Electricity And Electrical Safety

Dr Shiv Kumar Singh
Consultant Anaesthesia
Royal Liverpool University Hospital

shiv.singh@rlbuht.nhs.uk  shvkmrsngh@aol.com
"Knowledge is of two kinds: We know a subject ourselves, or we know where we can find information about it."

Samuel Johnson
Today’s Lec

• Basics of electricity
• Electrical and electronic components in anaesthesia equipments
• Electrical Safety: Principles and examples
• Electrical symbols: What do they mean and importance
• Diathermy: Principle and electrical safety issues
Basics of Electricity

Conductors, insulators and semiconductors

Current, Voltage & Resistance
Conductors, Insulators and Semi-conductors
Electric Field Direction

Conduction Band

Forbidden Band

Valence Band (Filled)

Hole
Current flow
Electrons

Shiv K Singh
shvkmrsgnh@aol.com
Relation between current, voltage and resistance?

Ohm’s law
$I = \frac{V}{R}$
$V = I \times R$
The power supply
R.M.S and Peak voltage

• U.K main Voltage:
  230V  [ 253 V (+10%) and 216 V (-6%)]

• R.M.S value of the voltage.

• The Peak Voltage:
  1.413 (√2) x 240 V i.e 340 V
Root mean square potential
Electricity

Components & applications
Capacitors
Q \propto V \rightarrow \text{Capacitance (C)} = \frac{Q}{V}

1 \text{ F} = 1 \text{ Coulomb} / 1 \text{ Volt}
Area Separation Capacitance

Area (A) Separation (d)
Energy stored

$E = Q \times V$

$Q \propto V \Rightarrow C = \frac{Q}{V}$ or $Q = C \times V$

Area = Work done

$= \frac{1}{2} Q \times V$

But $Q = CV \Rightarrow$ Energy stored $= \frac{1}{2} CV^2$
Charge $Q$

Voltage $V$

$E = \frac{1}{2} Q \times V$

$Q \propto V \Rightarrow C = \frac{Q}{V}$ or $Q = C \times V$

Area = Work done

$= \frac{1}{2} Q \times V$

But $Q = CV \Rightarrow$ Energy stored $(E) = \frac{1}{2} CV^2$
Capacitance and interference

50 Hz

Capacitance link

INSULATOR
Inductors

Shiv K Singh
shvkmrsngh@aol.com
Inductors

Magnetic field
Continuous alternating current through an inductor produces a continuously varying magnetic field upon switching.
Inductance and interference

Diathermy
Oscillator

CAPACITOR

INDUCTOR

MAGNETIC FIELD
Reactance and Frequency

Capacitors
And
Inductors
Transformers

Application of Inductance
\[ \frac{V_P}{V_S} = \frac{N_P}{N_S} \]

\[ V_S = V_P \times \frac{N_S}{N_P} \]
Diodes

Semiconductors
Diodes
Bridge Rectifier

Input

Positive cycle

Negative cycle

Output
Defibrillators

Circuit

Waveforms
5000-9000 V

Diode

Inductor
Monophasic

Current (Amps)

Time (msecs)

Damped sine wave
Biphasic

Biphasic Truncated Exponential - BTE (SMART, Philips)
Biphasic

Rectilinear Biphasic waveform (Zoll)
Biological signals

Amplifiers

&

Filters
Amplifiers

Device that responds to a small input signal (current, voltage, power) and delivers a larger output signal that contains the essential waveform features of the input signal.
Single ended pre-amplifier

Input

Amp

Output

Ref earth
Single ended pre-amplifier

Input

Amp

Output

Ref earth
Differential / balanced pre-amplifier

Input
- Inverting
- Non-Inverting

Ref earth

Amp

Output
Differential / balanced pre-amplifier

Inputs

Ref earth

Noise

Amp

Output

Noise
Input

\[\text{Non Inv} \quad \text{Inv} \quad \text{Non} \quad \text{Inv} \quad \text{Inv} \quad \text{Non} \quad \text{Inv} \quad \text{Inv} \]

Amp

Output

\[\uparrow \quad \downarrow \quad \uparrow \quad \downarrow \quad \uparrow \]
Differential / balanced pre-amplifier

Ref earth

Input

Output

RA
LA
LL

I
II
III
Interference

COMMON MODE REJECTION
Filters

What are they?
Why do we need them?
Filters

Arrangement of electronic components that allow only those electric waves lying within a certain range, or band, of frequencies to pass and block others.
High pass circuit
Low pass circuit
Band pass circuit
Amplifier

High f

Low f
Filters & amplifiers

Channel → Filter

Volume? → Amplifier
Resistances

Wheatstone Bridge
\[
\frac{R_1}{R_2} = \frac{R_3}{R_4}
\]
\[
\frac{R_1}{R_2} = \frac{R_v}{R_m}
\]

\[
R_m = \frac{R_2}{R_1} \cdot R_v
\]
SIMPLE CIRCUIT

BULB

BATTERY

SWITCH