REDUCING THE EFFECT OF COUPLING IN SIGNAL AND CONTROL CABLES

WHERE THERE IS A COMBINATION OF POWER, LIGHTING, CONTROL INSTRUMENTATION AND COMMUNICATION CABLES, THE CABLE LAY OUT SHOULD BE DESIGNED AS FAR AS POSSIBLE TO AVOID (OR) REDUCE THE EFFECTS OF CAPACITIVE AND INDUCTIVE COUPLING.

- REMOVAL OF THE CAUSES OF COUPLED NOISE AND INTERFERENCE
- SHIELDING THE ELECTRONIC CIRCUITS FROM THE SOURCE OF NOISE AND INTERFERENCE
- REDUCING THE EFFECT OF COUPLED NOISE AND INTERFERENCE.

ELECTRICAL SHIELDING

THE WALL OF BUILDING OF A CONTROL ROOM (OR) OF A METAL ENCLOSURES (CABINET (OR) PANEL) COULD BE DESIGNED AS THE EQUIPOTENTIAL BOUNDARY BETWEEN ZONES OF DIFFERENT ELECTROMAGNETIC ENVIRONMENTS.

ELECTROMAGNETIC SHIELD FOR

- METALLIC EQUIPMENTS, ENCLOSURES AND CABINETS
- THE WALL OF EQUIPMENT ROOM
- STRUCTURAL STEEL IN STEEL BUILDING
- REINFORCING STEEL IN REINFORCED CONCRETE MUST BE PROVIDED

SURGE

AT THE
MUST BE
- SCREENIN
PATHS B
- ONCE A
DESIGN
THAT

SP
SP

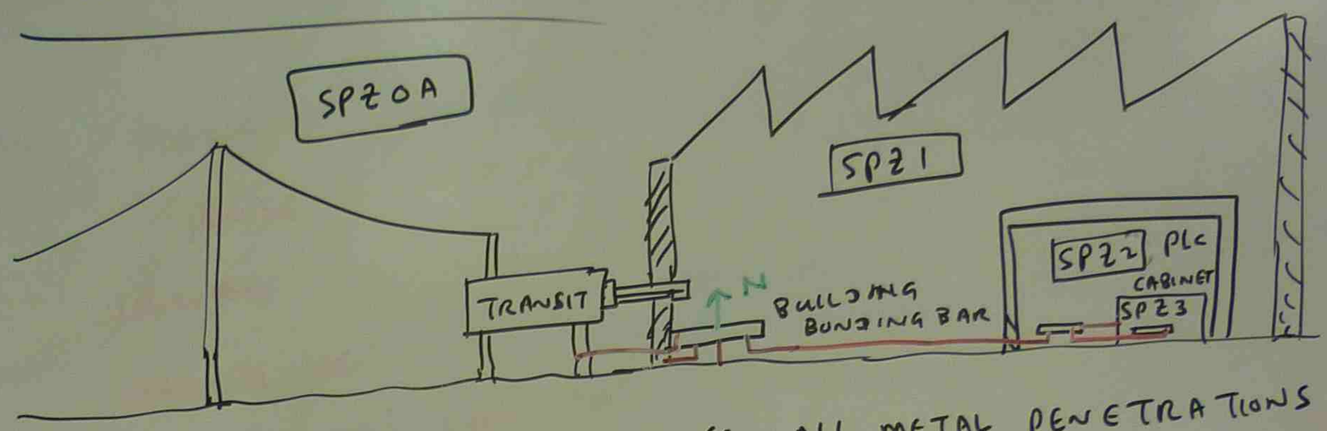
ROL INSTRUMENTATION
NED AS FAR AS
AND INDUCTIVE COUPLING.
ENCE
NOISE AND INTERFERENCE

F A METAL ENCLOSURES
EQUIPOTENTIAL BOUNDARY
URONMENTS.

ABINETS

ONCRETE MUST BE PROVIDED

SURGE PROTECTION ZONES

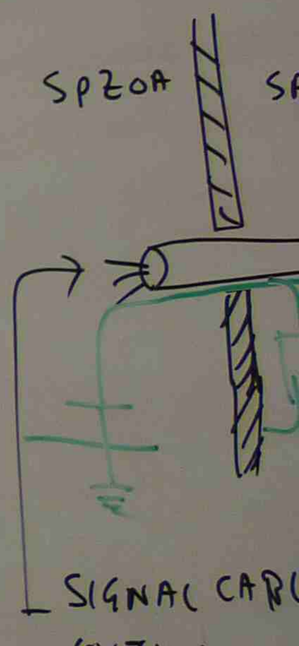


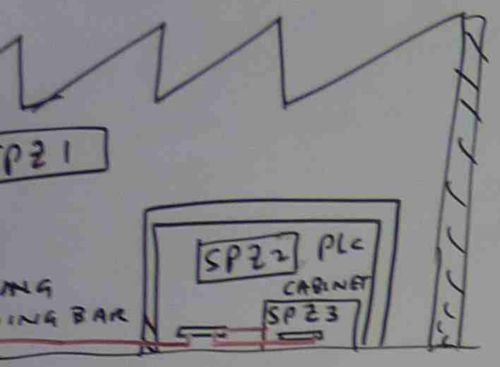
- AT THE BOUNDARY OF THE ZONES, ALL METAL PENETRATIONS MUST BE BONDED TO EARTH.
- SCREENING MEASURES MUST BE INTRODUCED FOR ELECTRICAL PATHS BETWEEN ZONES.
- ONCE A ZONE IS DEFINED, THE ELECTRICAL SYSTEM MUST BE DESIGNED, INSTALLED AND MAINTAINED IN SUCH A MANNER THAT THE ZONE DEFINITIONS REMAIN TRUE.

SPZ0A - AREA of DIRECT LIGHTNING STRIKE
SPZ1 - AREA of NO DIRECT LIGHTNING STRIKE BUT WITH CURRENT ON CONDUCTIVE PARTS AND ELECTROMAGNETIC FIELDS ATTENUATED WITH RESPECT TO SPZ0A

SPZ2 - AREA O
BUT W
AND ELE
WITH RE

SPZ3 - AREA OF
WITH C
ELECTRO
RESPECT





METAL PENETRATIONS

RODUCED FOR ELECTRICAL

ERICAL SYSTEM MUST BE

ED IN SUCH A MANNER

TRUE.

IGHTNING STRIKE

T LIGHTNING STRIKE

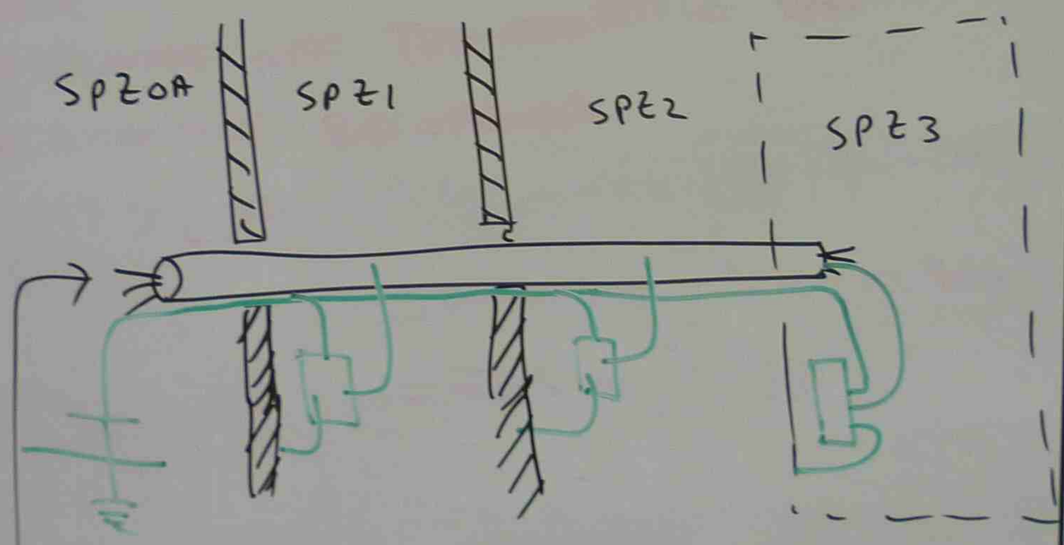
ON CONDUCTIVE PARTS AND

ELDS ATTENUATED WITH

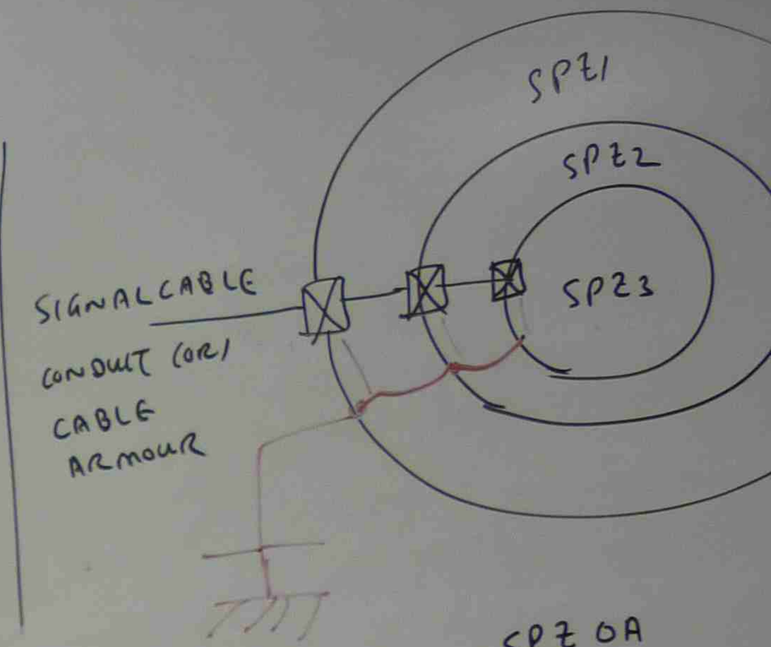
A

SPZ2 – AREA of NO DIRECT LIGHTNING STRIKE BUT WITH CURRENTS ON CONDUCTIVE PARTS AND ELECTROMAGNETIC FIELD ATTENUATED WITH RESPECT TO SPZ1

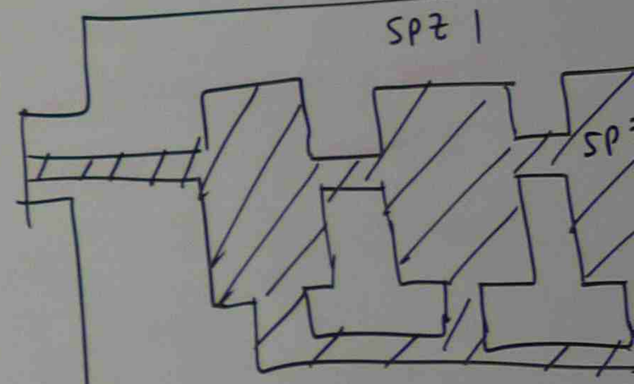
SPZ3 – AREA OF NO DIRECT LIGHTNING STRIKE BUT WITH CURRENT ON CONDUCTIVE PARTS & ELECTROMAGNETIC FIELD ATTENUATED WITH RESPECT TO SPZ2.



SIGNAL CABLE IS INSIDE A GALVANICALLY CONTINUOUS STEEL CONDUIT. (OR) STEEL WIRE



SPZ OA



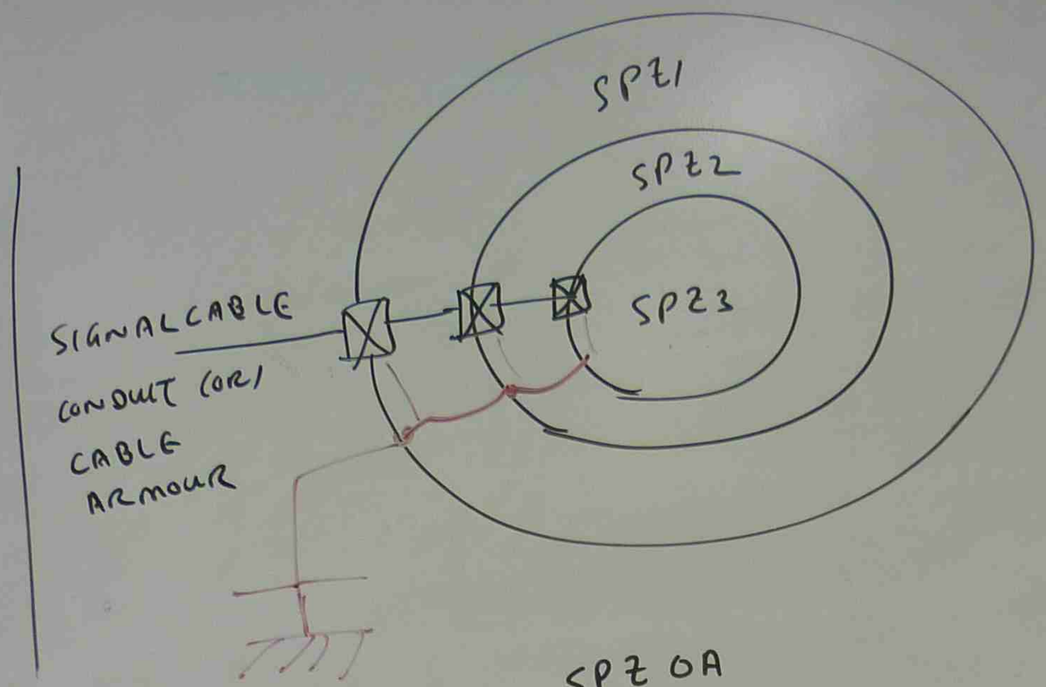
ARMOURED. (SWA)

RECT LIGHTNING STRIKE
ENTS ON CONDUCTIVE PARTS
NETIC FIELD ATTENUATED
SPZ1

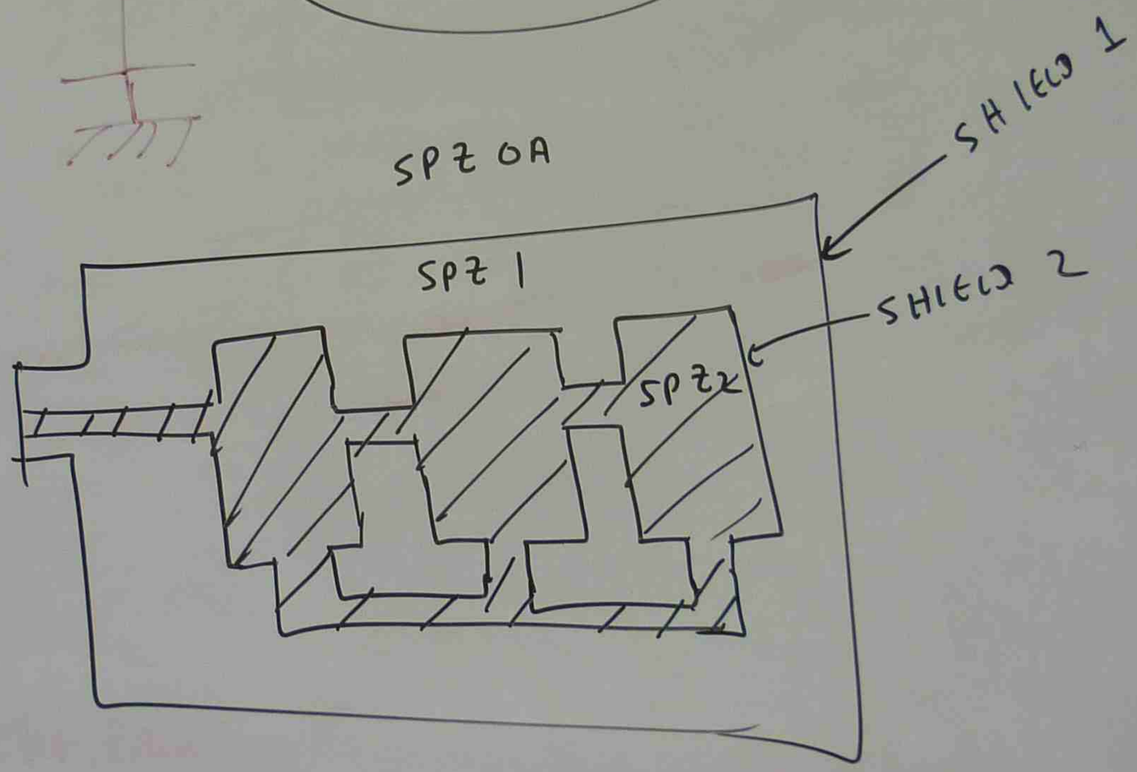
T LIGHTNING STRIKE BUT
ON CONDUCTIVE PARTS &
C FIELD ATTENUATED WITH
SPZ2.

SPZ2
SPZ3

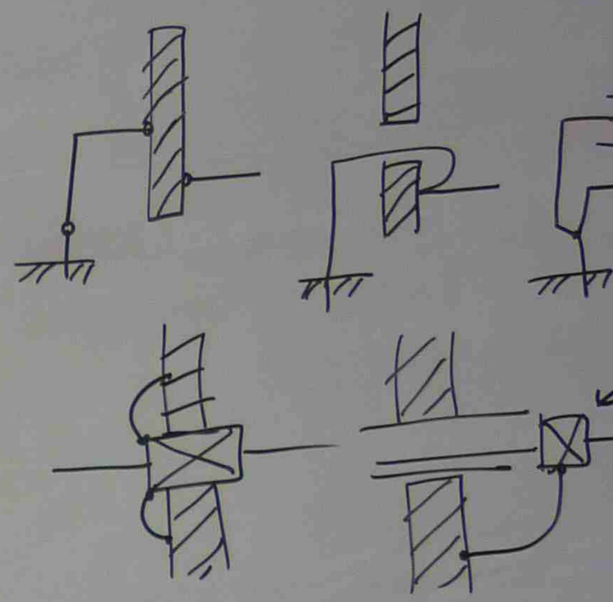
DE A GALVANICALLY
DUIT. (OR) STEEL WIRE



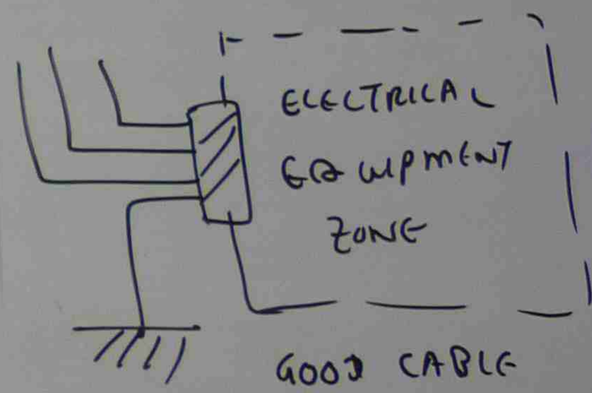
ARMOURED. (SWA)



CONNECTION of EARTHING CONDUCT



CONNECTION METHODS OF

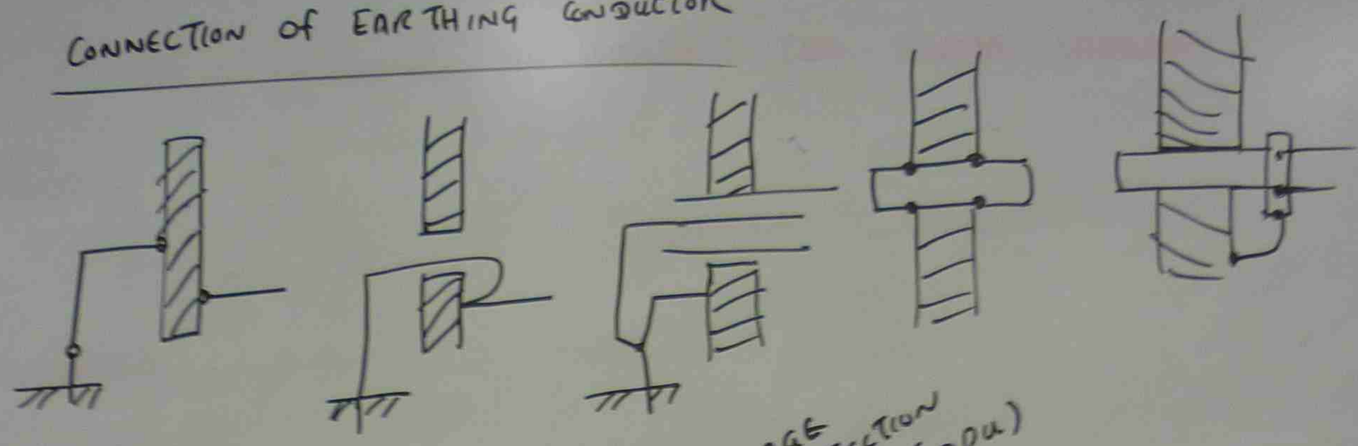


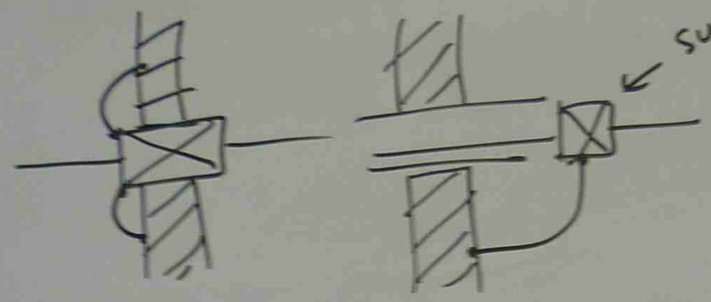
SHIELD 1

SHIELD 2

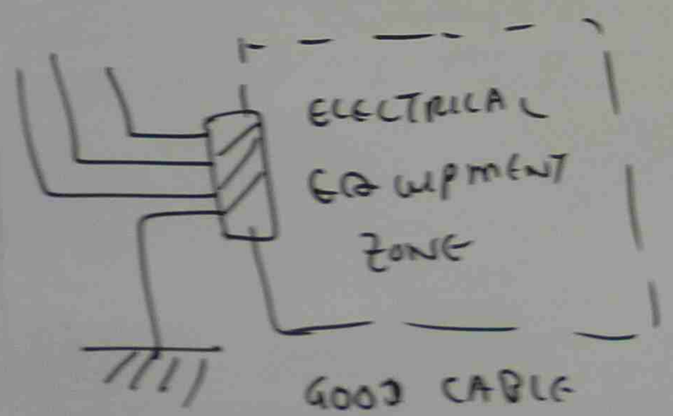
SPZ2

CONNECTION of EARTHING CONDUCTOR

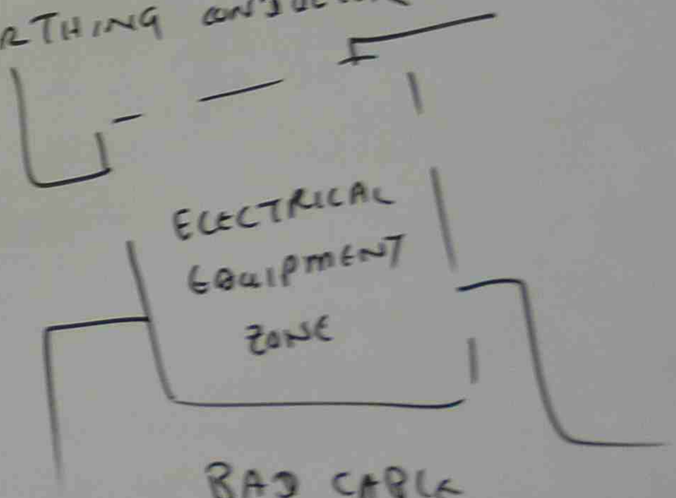




CONNECTION METHODS of EARTHING CONDUCTOR

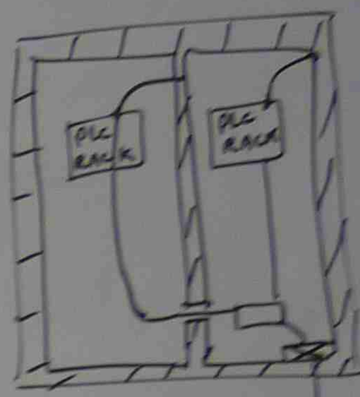


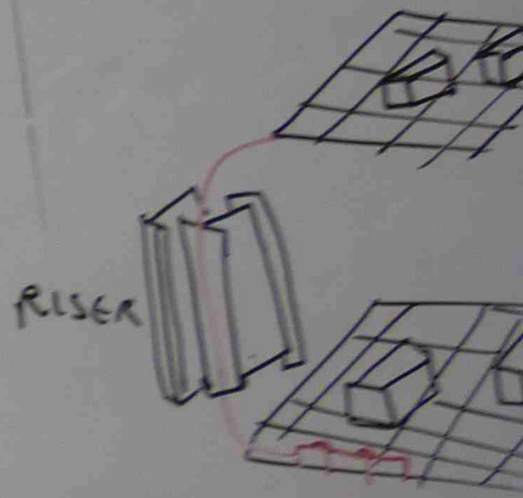
GOOD CABLE TERMINATION

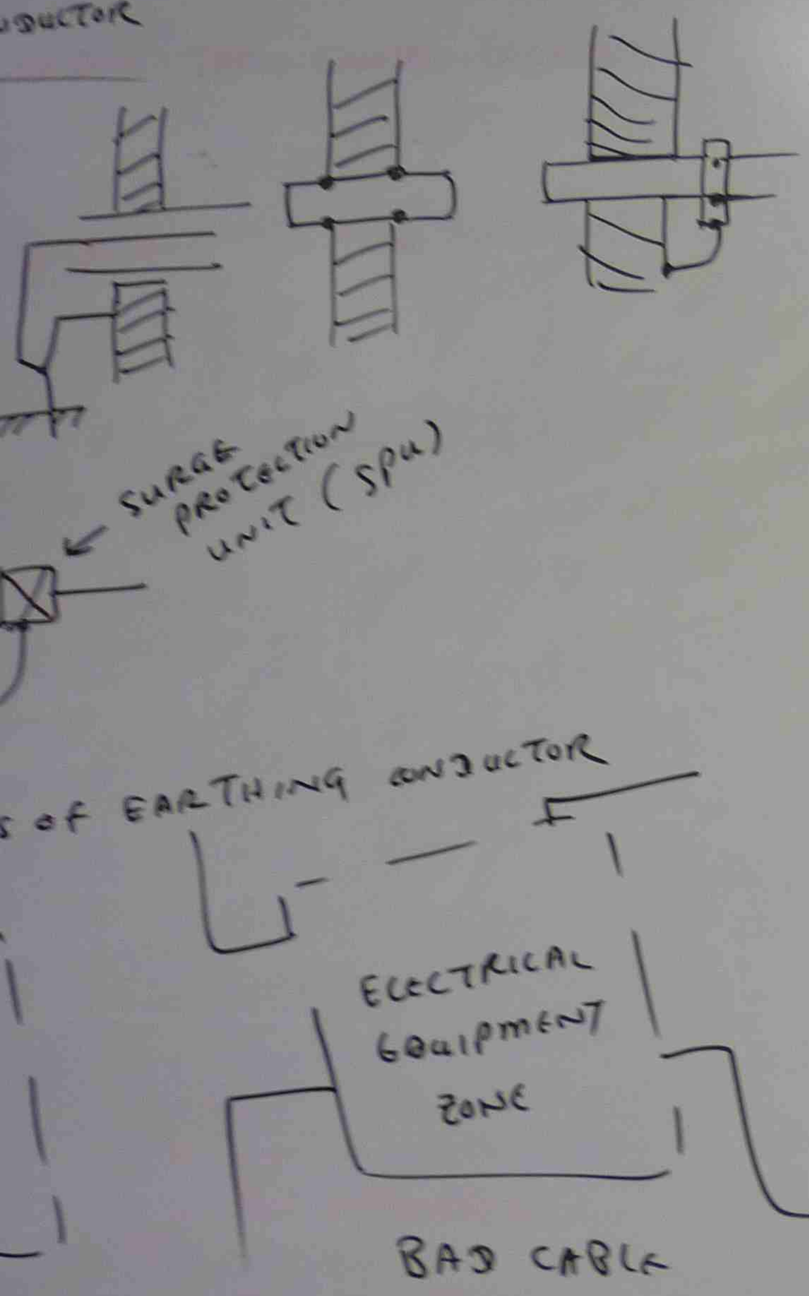


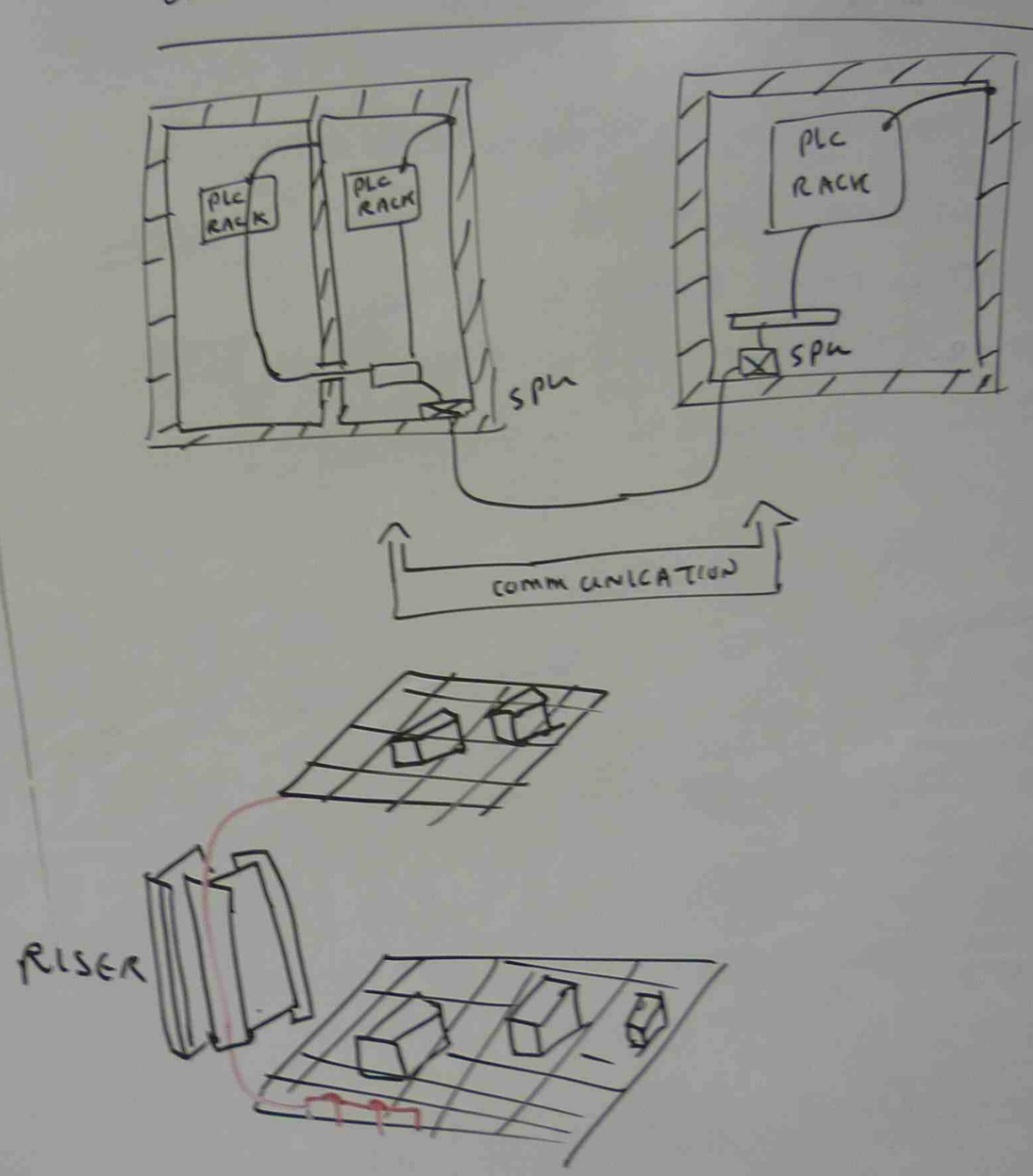
BAD CABLE TERMINATION.

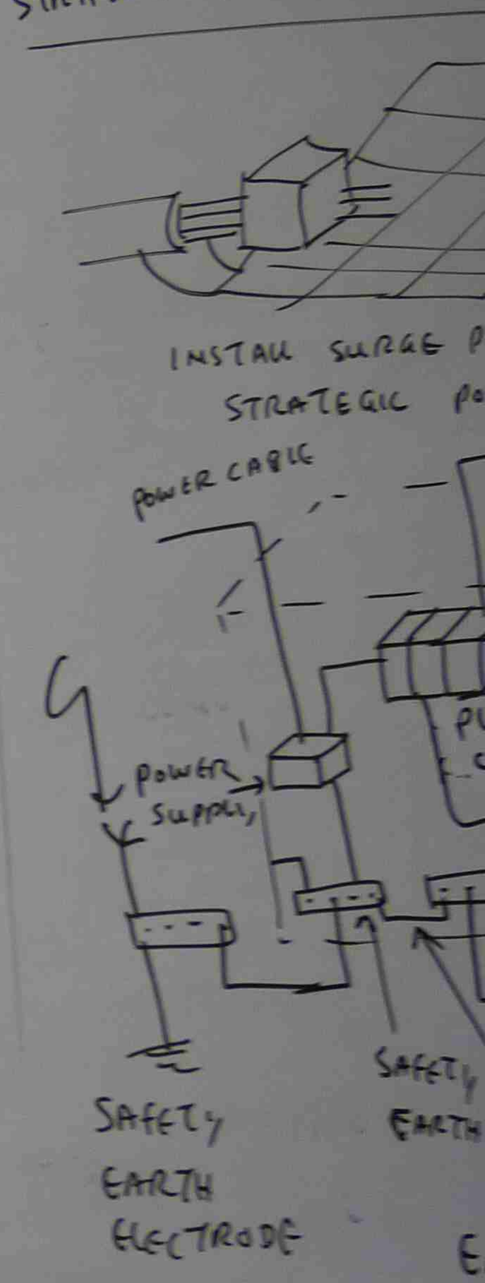
BONDING of ELECTR



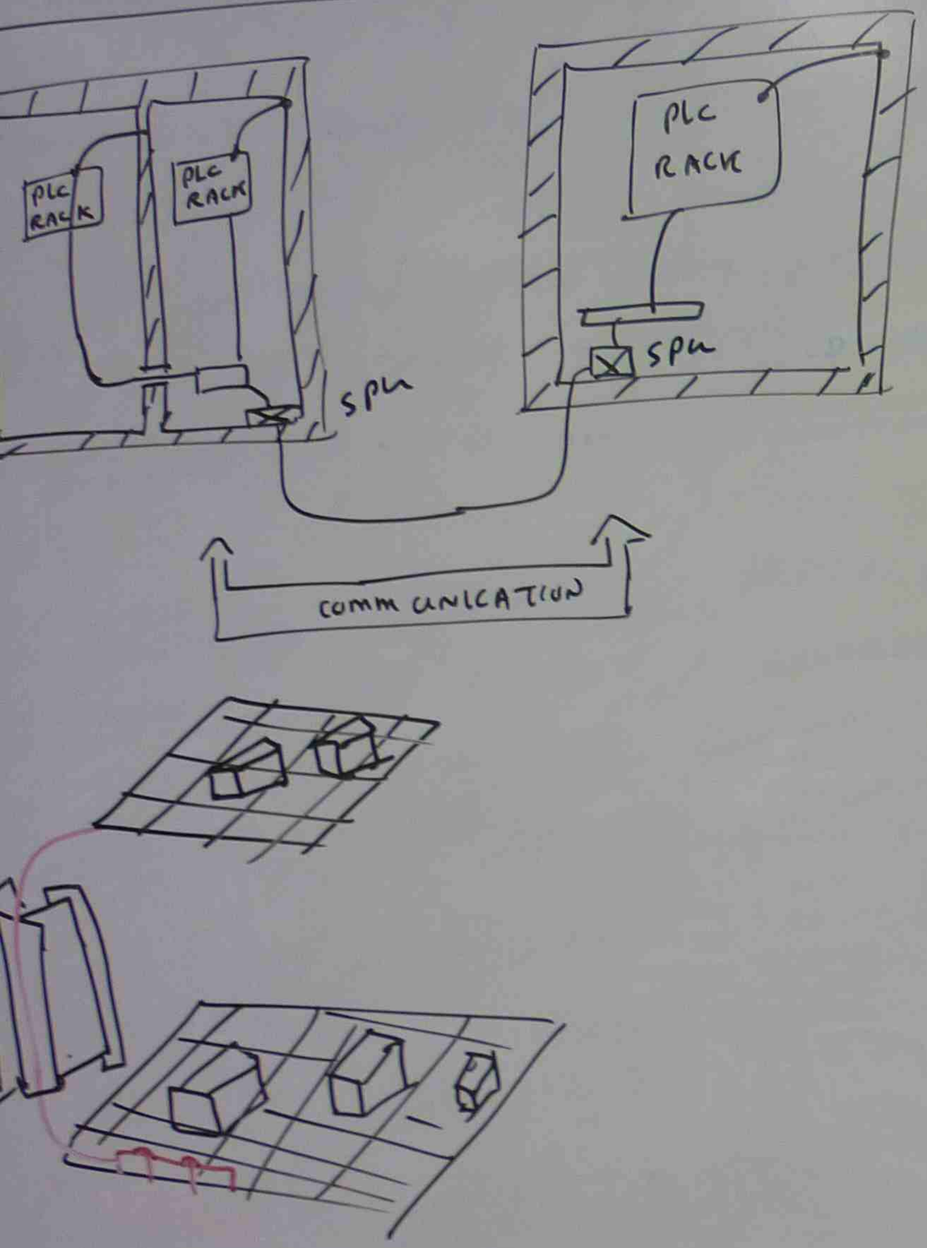



SURGE PROTECTION UNIT (SPU)
EARTHING CONDUCTOR
ELECTRICAL EQUIPMENT ZONE
BAD CABLE TERMINATION.

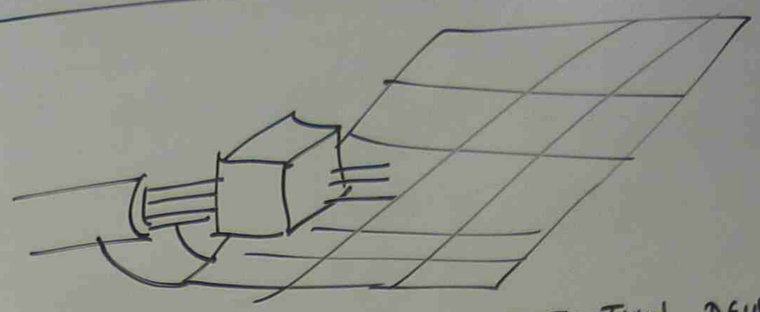

BONDING OF ELECTRONIC EQUIPMENTS AT A LOCAL LEVEL
PLC RACK
PLC RACK
PLC RACK
SPU
SPU
COMMUNICATION
RISER


STRATEGIC POINT PROTECTION
INSTALL SURGE
STRATEGIC
POWER CABLE
POWER SUPPLY
SAFETY EARTH ELECTRODE

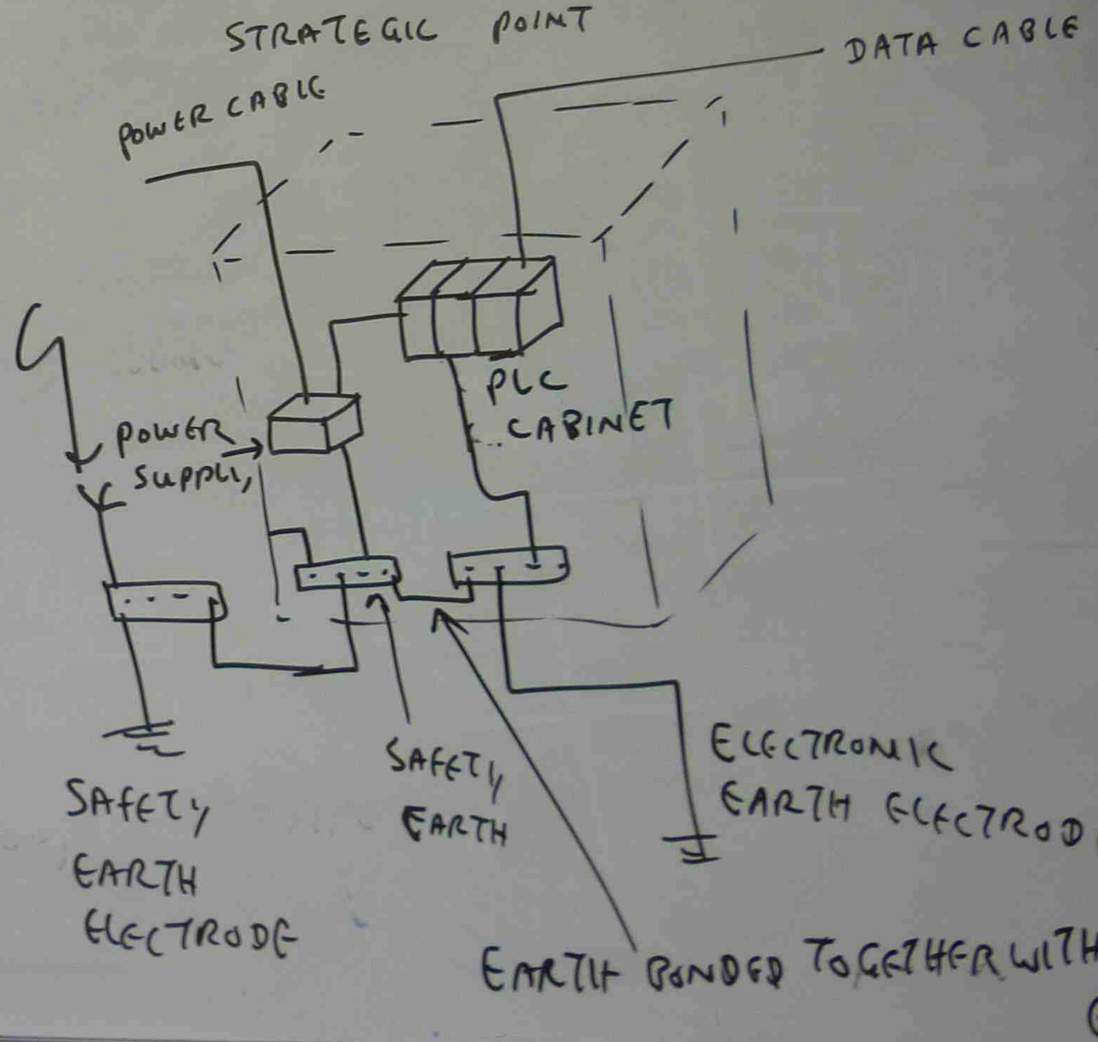
BONDING OF ELECTRONIC EQUIPMENTS AT A LOCAL LEVEL

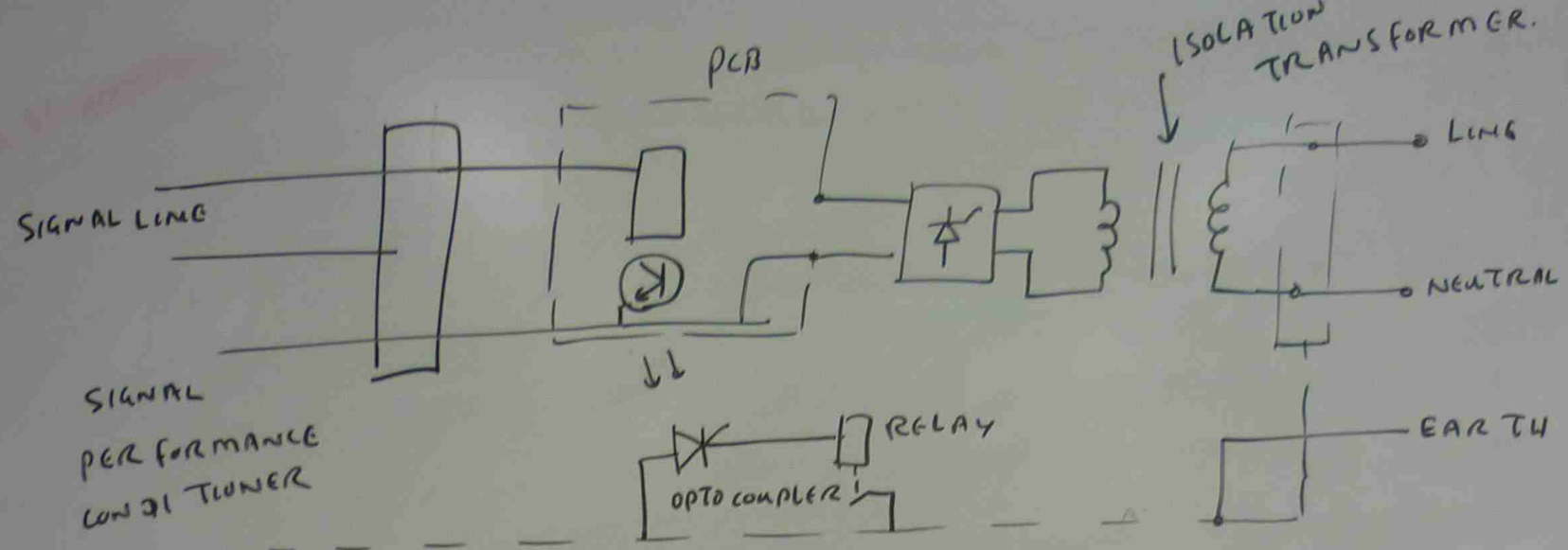


STRATEGIC POINT PROTECTION



INSTALL SURGE PROTECTION DEVICES AT STRATEGIC POINT





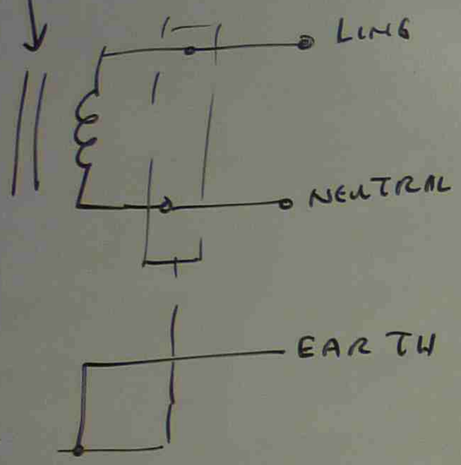
THE MAIN PURPOSE of SURGE PROTECTION UNIT (SPU) IS TO CLAMP THE VOLTAGE BETWEEN THE SIGNAL LINES AND SIGNAL REFERENCE CONDUCTOR TO ENSURE THAT THE VOLTAGE NEVER EXCEEDS THE DESIGNATED VALUE.

FINE PROTECTION ⟶ SILICON SUPPRESSOR

MEDIUM PROTECTION ⟶ METAL OXIDE VARISTOR

COARSE PROTECTION ⟶ SPARK GAP ARRESTER.

ISOLATION TRANSFORMER.



ROTECTION UNIT (SPU) IS

THE SIGNAL LINES AND

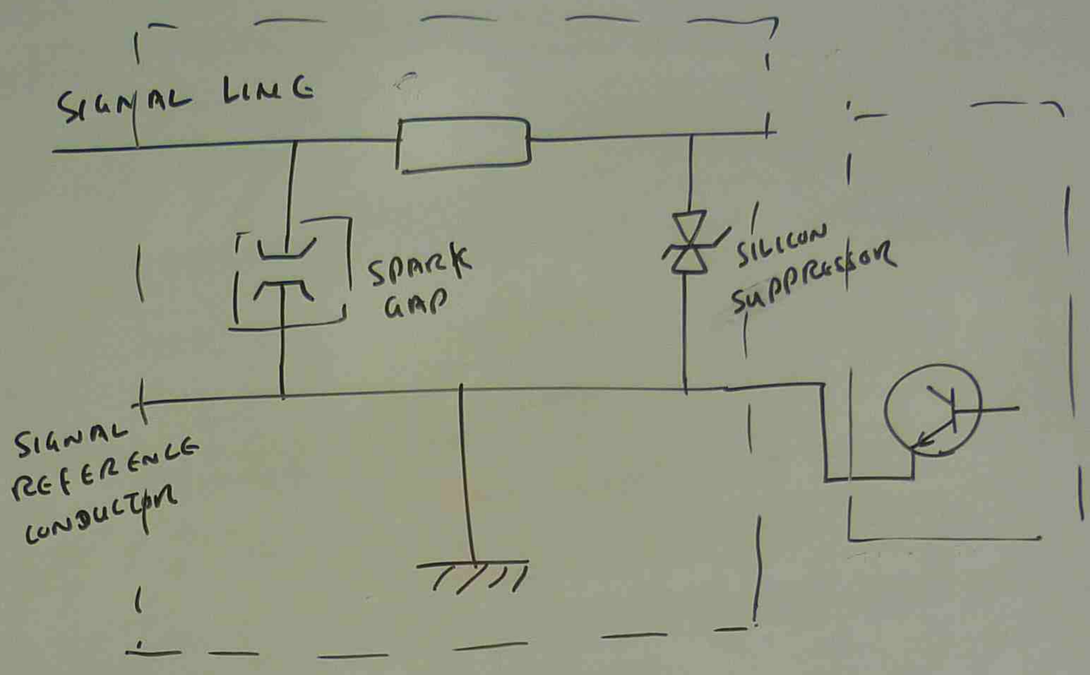
TO ENSURE THAT THE

DESIGNATED VALUE.

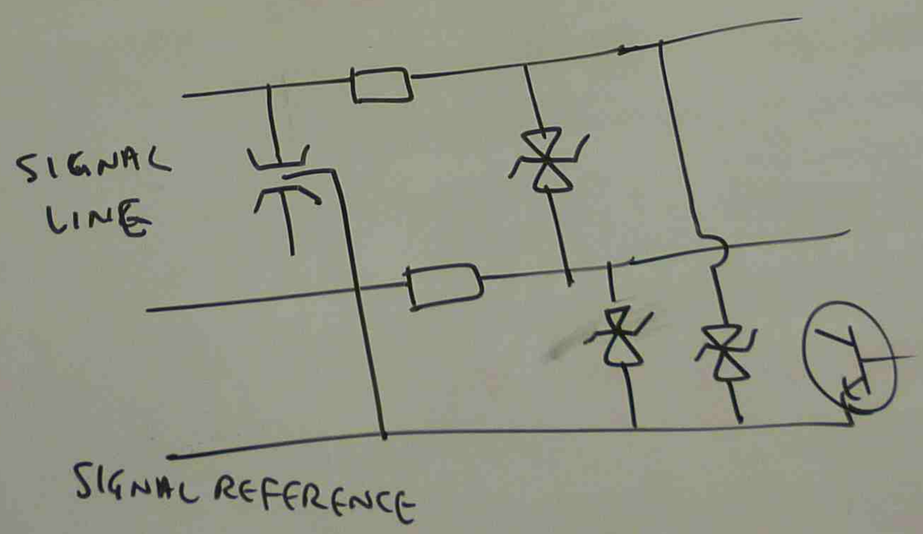
ION SUPPRESSOR

TAL OXIDE VARISTOR

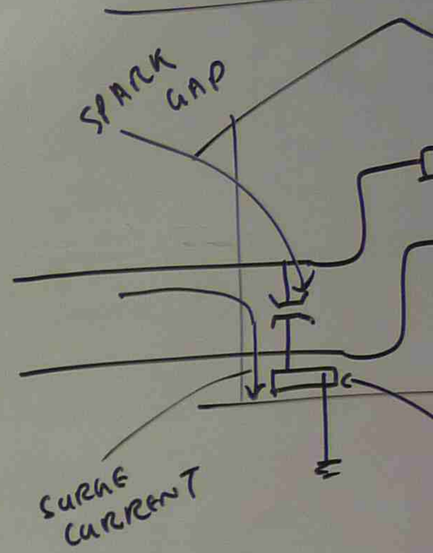
ARK GAP ARRESTER.



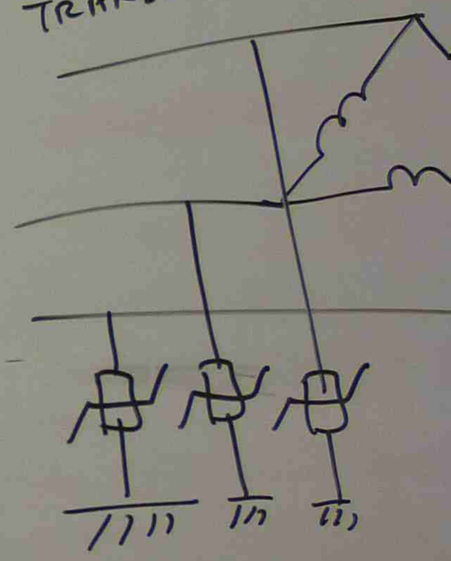
BASIC DESIGN OF SPU

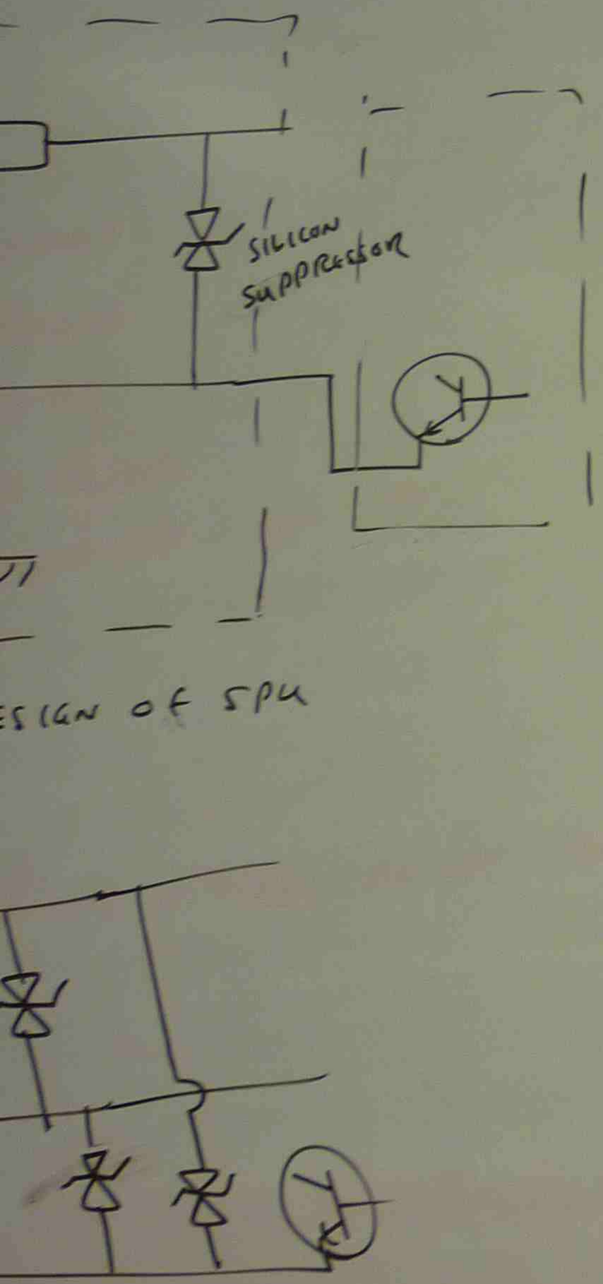


LOCATION of Su



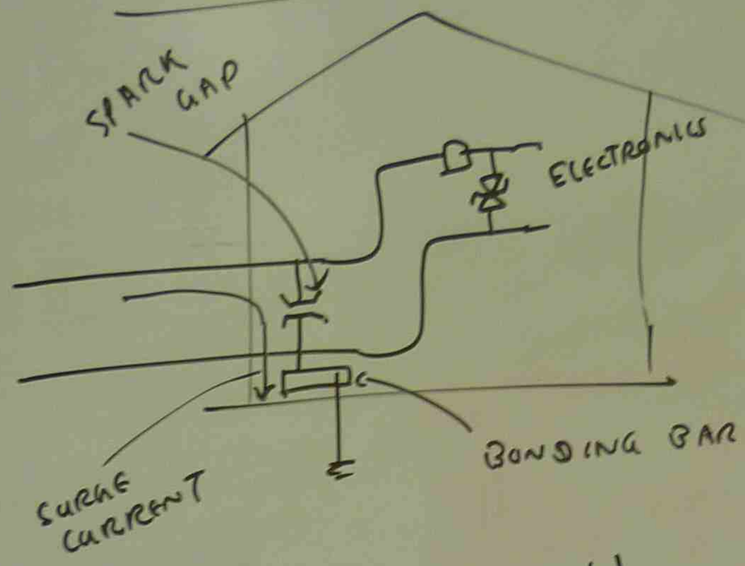
TRANSMISSION



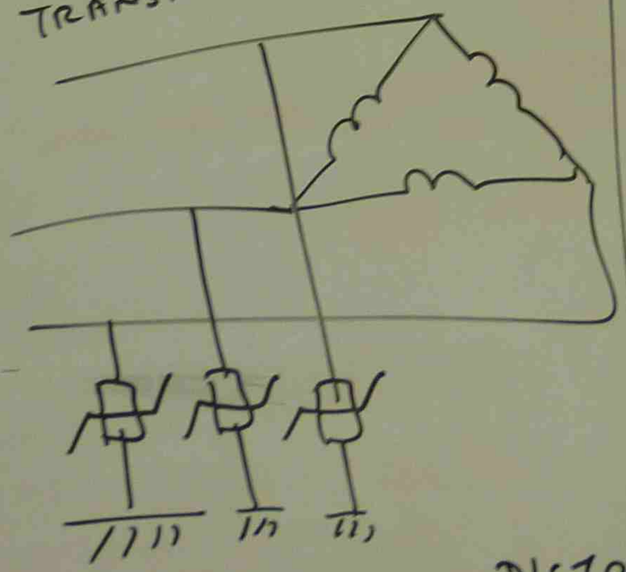


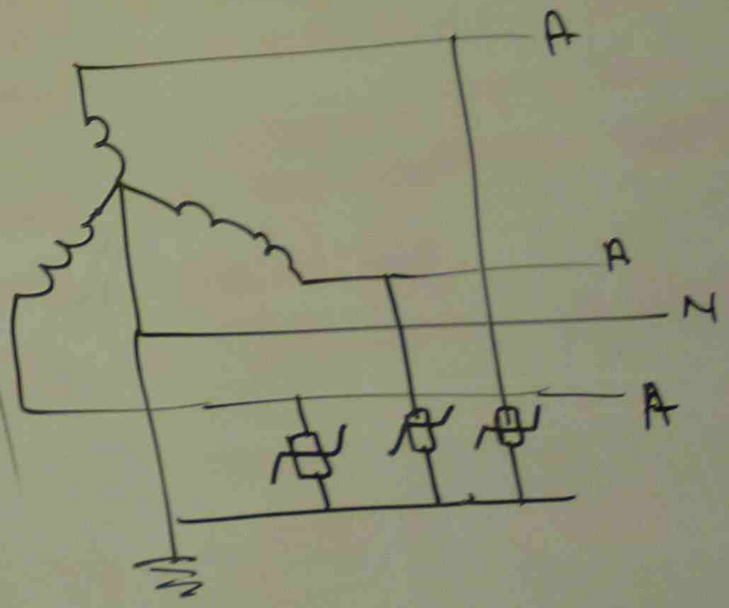
ESIGN OF SPU

LOCATION of SURGE PROTECTION UNIT



TRANSMISSION

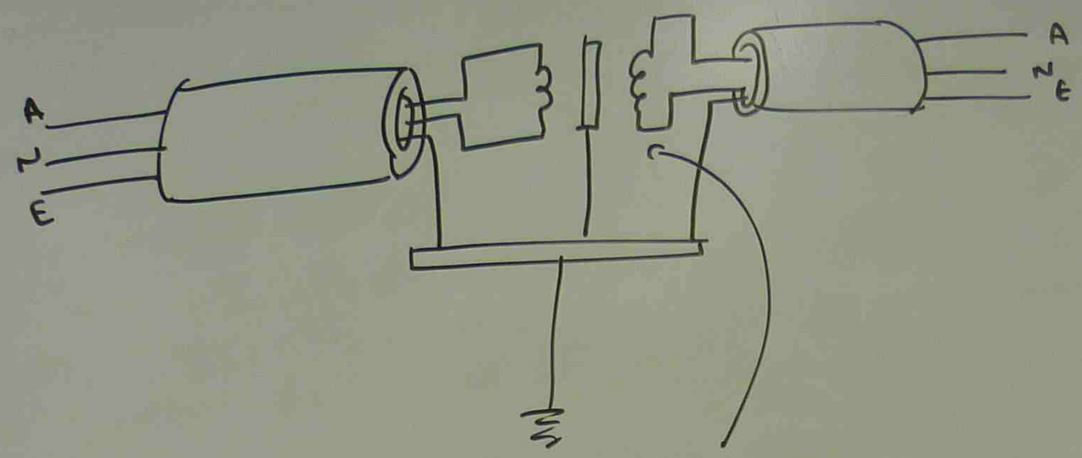




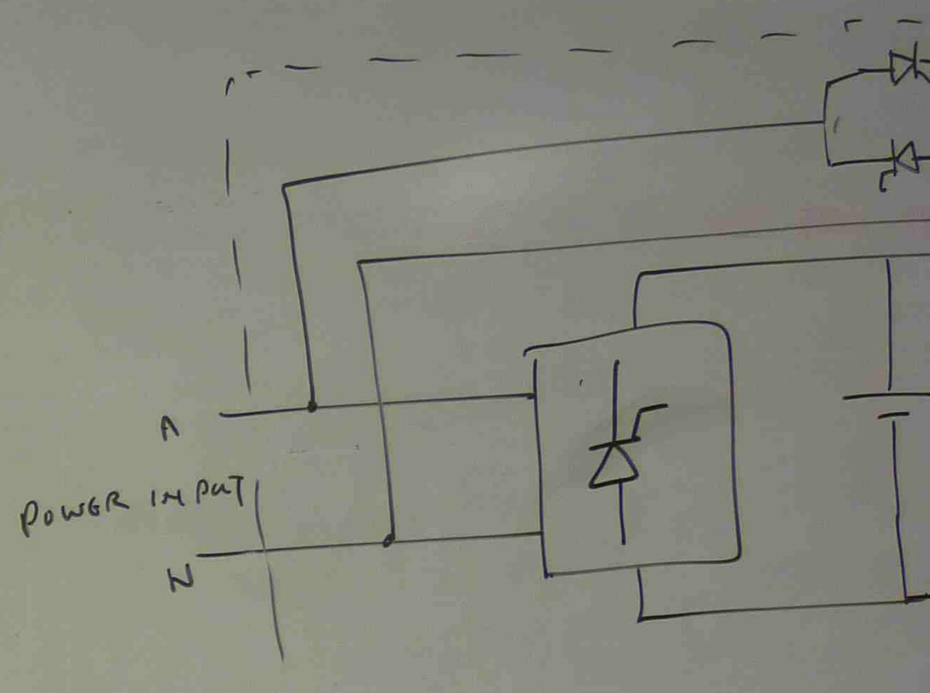
DISTRIBUTION TRANSFORMER EARTHING

ARRANGEMENT.

IRE ARMOURE



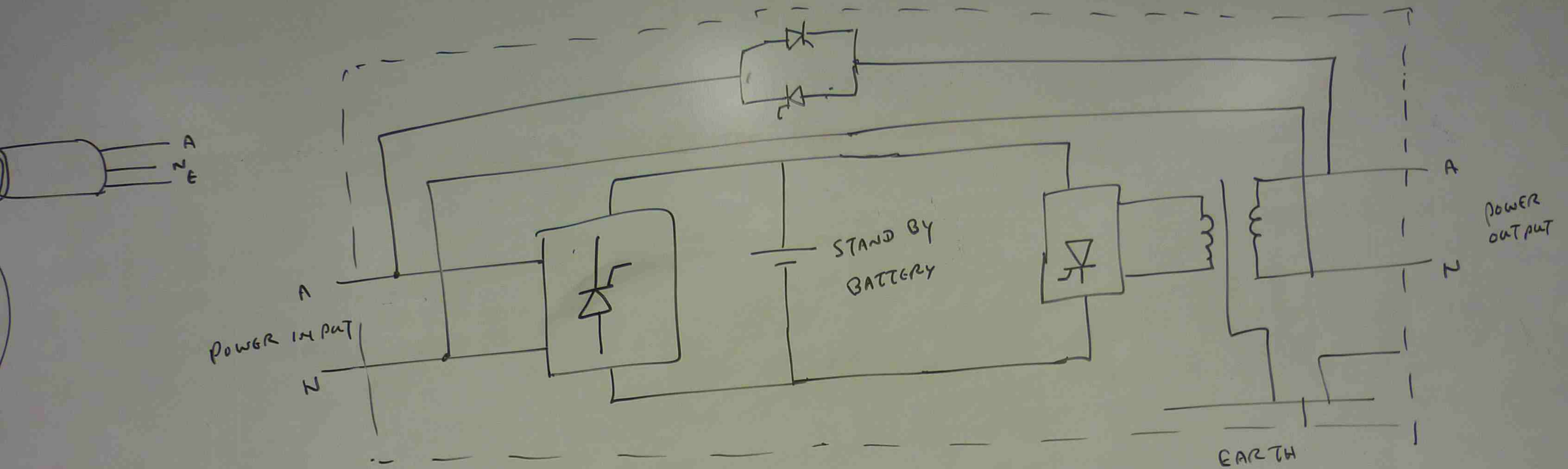
ISOLATION TRANSFORMER



POWER LINE CONDITIONER

A POWER LINE CONDITIONER IS AN ISOLATION TRANSFORMER WITH ADDITIONAL FEATURES FOR REGULATING THE SECONDARY OUT PUT VOLTAGE.

IT CAN - ISOLATE THROUGH TRANSFORMER
REGULATE OUTPUT VOLTAGE
FILTER EXTERNAL NOISE AND HARMONICS
ABSORB EXTERNAL SURGE ENERGY
PROVIDE SHORT CIRCUIT PROTECTION.



IS AN ISOLATION
FEATURES FOR
OUT PUT VOLTAGE.
UGH TRANSFORMER
T PUT VOLTAGE
TERNAL NOISE AND HARMONICS
XTERNAL SURGE ENERGY

SHORT CIRCUIT PROTECTION.

SOIL RESISTIVITY AND EARTH ELECTRODE

THE MAIN OBJECTIVE OF EARTHING ELECTRICAL SYSTEM IS TO ESTABLISH A COMMON REFERENCE POTENTIAL FOR THE POWER SUPPLY SYSTEM, BUILDING STRUCTURE PLANT STEEL WORK, ELECTRICAL CONDUITS, CABLE LADDERS, TRAYS AND INSTRUMENTATION SYSTEM.

A SUITABLE LOW RESISTANCE CONNECTION TO EARTH IS DESIRABLE. HOWEVER IT DEPENDS ON THE FOLLOWING FACTORS

- SOIL RESISTIVITY
- SIZE & TYPE OF ELECTRODE USED
- DEPTH TO WHICH THE ELECTRODE IS BURIED
- MOISTURE AND CHEMICAL CONTENTS OF SOIL.

E =

R =

E= POTENTIAL
THE CONDU

I= CURRENT
CONDUCTOR

R = RESISTA

ρ = RES

L= LENG

A = CRO
EA

$$E = IR$$

$$R = \frac{\rho L}{A}$$ ← BURIED LENGTH

E = POTENTIAL DIFFERENCE ACROSS THE CONDUCTOR (VOLT)

I = CURRENT FLOWING THROUGH THE CONDUCTOR (Amp)

R = RESISTANCE OF CONDUCTOR (Ω)

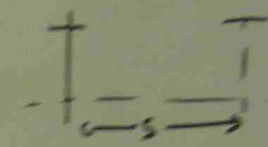
ρ = RESISTIVITY (Ω - m)

L = LENGTH OF EARTHING ELECTRODE

A = CROSS SECTIONAL AREA OF EARTH ELECTRODE (m^2)

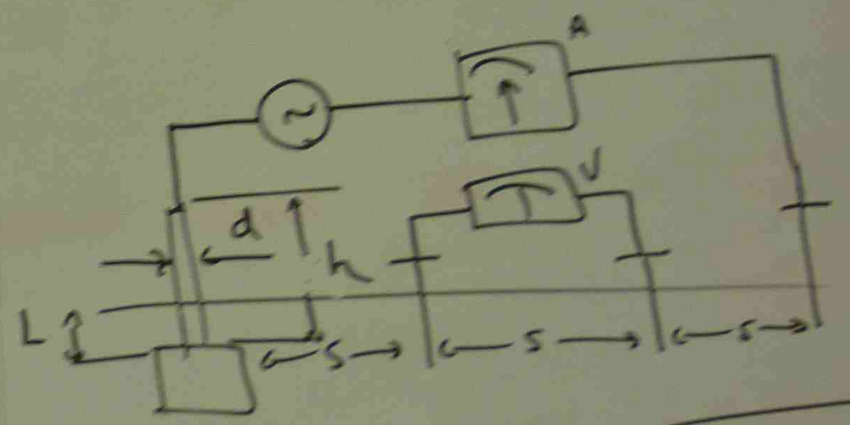
$$\rho = 2\pi S R$$

S = SEPARATION DISTANCE



R = MEASURED RESISTANCE (Ω)

n = NO. OF ELECTRODE



PERMANENT EARTH

4 POINTS METHOD

R_g =

(Ω)

R_g =

d =

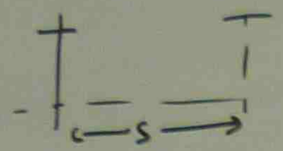
h =

L =

(L_n = NAT

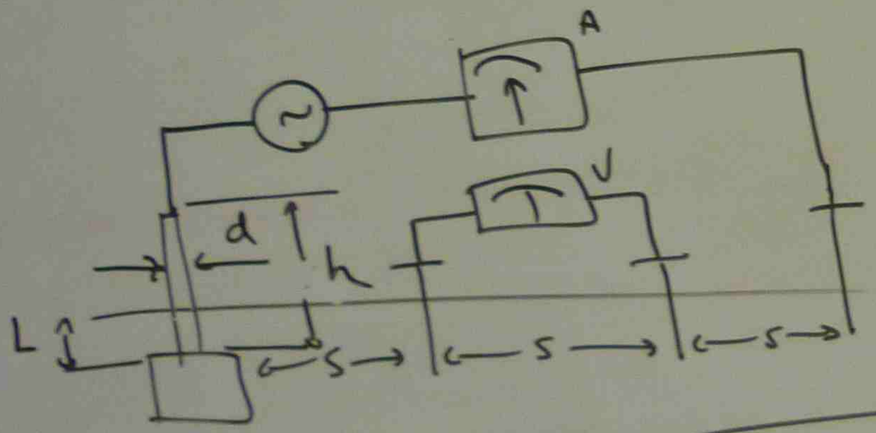
$$\rho = 2\pi S R$$

S = SEPARATION DISTANCE



R = MEASURED RESISTANCE (Ω)

n = NO. OF ELECTRODE



PERMANENT EARTH

4 POINTS METHOD

$$R_g = \frac{\rho}{\pi L}\left[\ln\left\{\frac{4L}{(dh)^{3/2}} - 1\right\}\right]$$

(Ω)

R_g = EARTHING RESISTANCE (GROUND RESISTANCE) (Ω)

d = DIAMETER OF EARTH ELECTRODE (m)

h = TOTAL LENGTH OF EARTH ELECTRODE (m)

L = BURIED LENGTH OF EARTH ELECTRODE (m)

($\ln$ = NATURAL LOGARITHM)

$$R_g = \frac{\rho}{\pi L}\left[Ln\left\{\frac{4L}{(dh)^{3/2}}\right\} - 1\right]$$

(Ω)

(Ω)

R_g = EARTHING RESISTANCE

(GROUND RESISTANCE) (Ω)

d = DIAMETER of EARTH ELECTRODE (m)

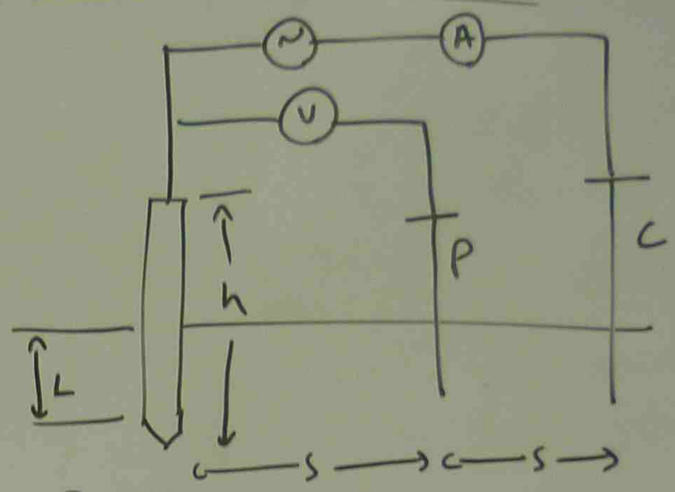
h = TOTAL LENGTH OF EARTH ELECTRODE (m)

L = BURIED LENGTH OF EARTH ELECTRODE (m)

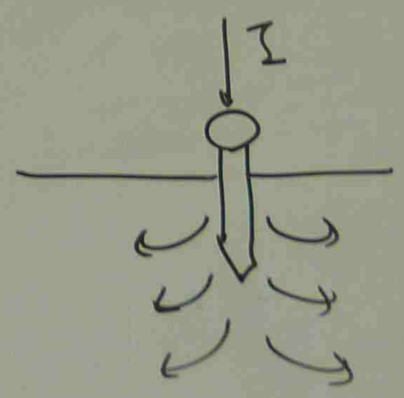
METHOD

(L_n = NATURAL LOGARITHM)

3 POINTS METHOD



EARTH ELECTRODE



$E = J\rho$

E = ELECTRIC FIELD IN SOIL

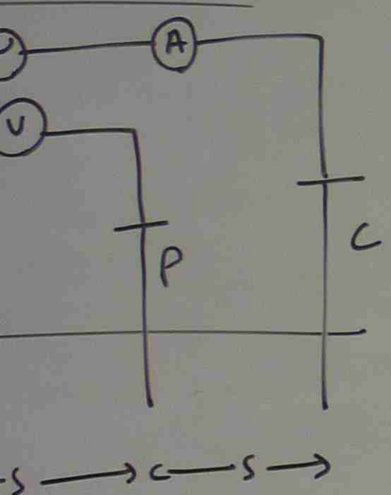
J = CURRENT DENSITY IN SOIL

ρ = SOIL RESISTIVITY

EARTH

- SINGLE
- MULTIPLE
- ONE CONDU
- SEVERAL

S METHOD



I

= J ρ

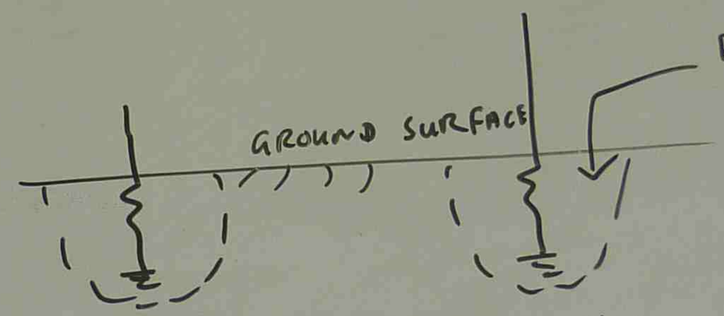
E = ELECTRIC FIELD IN SOIL

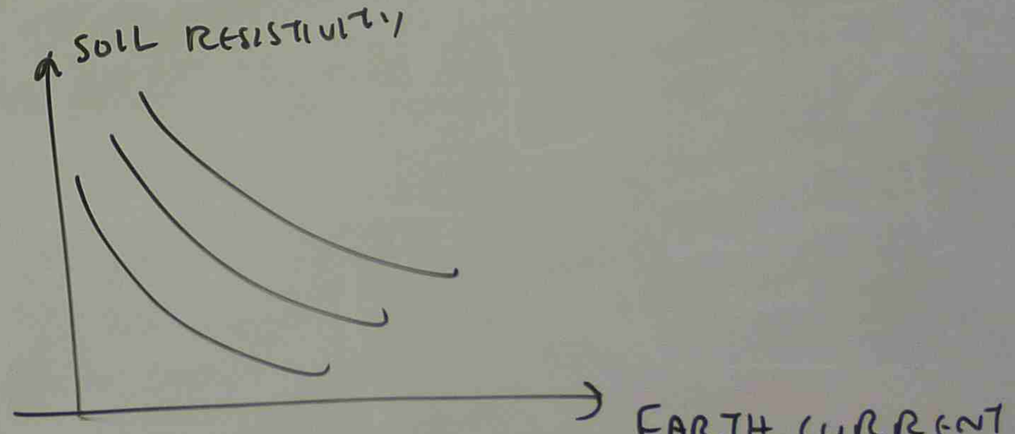
J = CURRENT DENSITY IN SOIL

ρ = SOIL RESISTIVITY

EARTH RESISTANCE DEPENDS ON

- SINGLE DRIVEN ROD
- MULTIPLE DRIVEN RODS
- ONE CONDUCTOR BURIED IN A TRENCH
- SEVERAL CONDUCTORS BURIED IN TRENCH.





R_2 = EARTH

R_2' = EART

LIG

HIGH RE

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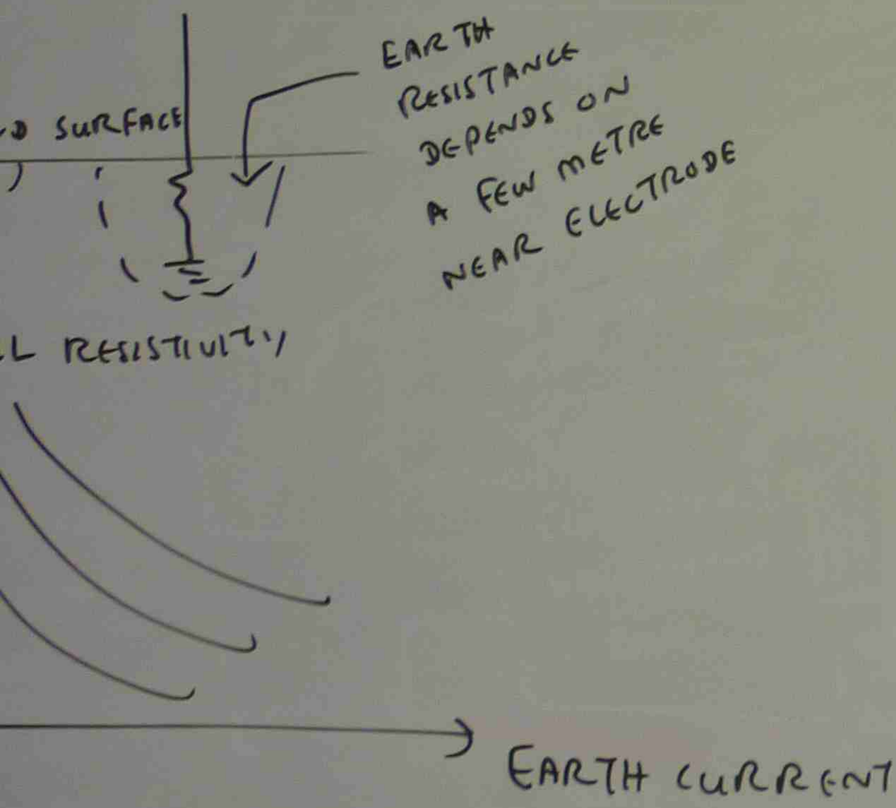
E DEPENDS ON

D

RODS

LED IN A TRENCH

BURIED IN TRENCH.



R_2 = EARTH RESISTANCE

R_2^1 = EARTH RESISTANCE SEEN BY LIGHTNING CURRENT.

HIGH RESISTIVITY SOIL $R_2^1 = 0.25\ R_2$

LOW RESISTIVITY SOIL $R_2^1 = 0.5\ R_2$

SOIL RESISTIVITY AND EARTH ELECTRODE

THE MAIN OBJECTIVE of EARTHING ELECTRICAL SYSTEM IS TO ESTABLISH A COMMON REFERENCE POTENTIAL FOR THE POWER SUPPLY SYSTEM, BUILDING STRUCTURE PLANT STEEL WORK, ELECTRICAL CONDUITS, CABLE LADDERS, TRAYS AND INSTRUMENTATION SYSTEM.

A SUITABLE LOW RESISTANCE CONNECTION TO EARTH IS DESIRABLE. HOWEVER IT DEPENDS ON THE following FACTORS

- SOIL RESISTIVITY
- SIZE & TYPE of ELECTRODE USED
- DEPTH TO WHICH THE ELECTRODE IS BURIED
- MOISTURE AND CHEMICAL CONTENTS of SOIL.

$E = I$

$R = \frac{\rho}{A}$

E = POTENTIAL
THE CONDUCT

I = CURRENT F
CONDUCTOR

R = RESISTANC

ρ = RESIST

L = LENGTH

A = CROSS
EARTH

$$E = IR$$

$$R = \frac{\rho L}{A}$$ ← BURIED LENGTH

E = POTENTIAL DIFFERENCE ACROSS THE CONDUCTOR (VOLT)

I = CURRENT FLOWING THROUGH THE CONDUCTOR (AMP)

R = RESISTANCE OF CONDUCTOR (Ω)

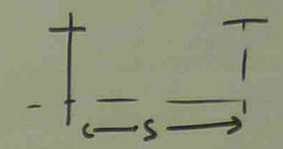
ρ = RESISTIVITY ($\Omega - m$)

L = LENGTH OF EARTHING ELECTRODE

A = CROSS SECTIONAL AREA OF EARTH ELECTRODE (m^2)

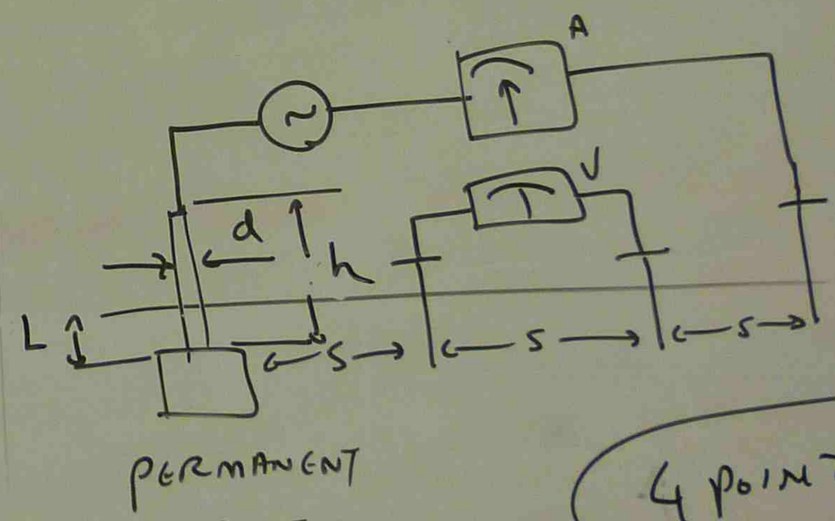
$$\rho = 2\pi s R$$

S = SEPARATION DISTANCE



R = MEASURED RESISTANCE (Ω)

n = NO. OF ELECTRODE



PERMANENT EARTH

$$R_g = \frac{\rho}{\pi L}$$ (Ω)

4 POINTS METHOD

R_g = EARTH

(GROUN

d = DIAME ELECT

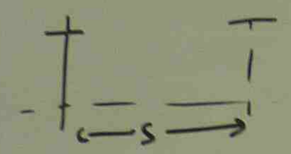
h = TOTA EARTH

L = BURIED

(L_n = NATURAL

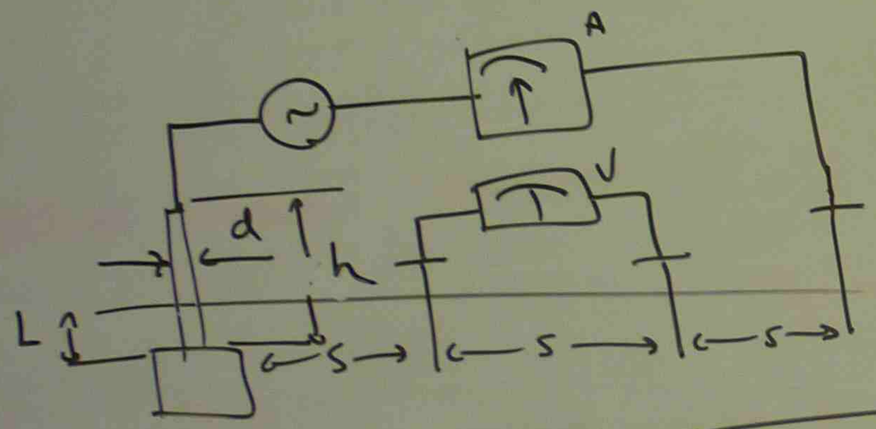
$$\rho = 2\pi S R$$

S = SEPARATION DISTANCE



R = MEASURED RESISTANCE (Ω)

n = NO. OF ELECTRODE



PERMANENT EARTH

4 POINTS METHOD

$$R_g = \frac{\rho}{\pi L}\left[\ln\left\{\frac{4L}{(dh)^{3/2}} - 1\right\}\right]$$

(Ω)

R_g = EARTHING RESISTANCE (GROUND RESISTANCE) (Ω)

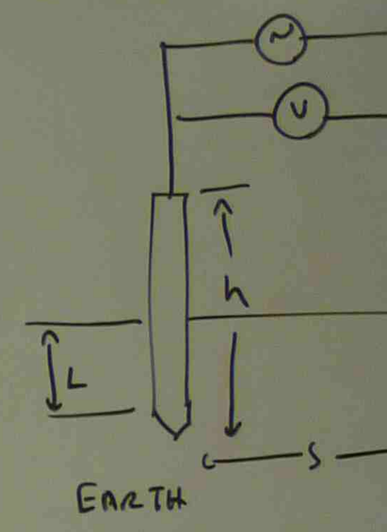
d = DIAMETER OF EARTH ELECTRODE (m)

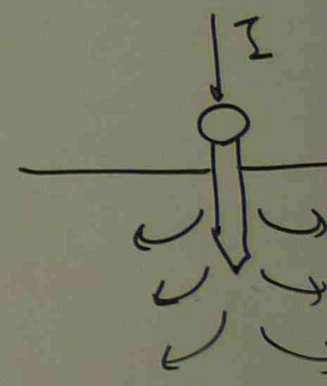
h = TOTAL LENGTH OF EARTH ELECTRODE (m)

L = BURIED LENGTH OF EARTH ELECTRODE (m)

($\ln$ = NATURAL LOGARITHM)

3 POINTS m





E =

$$\left[Ln \left\{ \frac{4L}{(dh)^{3/2}} - 1 \right\} \right]$$

RTHING RESISTANCE

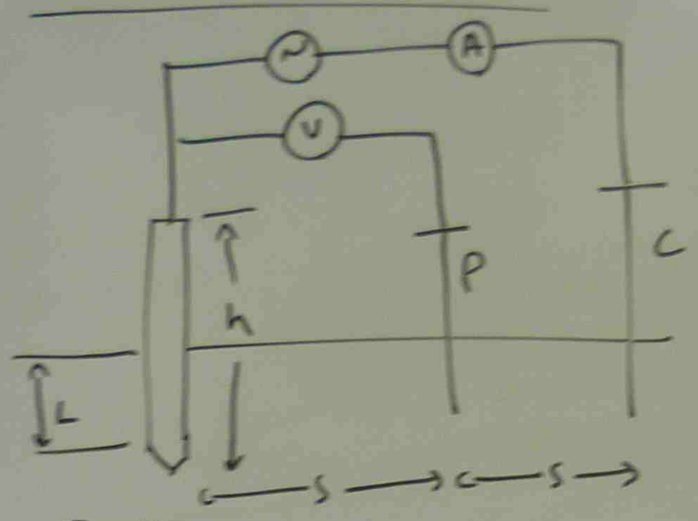
OUND RESISTANCE) (Ω)

METER OF EARTH
ECTRODE (m)

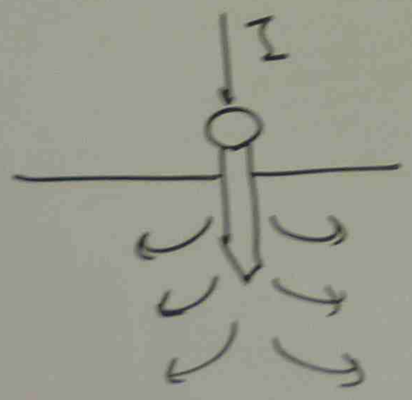
TIAL LENGTH OF
RTH ELECTRODE (m)
UED LENGTH OF EARTH
ELECTRODE (m)

TL LOGARITHM)

3 POINTS METHOD



EARTH ELECTRODE



$E = J \rho$

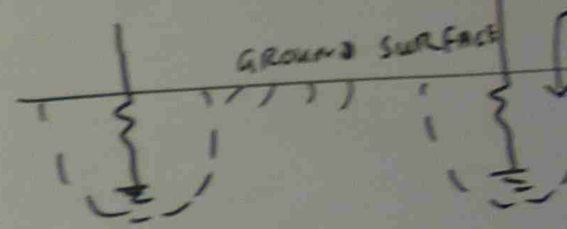
E = ELECTRIC FIELD IN SOIL

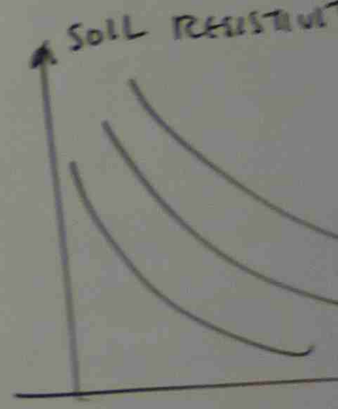
J = CURRENT DENSITY IN SOIL

ρ = SOIL RESISTIVITY

EARTH RESISTANCE DEPENDS ON

- SINGLE DRIVEN ROD
- MULTIPLE DRIVEN RODS
- ONE CONDUCTOR BURIED IN A TR
- SEVERAL CONDUCTORS BURIED IN





C

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EARTH RESISTANCE DEPENDS ON

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- MULTIPLE DRIVEN RODS
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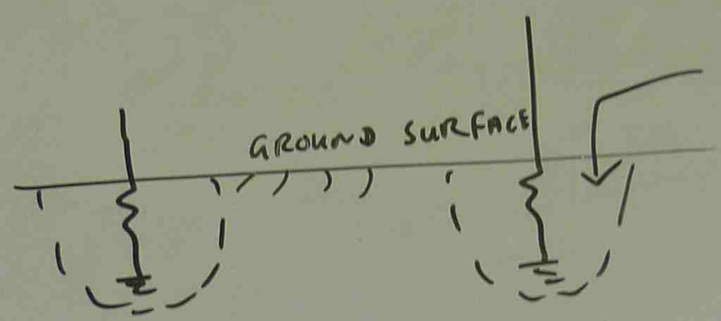
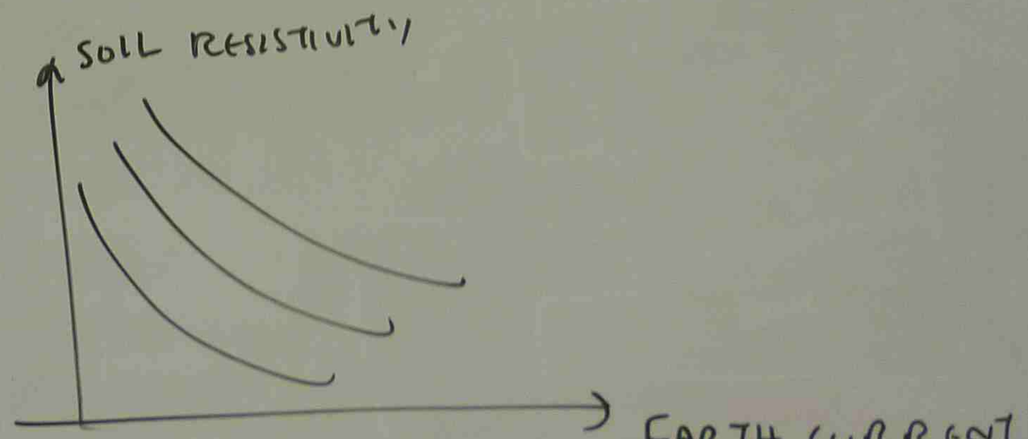




R_2 = EARTH RESIST

R_2' = EARTH RESI
LIGHTNING

HIGH RESISTVI

LOW RESISTIVITY

E = ELECTRIC FIELD IN SOIL

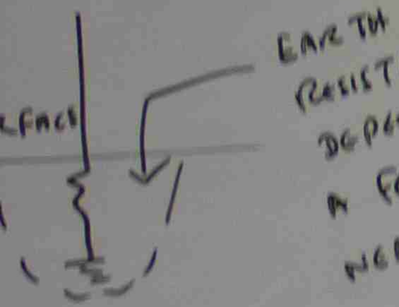
J = CURRENT DENSITY IN SOIL

ρ = SOIL RESISTIVITY

PENDS ON

N A TRENCH

LED IN TRENCH.



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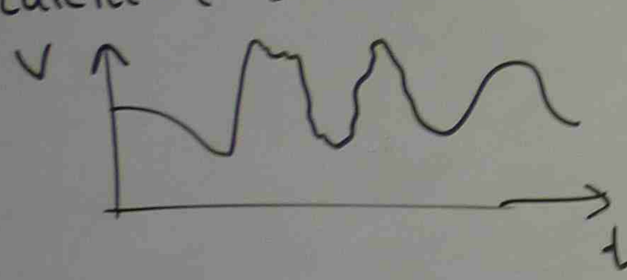
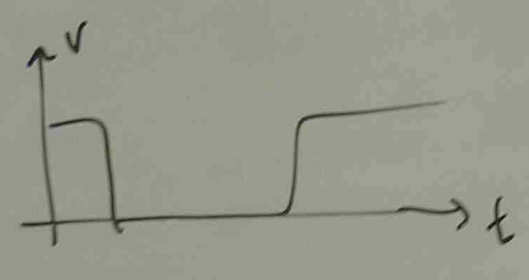
POWER QUALITY

INTERRUPTION

INTERRUPTION OCCURS WHEN THE SUPPLY VOLTAGE (OR) LOAD CURRENT DECREASES TO LESS THAN 1 MINUTE.

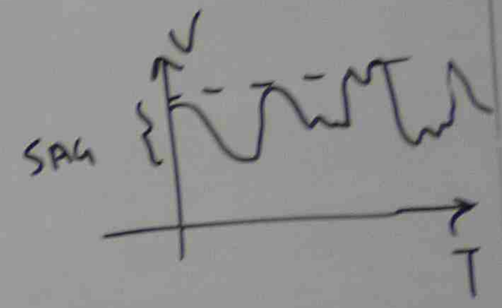




POOR POWER QUALITY

SAG (DIP)

SAGS ARE SHORT DURATION REDUCTIONS IN THE RMS VOLTAGE BETWEEN 0.1 AND 0.9 PU.



VOLTAGE SAGS ARE CAUSED BY

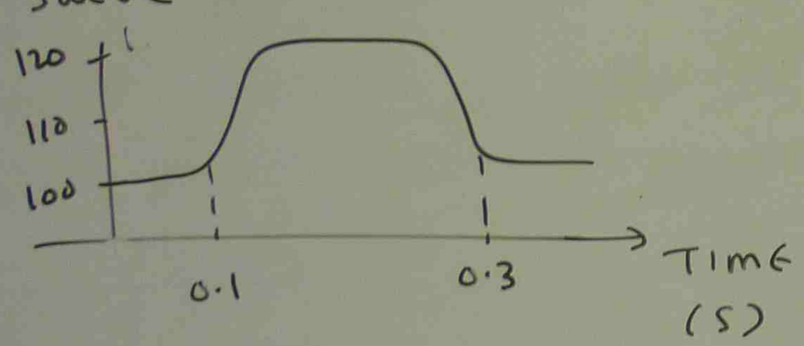
- ENERGIZING THE HEAVY LOADS
- STARTING THE LARGE INDUCTION MOTOR
- SINGLE LINE TO GROUND FAULT
- LOAD TRANSFERRING FROM ONE POWER SOURCE TO ANOTHER POWER SOURCE.

230 V = 1 pu ← PER UNIT

0.1 pu = 0.1 × 230 = 23V

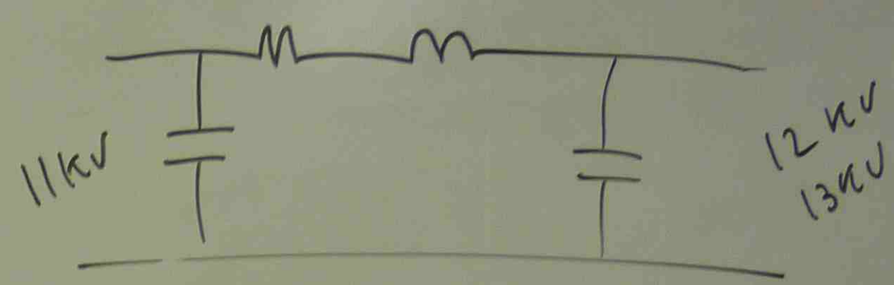
SWELL

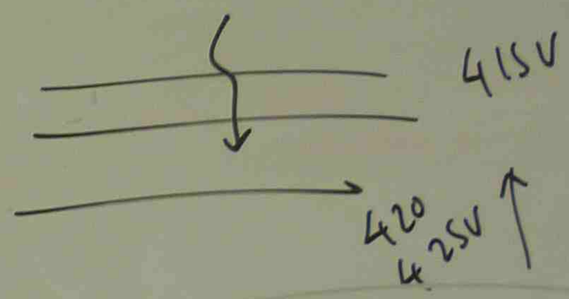
THE INCREASE of VOLTAGE MAGNITUDE BETWEEN 1.1 TO 1.2 pu IS CALLED SWELL



THE SWELL IS CAUSED BY

- SWITCHING OFF OF A LARGE LOAD
- ENERGIZING A CAPACITOR BANK
- VOLTAGE INCREASE OF THE UNFAULTED PHASE DURING A SINGLE LINE TO LINE FAULT.





INTERACTION BETWEEN CUSTOMER FACILITY & POWER SYSTEM

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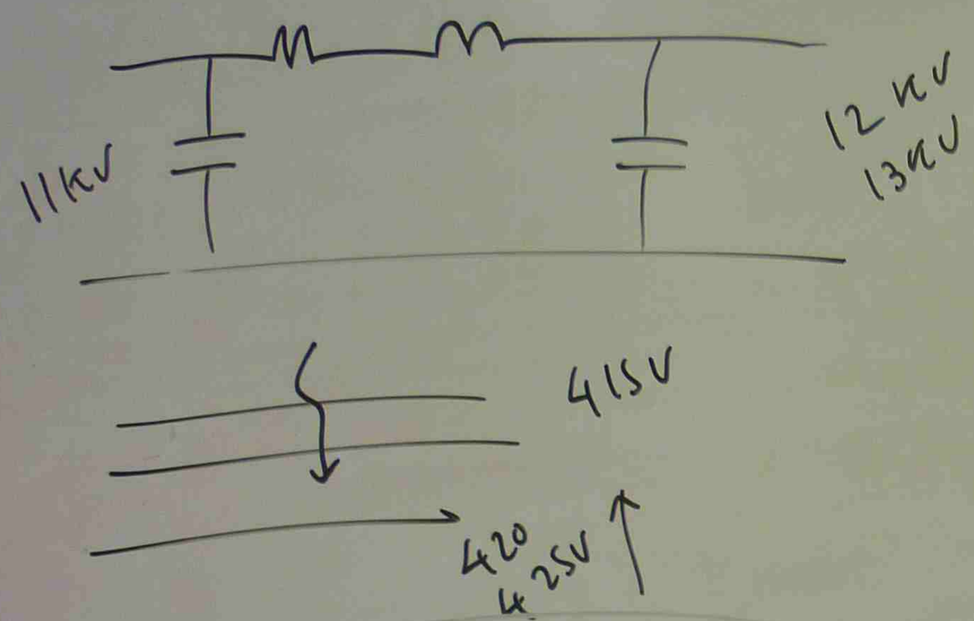
CUSTOM



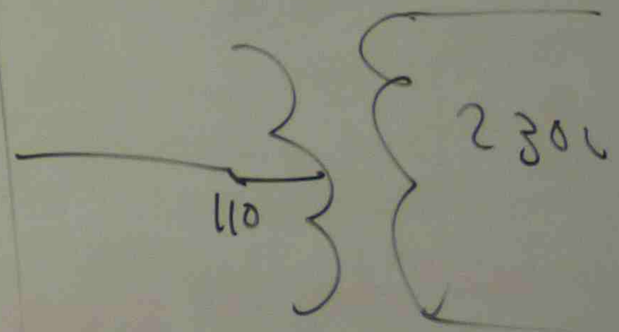
INTERACTION BETWEEN
CUSTOMER FACILITY &
POWER SYSTEM

ELECTRICITY
UTILITY MANAGER

CUSTOMER

UPLOADING.com

CIVIL ENGINEER
ARCHITECT TO DESIGN
THE BUILDING TO
MAINIMIZE THE
POWER QUALITY PROBLEM.



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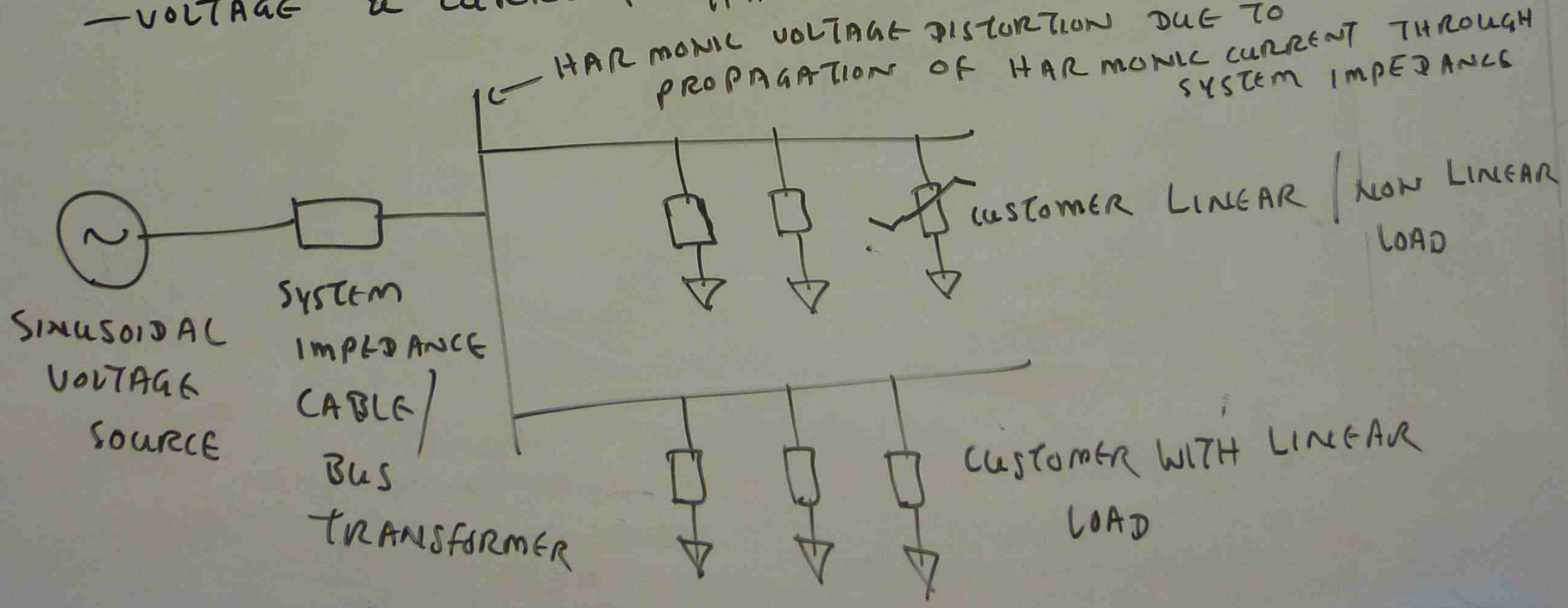
DEFINITION of POWER QUALITY

THE QUALITY of VOLTAGE AND/OR THE QUALITY of CURRENT AND CAN BE DEFINED AS THE MEASURE, ANALYSIS AND IMPROVEMENT OF THE BUS VOLTAGE TO MAINTAIN A SINUSOIDAL WAVE FORM AT RATED VOLTAGE AND FREQUENCY.

CAUSES OF DISTURBANCES IN POWER SYSTEM

—VOLTAGE & CURRENT HARMONIC STRESS IN POWER SYSTEM.



OF CURRENT AND

AND IMPROVEMENT

IL WAVE FORM AT

POWER SYSTEM.

E TO
CURRENT THROUGH
YSTEM IMPEDANCE

INEAR | NON LINEAR
LOAD

TH LINEAR

THE CAUSES OF DESTABILIZING POWER SYSTEM AND POWER QUALITY

ELECTRICITY UTILITY → UNBALANCED LOAD TRANSFER

TRANSMISSION SYSTEM → HIGH WIND, RANDOM VOLTAGE VARIATION
SPIKE, LIGHTNING STRIKE
TRANSIENT VOLTAGE

DISTRIBUTION SYSTEM → VOLTAGE DROP, SPIKE, INTERRUPTION,
OVER VOLTAGE, TRANSFORMER ENERGIZING
IMPROPER OPERATION OF REGULATING DEVICES

CUSTOMER → NON LINEAR LOAD, HIGHLY INDUCTIVE LOADS.
FREQUENCY VARIATION.