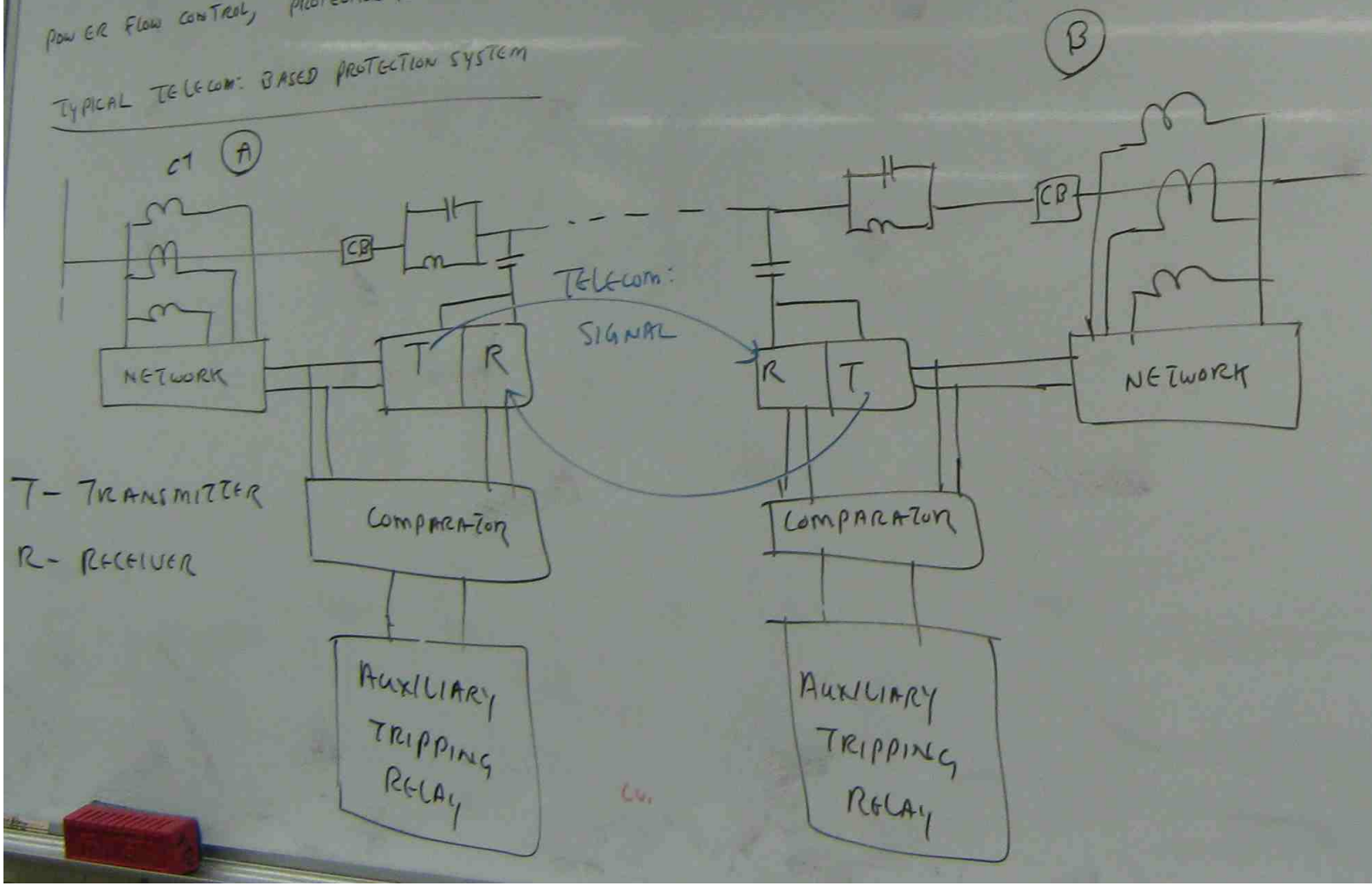
APPLICATION OF TELECOMMUNICATION SYSTEM IN POWER SYSTEM

TELECOMMUNICATION IS APPLIED IN POWER SYSTEM FOR POWER FLOW CONTROL, PROTECTION RELAYING.

TYPICAL TELECOM: BASED PROTECTION SYSTEM



T- TRANSMITTER

R- RECEIVER

THE LINE CURRENT / VOLTAGE IN POWER LINE IS SENSED BY DETECTOR NETWORK THAT PRODUCES THE CONTROL SIGNAL.

THE TRANSMITTER SENDS THE CONTROL SIGNAL OVER TELECOMM: CARRIER FREQUENCY.

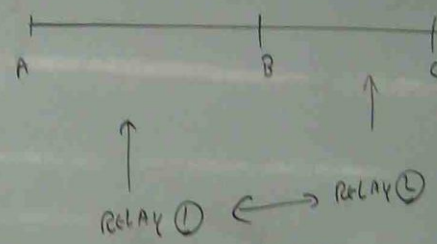
THE RECEIVER OF THE OTHER SIDE OF THE LINE ACCEPTS THE CONTROL SIGNAL AND FEEDS IT TO THE COMPARATOR.

IN COMPARATOR, THE SIGNAL IS COMPARED WITH REFERENCE AND SENT IN TO AUXILIARY TRIPPING RELAY NETWORK THAT OPERATES CIRCUIT BREAKER

HIGH FREQUENCY RADIO FREQUENCY

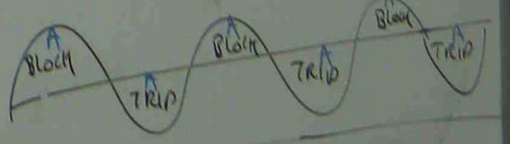
900 MHZ

DIFFERENTIAL PROTECTION (TELECOM: BASED)

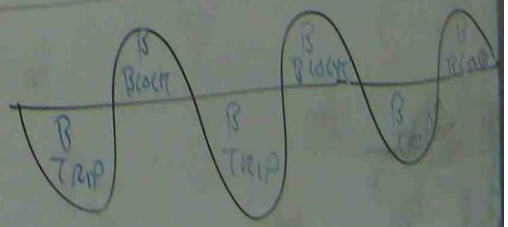


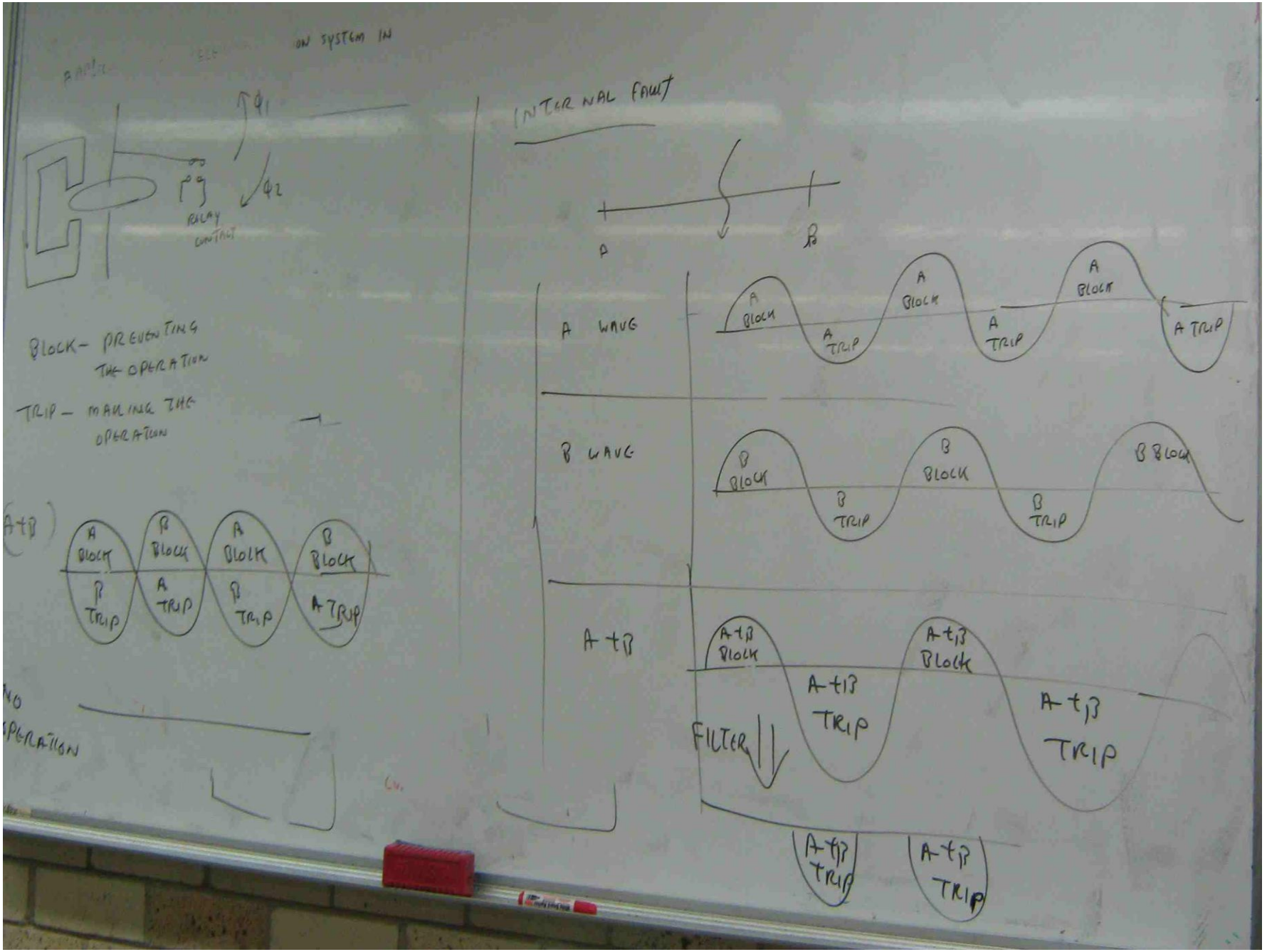
EXTERNAL FAULT

(A) POINT WAVE FORM (VOLTAGE/CURRENT)



(B) POINT WAVEFORM




ON SYSTEM IN
ϕ_1
ϕ_2
RELAY CONTACT
BLOCK- PREVENTING THE OPERATION
TRIP- MAKING THE OPERATION
A+B
A BLOCK
B TRIP
B BLOCK
A TRIP
A BLOCK
B TRIP
B BLOCK
A TRIP
NO OPERATION
INTERNAL FAULT
A
B
A WAVE
A BLOCK
A TRIP
A BLOCK
A TRIP
A BLOCK
A TRIP
B WAVE
B BLOCK
B TRIP
B BLOCK
B TRIP
B BLOCK
A+B
A+B BLOCK
A+B TRIP
A+B BLOCK
A+B TRIP
FILTER
A+B TRIP
A+B TRIP

THE PROTECTIVE RELAYS TAKE RESPONSIBILITY FOR PROVIDING THE PROTECTION IN SPECIFIC LINE SECTION.

FOR EXAMPLE, IN LINE SECTION A – B, WHEN EXTERNAL FAULT OCCURS, THE WAVE FORMS AT A AND B POINTS CANCEL EACH OTHER'S TRIP SIGNALS. THERE IS NO RESULTANT TRIP SIGNAL.

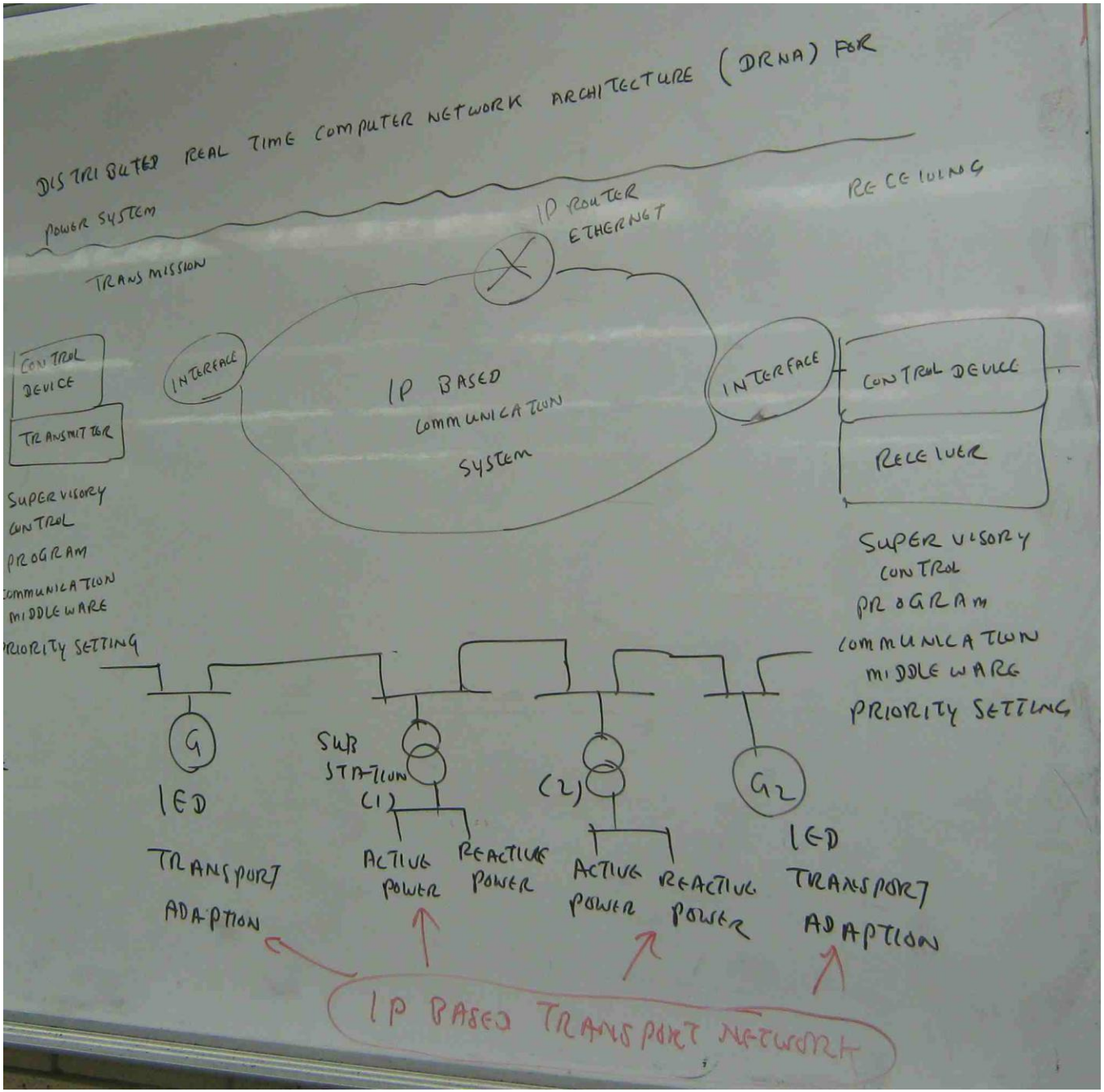
WHEN INTERNAL FAULT OCCURS, THE TRIP SIGNALS OF THE WAVES ARE COMBINED TO OUT PUT THE RESULTANT TRIP SIGNAL THAT OPERATES THE PROTECTIVE RELAYS.

THOSE SIGNALS ARE PRODUCED BY TRANSDUCERS AND SENT TO STATION OVER TELECOM: SYSTEM.

IN POWER LINE COMMUNICATION SYSTEM, BOTH CONTROL SIGNAL AND POWER VOLTAGE/ CURRENTS ARE CARRIED BY THE SAME LINE.

CONTROL AND COMMUNICATION SIGNALS ARE INJECTED IN TO THE LINE FROM MODULATOR THROUGH COUPLERS.

AT THE END OF THE LINE, THEY ARE PICKED UP BY DEMODULATOR TO FEED THE CONTROL DEVICES WHILE POWER VOLTAGE AND CURRENT ARE SUPPLIED TO POWER LOAD.

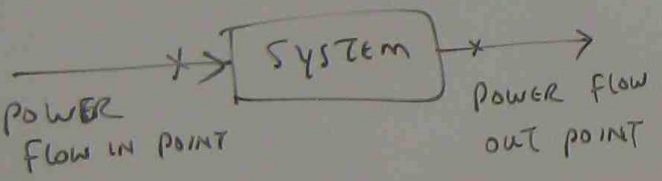

DISTRIBUTED REAL TIME COMPUTER NETWORK ARCHITECTURE (DRNA) FOR
POWER SYSTEM
TRANSMISSION
IP ROUTER
ETHERNET
RECEIVING
CONTROL DEVICE
TRANSMITTER
INTERFACE
IP BASED
COMMUNICATION
SYSTEM
INTERFACE
CONTROL DEVICE
RECEIVER
SUPERVISORY
CONTROL
PROGRAM
COMMUNICATION
MIDDLEWARE
PRIORITY SETTING
SUPERVISORY
CONTROL
PROGRAM
COMMUNICATION
MIDDLEWARE
PRIORITY SETTING
G
IED
TRANSPORT
ADAPTION
SUB
STATION
(1)
ACTIVE
POWER
REACTIVE
POWER
(2)
ACTIVE
POWER
REACTIVE
POWER
G2
IED
TRANSPORT
ADAPTION
IP BASED TRANSPORT NETWORK

REMOTE AND COMPUTERISED CONTROL IN POWER SYSTEM

CONTROL SYSTEM → POWER FLOW
CONTROL SYSTEM → SHORT CIRCUIT PROTECTION

MICRO WAVE PILOT SYSTEM IS UTILIZED FOR POWER FLOW CONTROL.
ULTRA HIGH FREQUENCY ABOVE 900 M HZ IS UTILIZED FOR CARRIER WAVE.

PHASE COMPARISON RELAYING BY REMOTE CONTROL SYSTEM



AT NORMAL CONDITION, THERE IS SPECIFIC VALUE FOR FLOW IN AND FLOW OUT CURRENT PHASE ANGLES.

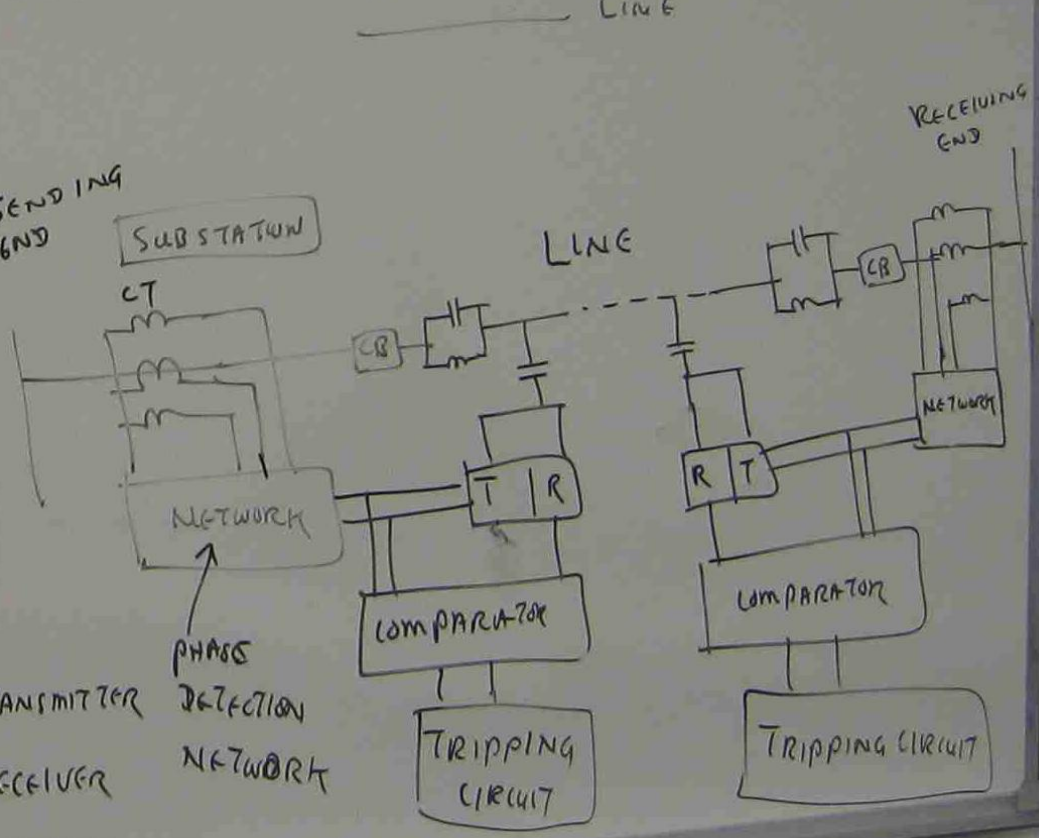
SEND GND

T- TRANSM

R- RECEIV

R SYSTEM

WHEN THE FAULT HAPPENS, THE PHASE ANGLES WILL BE DIFFERENT. THE PHASE COMPARISON RELAY DETECTS THE PHASE AND IF ABNORMALITY IS DETECTED, THEN IT SUPERVISES THE PROTECTION CONTROL SYSTEM TO TRIP THE CIRCUIT BREAKER.



THE LINE CURRENTS ARE DETECTED BY CTs AND PHASE ANGLES ARE SENSED. SENSING IS DONE AT THE ENDS OF THE LINE FOR A PARTICULAR LINE SECTION.

THE PHASE DETECTOR NETWORK PROVIDE THE RESULTS TO COMPARATOR.

THE COMPARATOR COMPARES THE QUANTITY WITH REFERENCE AND SUPERVISES THE TRIPPING CIRCUIT.

TELECOMMUNICATION SIGNAL WITH CARRIER FREQUENCY IS UTILIZED TO TRANSMIT THE SIGNAL.

T - TRANSMITTER, R - RECEIVER ARE UTILIZED TO TRANSMIT AND RECEIVE THE SIGNAL AT REMOTE SUBSTATION CONTROL CENTRE.

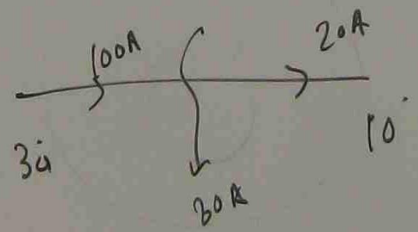
THE REASON TO PROVIDE THE PHASE COMPARISON RELAYING IS

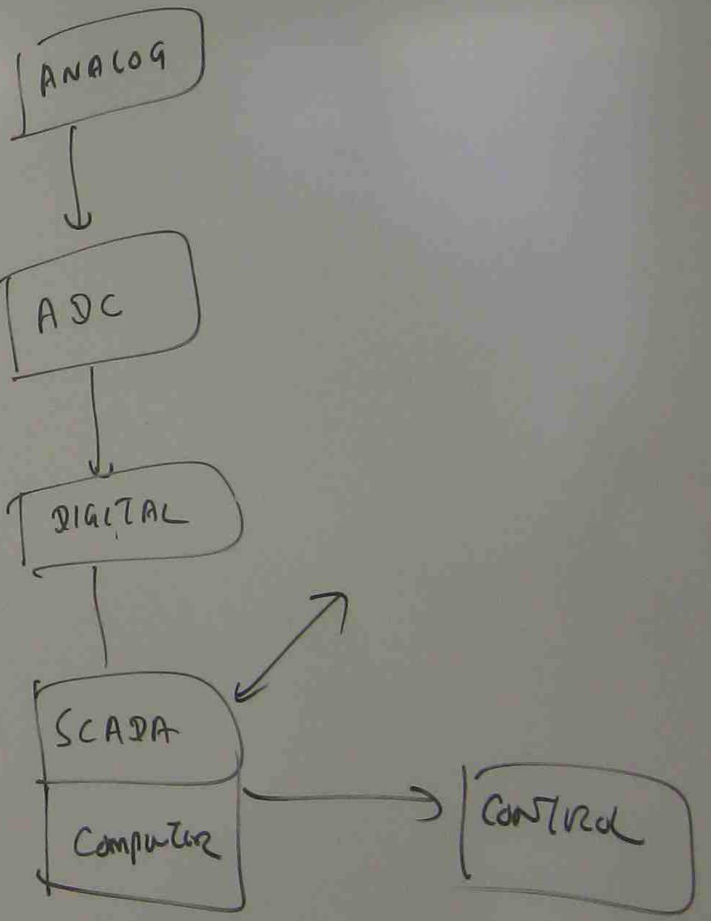
(1) TO INCREASE THE SENSISTIVITY
(2) TO PROVIDE THE PROTECTION

FOR L → G FAULT

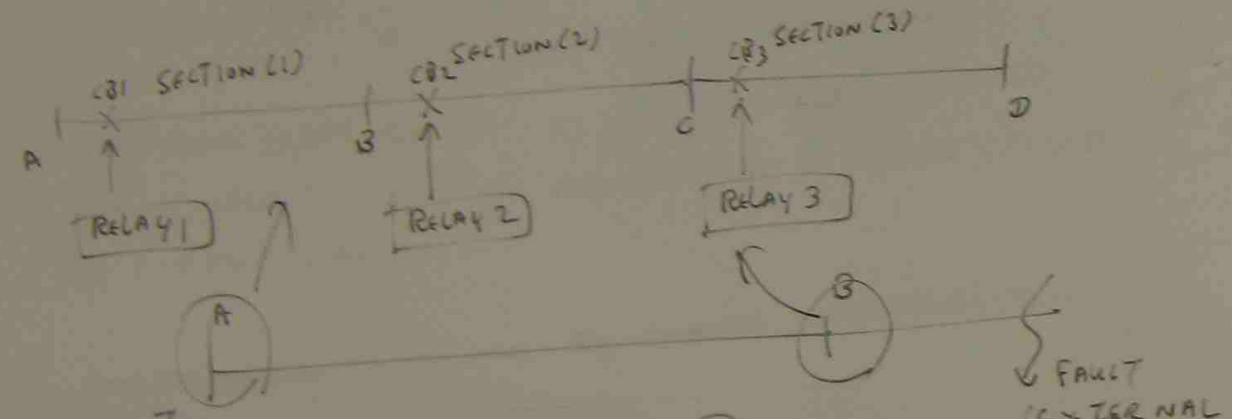
2L → G FAULT

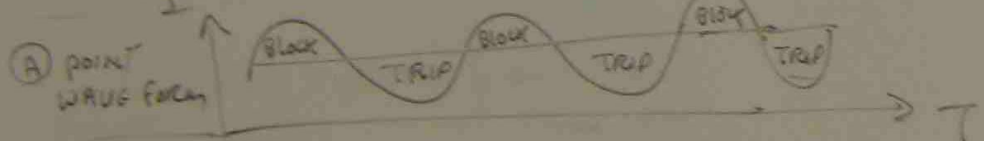
ETC.

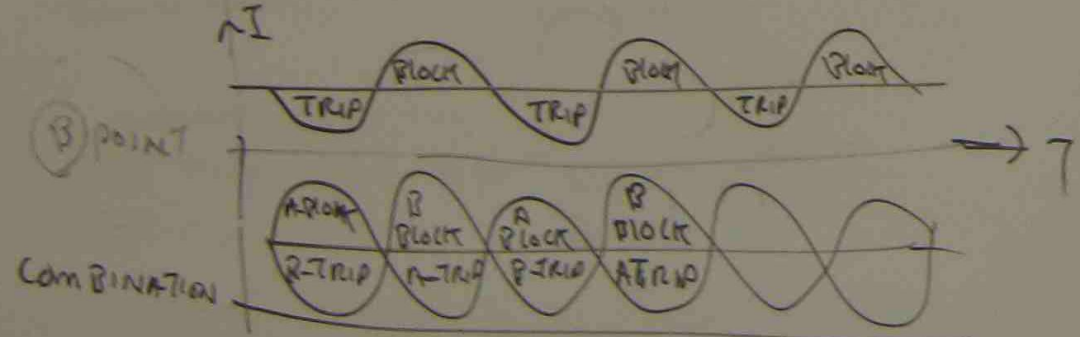


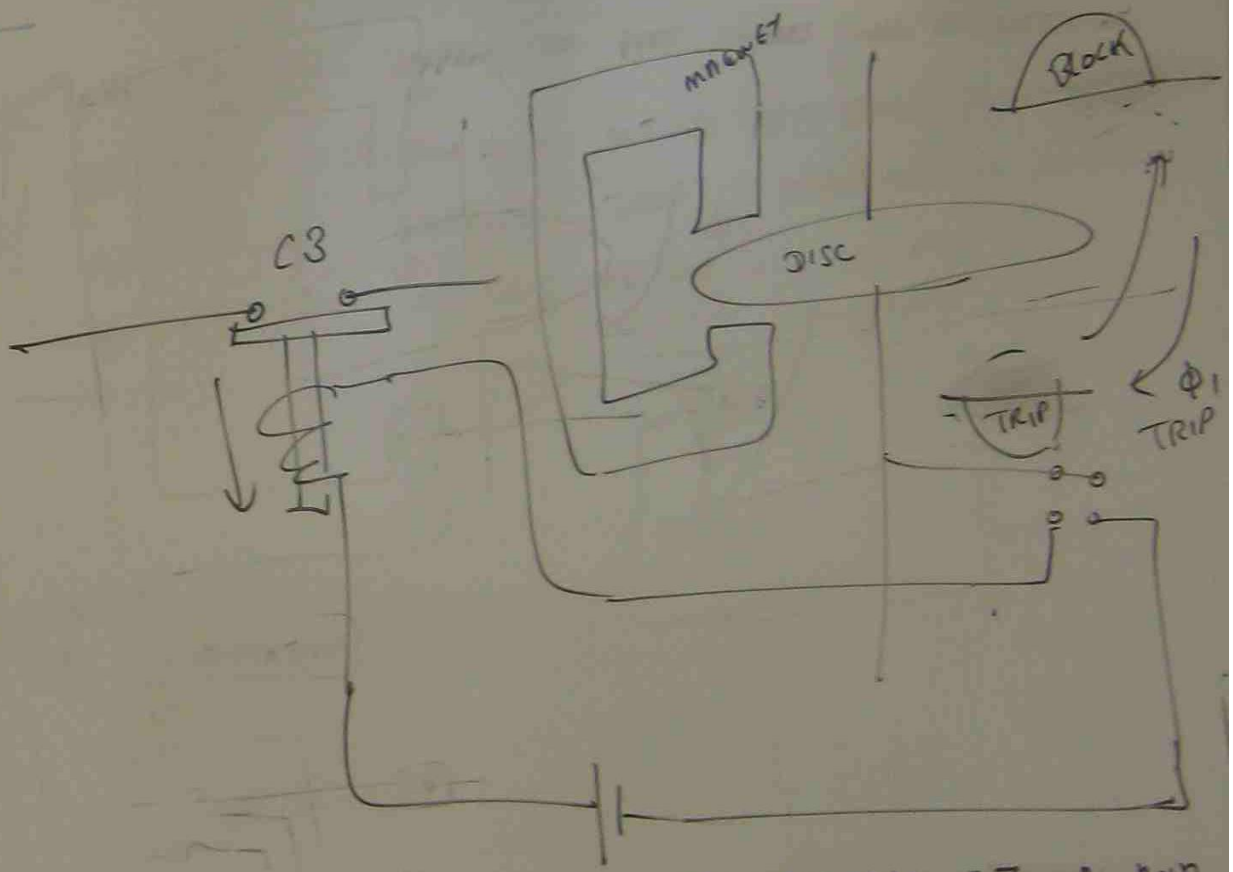


DISCRIMINATING INTERNAL FAULT AND EXTERNAL FAULT IN TRANSMISSION LINE SECTION







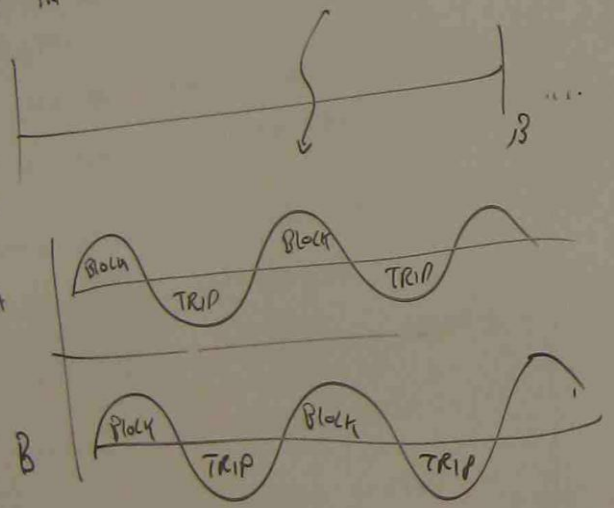


WHEN EXTERNAL FAULT OCCURS, THE SIGNALS AT A AND B ARE SHOWN IN FIGURE.

WHILE A SIDE RELAY TRIES TO TRIP THE CIRCUIT BREAKER, B SIDE RELAY BLOCK (OPPOSES THE TRIPPING)

BY COMBINING TWO WAVE FORMS, THE RESULTANT WAVE HAS ZERO LINE AND NO RELAY OPERATION TAKES PLACE

WHEN INTERNAL FAULT HAPPENS

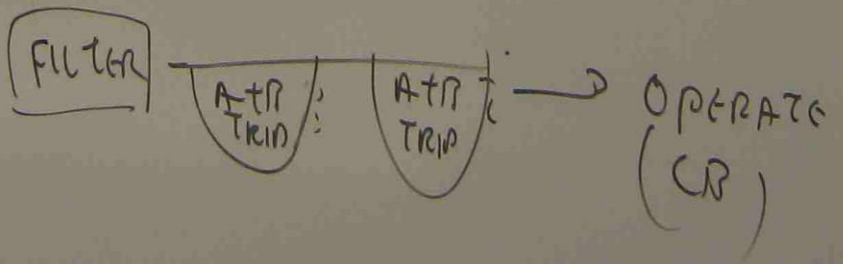


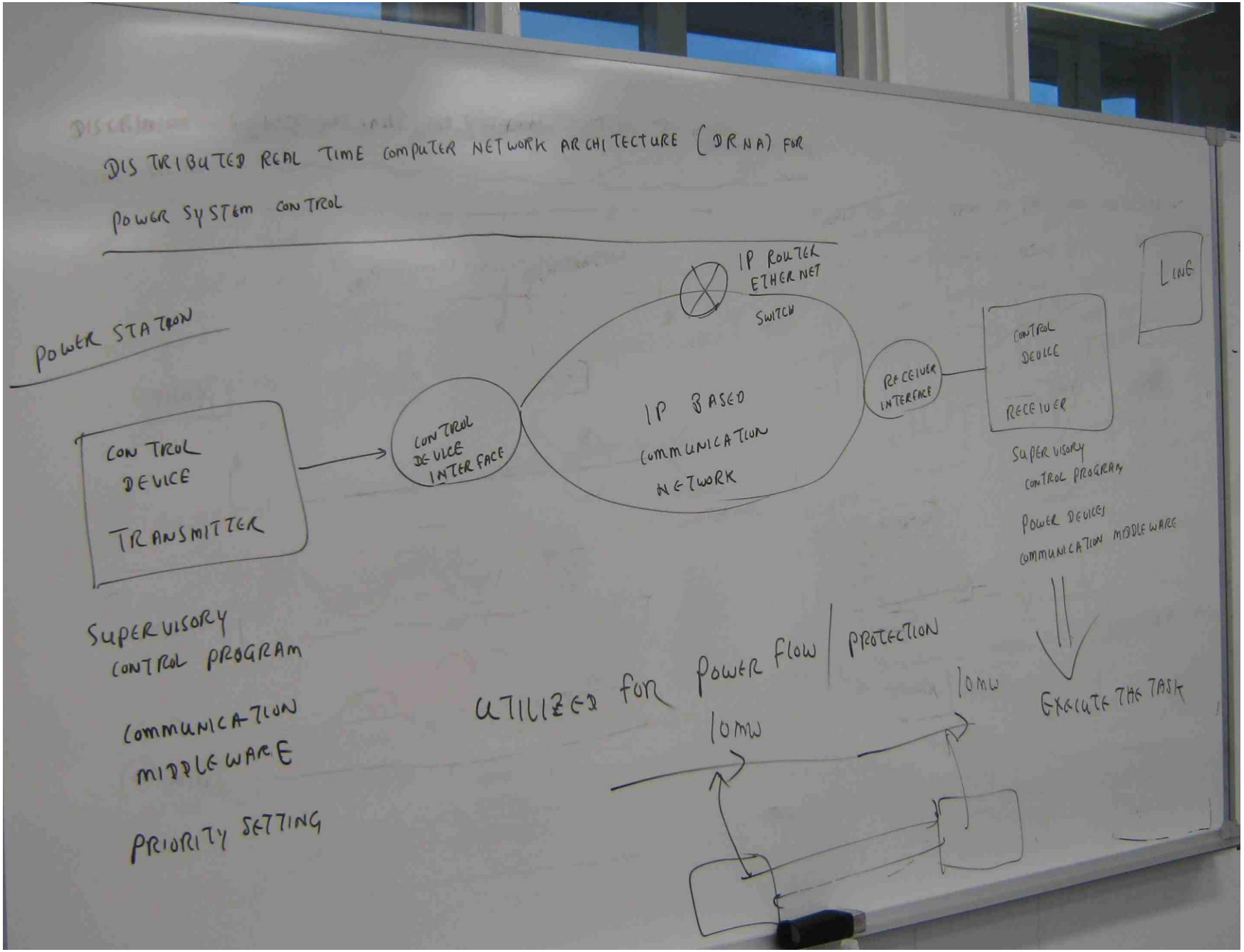
WHEN INTERNAL FAULT OCCURS, BOTH A AND B SIGNALS TRANSMITTERS SEND THE SIGNAL TO CONTROL STATION.

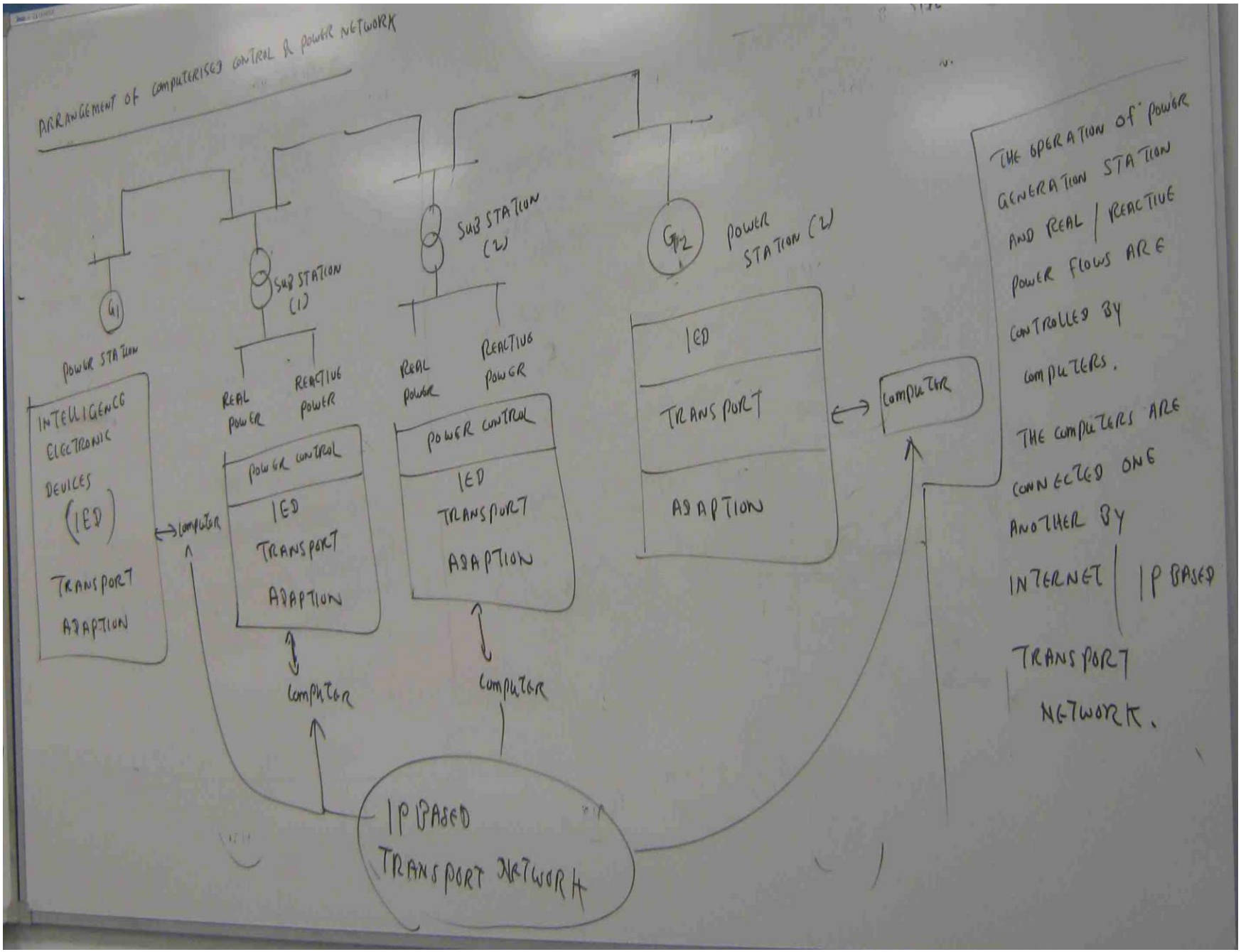
TWO SIGNALS ARE INPHASED.

TRIPPING PORTIONS ARE COMBINED.

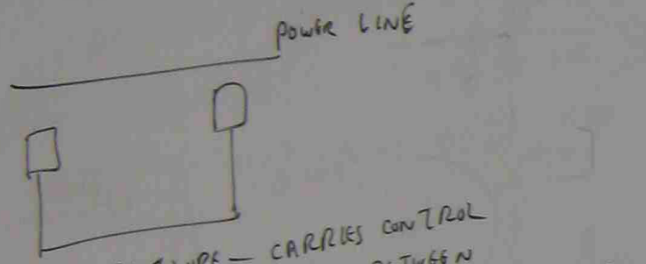
BY USING FILTER TO FILTER OUT THE BLOCK PORTION, TRIP SIGNAL OPERATES THE CIRCUIT BREAKER TO CUT OFF THE LINE.

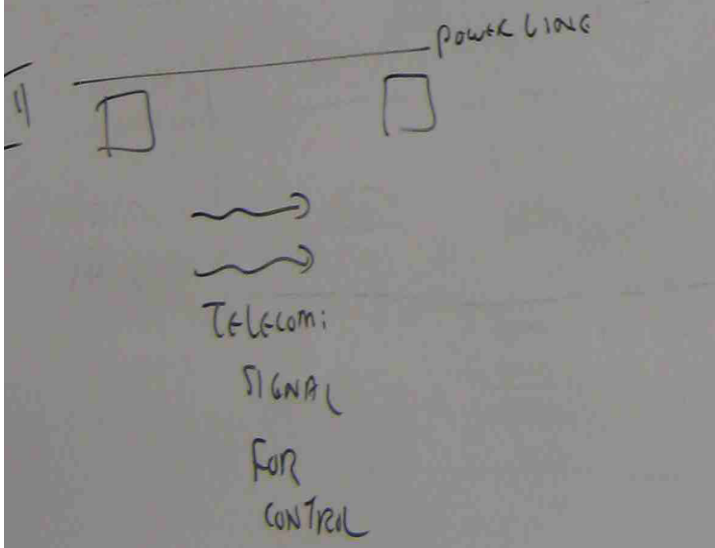


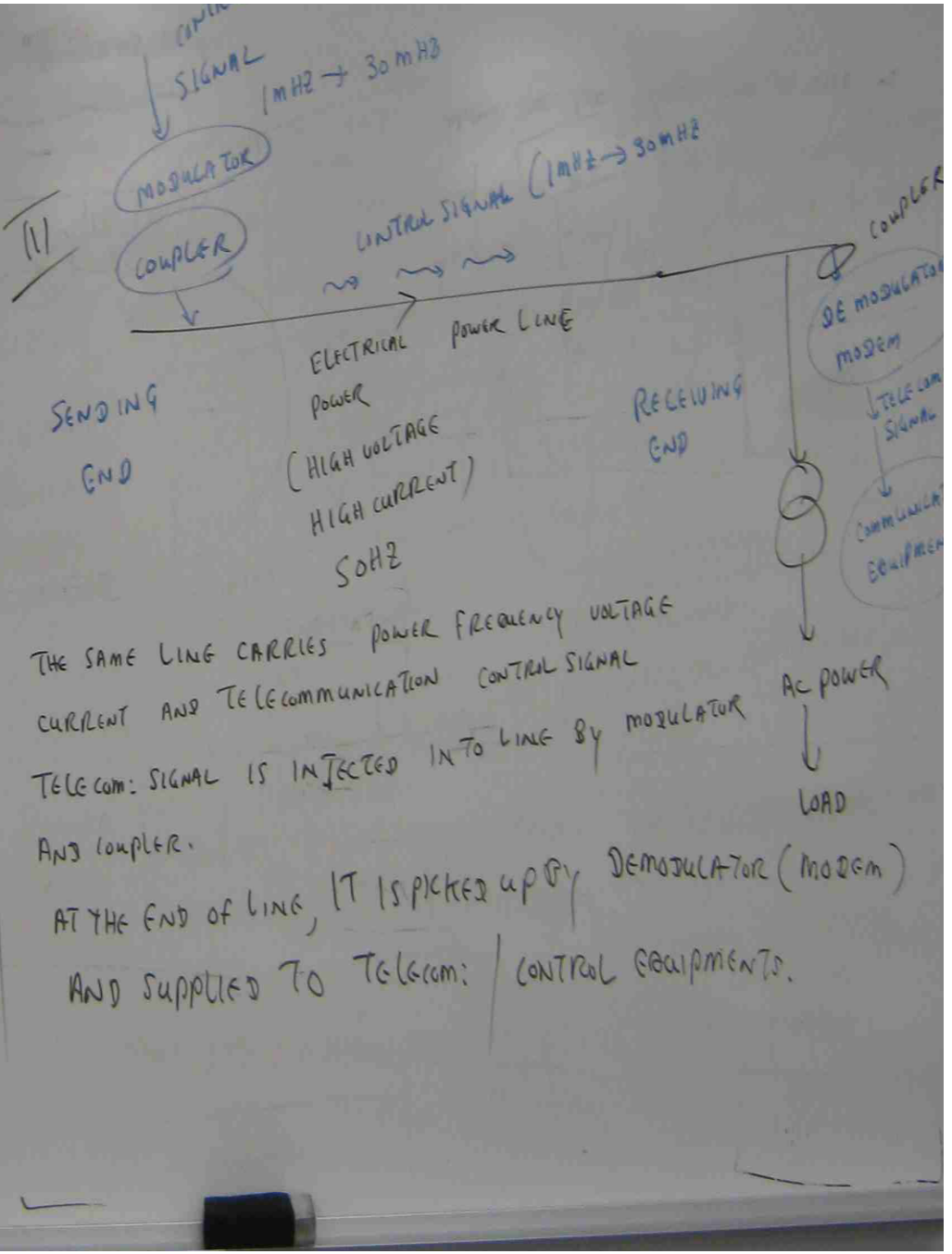

DISTRIBUTED REAL TIME COMPUTER NETWORK ARCHITECTURE (DRNA) FOR
POWER SYSTEM CONTROL
POWER STATION
CONTROL DEVICE TRANSMITTER
CONTROL DEVICE INTERFACE
IP ROUTER ETHERNET SWITCH
IP BASED COMMUNICATION NETWORK
RECEIVER INTERFACE
CONTROL DEVICE RECEIVER
LINE
SUPERVISORY CONTROL PROGRAM
POWER DEVICES COMMUNICATION MIDDLEWARE
SUPERVISORY CONTROL PROGRAM
COMMUNICATION MIDDLEWARE
PRIORITY SETTING
UTILIZED FOR POWER FLOW | PROTECTION
10MW
10MW
EXECUTE THE TASK


ARRANGEMENT OF COMPUTERISED CONTROL & POWER NETWORK
G1
POWER STATION
SUB STATION (1)
SUB STATION (2)
G2
POWER STATION (2)
REAL POWER
REACTIVE POWER
REAL POWER
REACTIVE POWER
INTELLIGENCE ELECTRONIC DEVICES (IED)
TRANSPORT
ADAPTION
COMPUTER
POWER CONTROL
IED
TRANSPORT
ADAPTION
POWER CONTROL
IED
TRANSPORT
ADAPTION
IED
TRANSPORT
ADAPTION
COMPUTER
COMPUTER
COMPUTER
IP BASED TRANSPORT NETWORK
THE OPERATION OF POWER GENERATION STATION AND REAL / REACTIVE POWER FLOWS ARE CONTROLLED BY COMPUTERS.
THE COMPUTERS ARE CONNECTED ONE ANOTHER BY INTERNET / IP BASED TRANSPORT NETWORK.

POWER LINE COMMUNICATION (PLC) SYSTEM





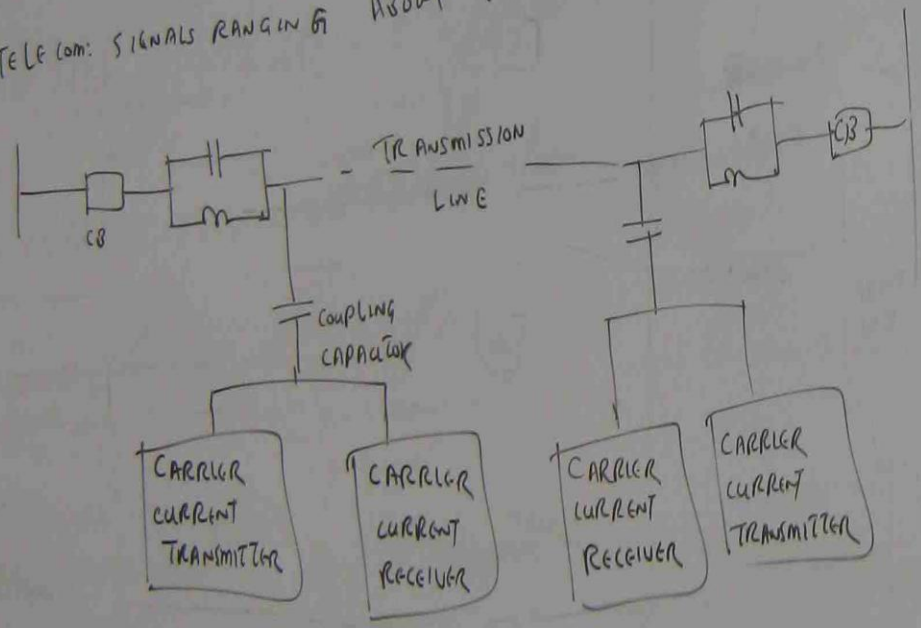


EXERCISE (10)

Q1 HOW IS TELECOMMUNICATION SYSTEM APPLIED IN POWER SYSTEM?

TELECOMMUNICATION SYSTEM IS UTILIZED TO CONTROL PROTECTIVE RELAYS AND TO CONTROL POWER FLOW IN POWER SYSTEM.

TELECOM: SIGNALS RANGING ABOUT 900 MHZ IS APPLIED.



FOR PROTECTION, PHASE COMPARISON RELAYING METHOD IS UTILIZED.

TELECOM: SIGNAL IS ALSO UTILIZED TO CONTROL ACTIVE AND REACTIVE POWER FLOW AT SUBSTATION.

IED - ARE UTILIZED TO INTERFACE TELECOM: LINE / POWER SYSTEM WITH COMPUTERS.

COMPUTERS ARE LINKED ONE ANOTHER BY IP BASED NETWORK.

POWER LINE COMMUNICATION SYSTEM IS APPLIED TO TRANSMIT BOTH ELECTRICAL POWER AND TELECOMM: SIGNAL ON THE SAME LINE.

PLC SIGNAL

BELOW 500 KHZ → CONTROL EQUIPMENT | RELAYS ⟷ NO RADIO INTERFERENCE

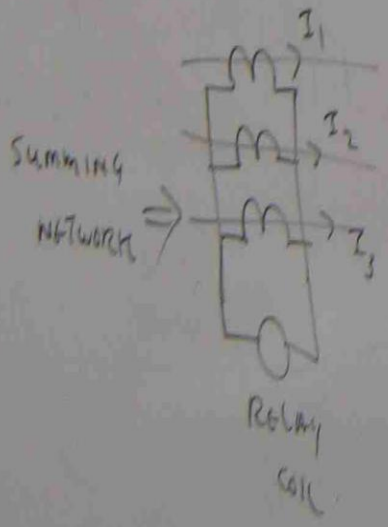
1 MHZ → 30 MHZ → COMMUNICATION CIRCUIT ⟷ SUBJECT TO RADIO INTERFERENCE

TYPE OF PROTECTIVE SCHEME

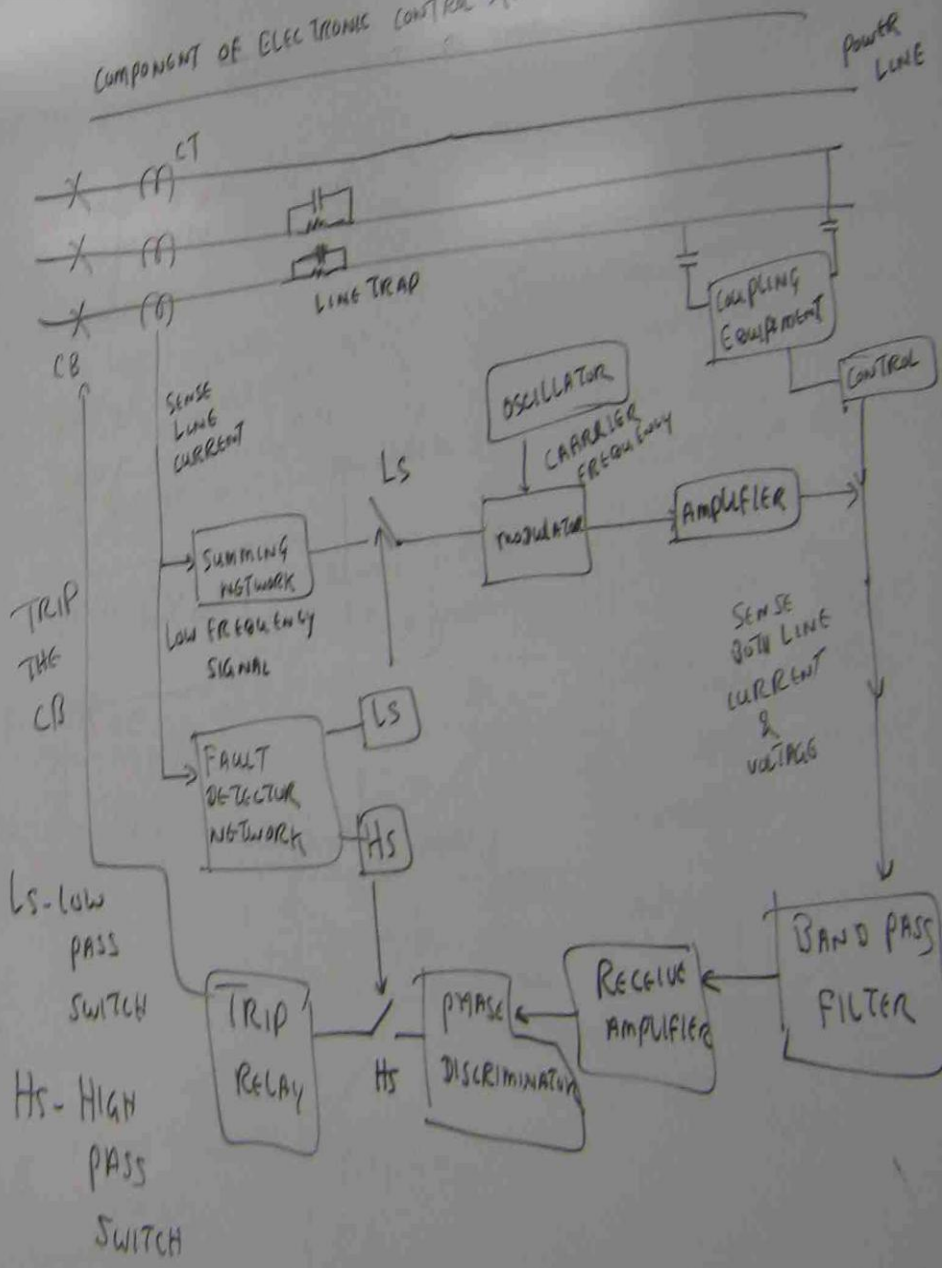
DIRECT TT - DIRECT TRANSFER TRIP

PERMISSIVE — OVER REACHING, UNDER REACHING → TRANSFER TRIP ALLOW THE SIGNAL TO PASS THROUGH

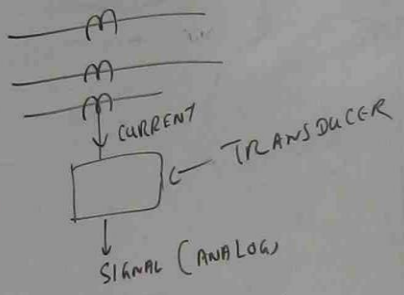
BLOCKING



COMPONENT OF ELECTRONIC CONTROL SYSTEM FOR POWER LINE



DIGITAL SIGNAL PROCESSING SUB SYSTEM FOR COMPUTER CONTROL POWER SYSTEM OPERATION

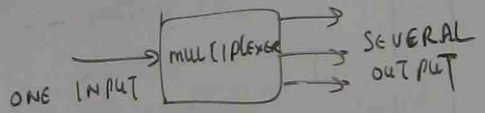


TRANSDUCER

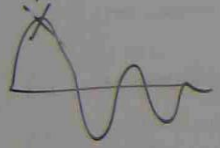
SURGE PROTECTIVE CIRCUIT

LOW PASS FILTER

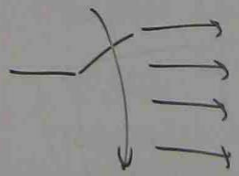
HIGH FREQUENCIES ARE ELIMINATED

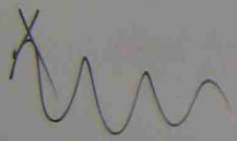


20A SAMPLE HOLD



ANALOG MULTIPLEXER





SAMPLE HOLD CIRCUIT

SAMPLING CIRCUIT

A/D CONVERTER

DIGITAL MULTIPLEXER

I/P INPUT

MEMORY

CPU

D/O

DIGITAL

D/A CONVERTER

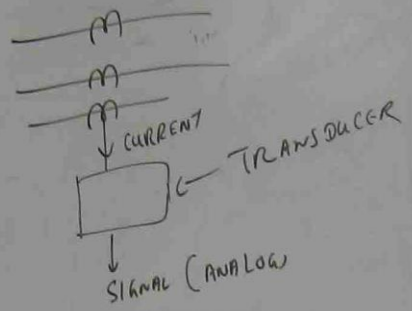
DIGITAL → ANALOG

TRIP CIRCUIT

CB

LINE

DIGITAL SIGNAL PROCESSING SUB SYSTEM FOR COMPUTER CONTROL POWER SYSTEM OPERATION



TRANSDUCER

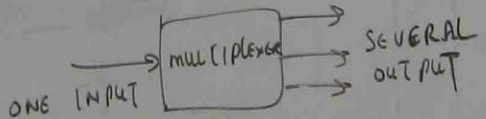
SURGE PROTECTIVE CIRCUIT

LOW PASS FILTER

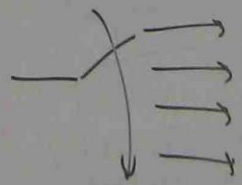
HIGH FREQUENCIES ARE ELIMINATED

20A

SAMPLE HOLD



ANALOG MULTIPLEXER



SAMPLE HOLD CIRCUIT

SAMPLING CIRCUIT

A/D CONVERTER

DIGITAL MULTIPLEXER

I/P INPUT

MEMORY

CPU

D/O

DIGITAL

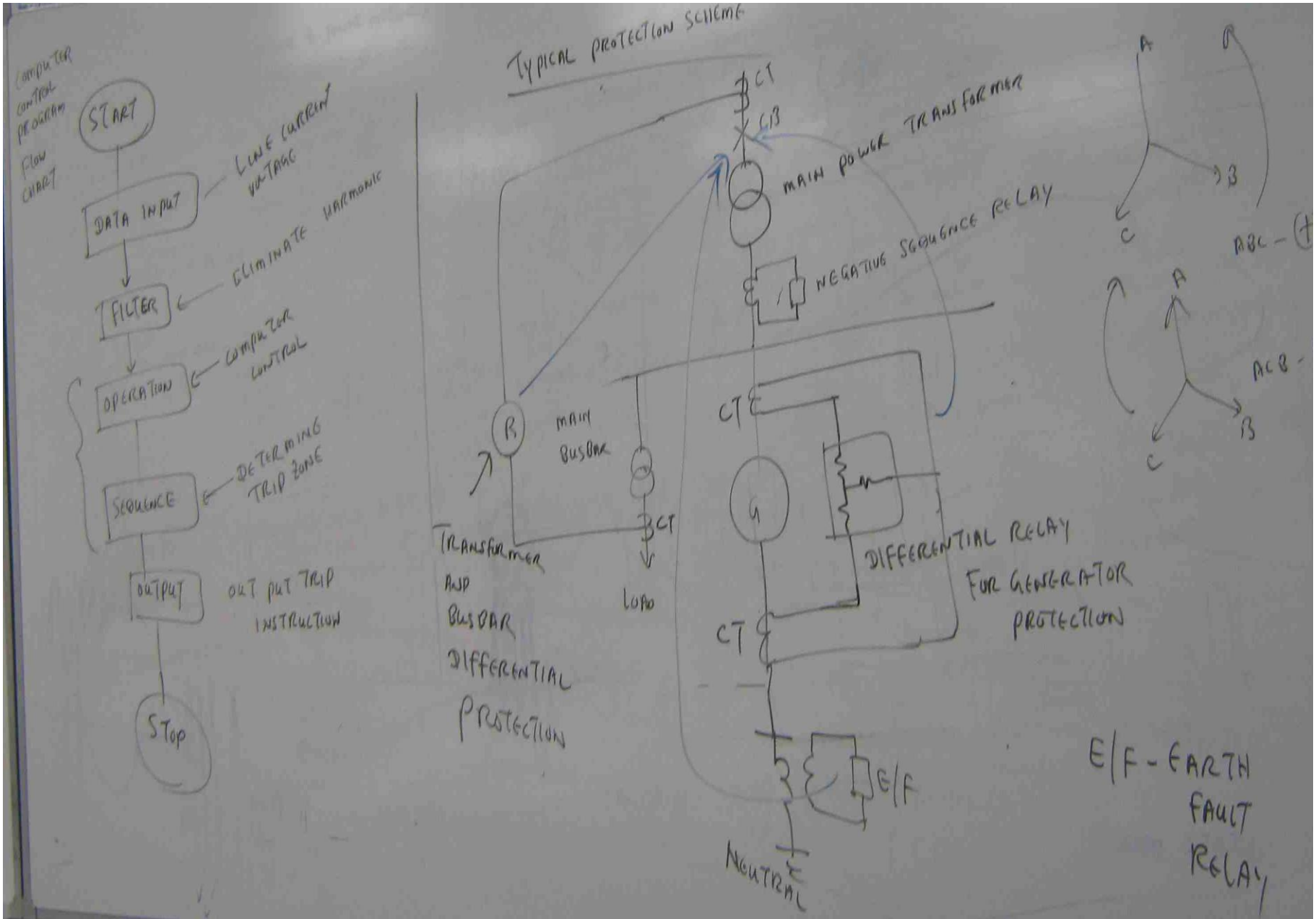
D/A CONVERTER

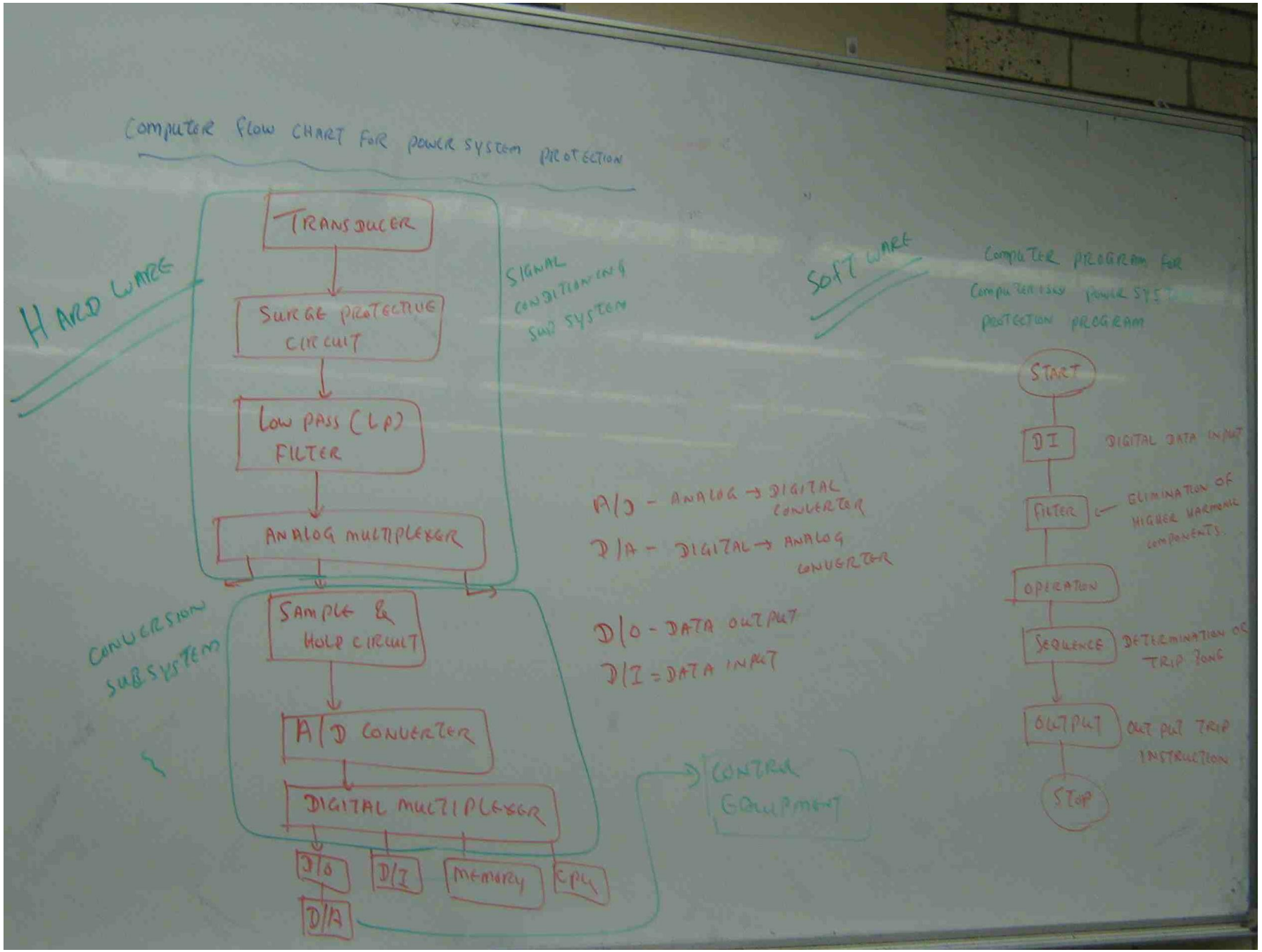
DIGITAL → ANALOG

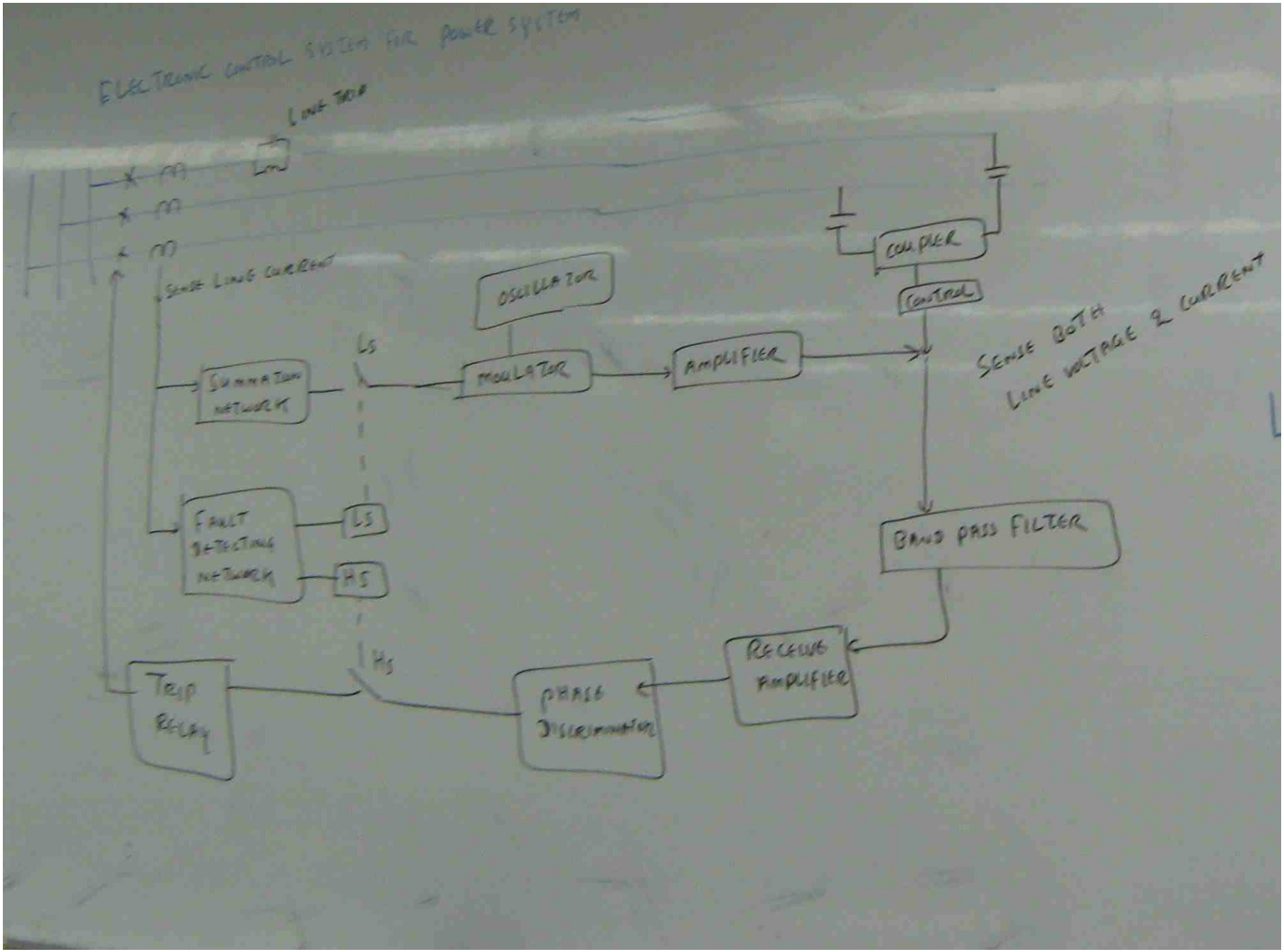
TRIP CIRCUIT

CB

LINE


Computer control program flow chart
START
DATA INPUT
Line current voltage
FILTER
Eliminate harmonic
OPERATION
Computer control
SEQUENCE
Determing trip zone
OUTPUT
Out put trip instruction
Stop
Typical protection scheme
CT
CB
Main power transformer
Negative sequence relay
R
Main Busbar
CT
Transformer and Busbar differential protection
Load
CT
G
Differential relay for generator protection
CT
E/F
Neutral
E/F - Earth fault relay
A
B
C
ABC - (+)
A
B
C
ACB -


Computer flow chart for power system protection
HARD WARE
TRANSDUCER
SURGE PROTECTIVE CIRCUIT
LOW PASS (LP) FILTER
ANALOG MULTIPLEXER
SIGNAL CONDITIONING SUB SYSTEM
CONVERSION SUB SYSTEM
SAMPLE & HOLD CIRCUIT
A/D CONVERTER
DIGITAL MULTIPLEXER
D/O
D/I
MEMORY
CPU
D/A
A/D - ANALOG → DIGITAL CONVERTER
D/A - DIGITAL → ANALOG CONVERTER
D/O - DATA OUTPUT
D/I - DATA INPUT
CONTROL EQUIPMENT
SOFT WARE
COMPUTER PROGRAM FOR COMPUTERISED POWER SYSTEM PROTECTION PROGRAM
START
DI
DIGITAL DATA INPUT
FILTER
ELIMINATION OF HIGHER HARMONIC COMPONENTS.
OPERATION
SEQUENCE
DETERMINATION OF TRIP ZONE
OUTPUT
OUT PUT TRIP INSTRUCTION
STOP


ELECTRONIC CONTROL SYSTEM FOR POWER SYSTEM
LINE TRIP
LINE
SENSE LINE CURRENT
OSCILLATOR
COUPLER
CONTROL
SUMMATION NETWORK
LS
MODULATOR
AMPLIFIER
SENSE BOTH LINE VOLTAGE & CURRENT
FAULT DETECTING NETWORK
LS
HS
BAND PASS FILTER
RECEIVER AMPLIFIER
TRIP RELAY
HS
PHASE DISCRIMINATOR