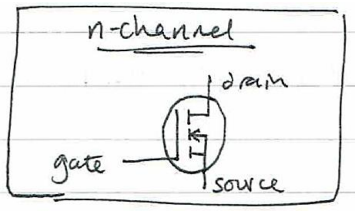
TRANSISTORS AND MOSFETS

(Bipolar) Junction Transistor



- npn amplifies a positive current
- pnp amplifies a negative current
- in normal operation, behaves like a forward biased diode – hence voltage of 0.7V between base and emitter when collector current passes
- transistor as a switch: V_{IN}<0.5V = 'off', V_{IN}>0.7V = 'on'
- base resistor protects the base from too much current
- BJTs are current controlled

(Enhancement mode) MOSFET



- n-channel: positive current, p-channel: negative current
- voltage operated, high input resistance and so high current gain
- MOSFET switches at about 2V
- unlike BJT has positive thermal coefficient – if temperature increases, resistance from drain to source increases, thus decreasing drain current flowing
- tend to be more expensive than BJTs

OUTPUT DEVICES

Electromagnetic relay

'Pull-in' current creates a magnetic field through a solenoid which attracts an armature to switch from NC (normally closed) contact to NO (normally open). When current reduced to 'drop-out' current, relay switches back to initial state.

When current to relay switched off, get large induced voltage due to energy stored in the solenoid's magnetic field (it's essentially an inductor), often known as back e.m.f. This high induced voltage will damage the transistor used to switch the relay.

To protect semiconductor devices switching any inductive load, we connect a protective diode in reverse bias around the load, offering an easy path for the induced voltage.

Solenoid

When solenoid energised, soft iron armature pulled into the coil, compressing the return spring. When de-energised, the spring pushes the armature back out.

Buzzer: piezoelectric, or old-fashioned bell + iron armature

Motors: inductive load, dc: direction depends on polarity

7-seg displays

1. common anode – all connected to +V
2. common cathode – all connected to 0V

choose the right IC!

Remember resistors needed. One per LED allows having multiple segments on at once and them all being at full brightness, whereas a common resistor means current limited for all and can end up with reduced brightness.

OP-AMPS

Properties

Ideal	Reality
open loop gain very large	depends on frequency
max output V = V_S	about 2V less
infinite input impedance so no current into terminals	a few nA may flow
zero output impedance so can supply any required current	designed to limit output I to a few mA
V_{OUT} = 0 when both inputs equal	small offset V, needs a variable resistor to balance out

$$V_{out} = A_{OL} \times (V_+ - V_-)$$

- op-amp multiples difference between the inputs by the open loop gain, approx. 100 000. If V_+ higher, will saturate at V_S, but if V_- higher, saturate at 0V / $-V_S$
- difference greater than about 10µV will lead to saturation
- when using a single rail supply, caution should be taken over the op-amps 'real' output voltage eg ~2V when saturated to low might mean an LED might light – would need resistor to correct

LOGIC GATES AND BOOLEAN ALGEBRA

AND	$Q = A \cdot B$
NAND	$Q = \overline{A \cdot B}$
OR	$Q = A + B$
NOR	$Q = \overline{A + B}$
X-OR	$Q = A \oplus B$
X-NOR	$Q = \overline{A \oplus B}$
NOT	$Q = \overline{A}$

Boolean algebra laws

$$A + B = B + A$$
$$A \cdot B = B \cdot A$$
$$A + (B + C) = (A + B) + C$$
$$A \cdot (B \cdot C) = (A \cdot B) \cdot C$$

Boolean identities

$A \cdot A = A$	$A + A = A$
$A \cdot \overline{A} = 0$	$A + \overline{A} = 1$
$A \cdot 1 = A$	$A + 1 = 1$
$A \cdot 0 = 0$	$A + 0 = A$
$A + A \cdot B = A$	$A \cdot (A + B) = A$
$\overline{\overline{A}} = A$	$A \cdot \overline{B} + \overline{A} \cdot B = A \oplus B$

When working with Boolean, remember: *'break the line, change the sign'* (or make etc)

Simplify using Boolean identities or the superior Karnaugh map (make pairs, OR all the pairs together).