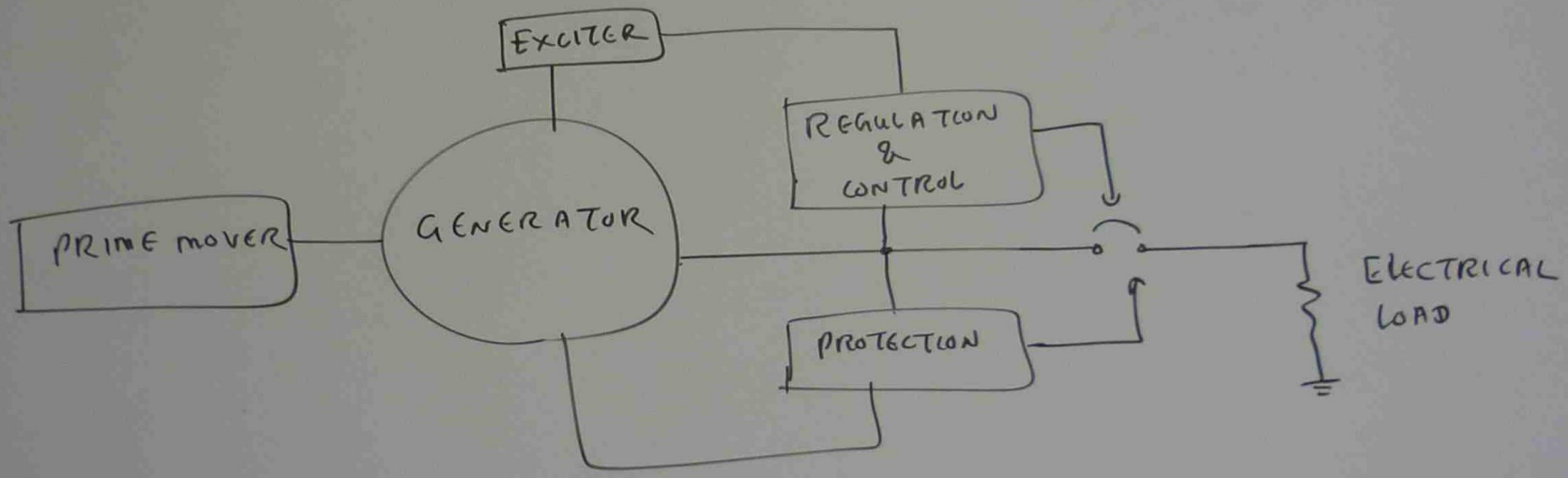
CONTROL of ELECTRIC GENERATING SYSTEMS

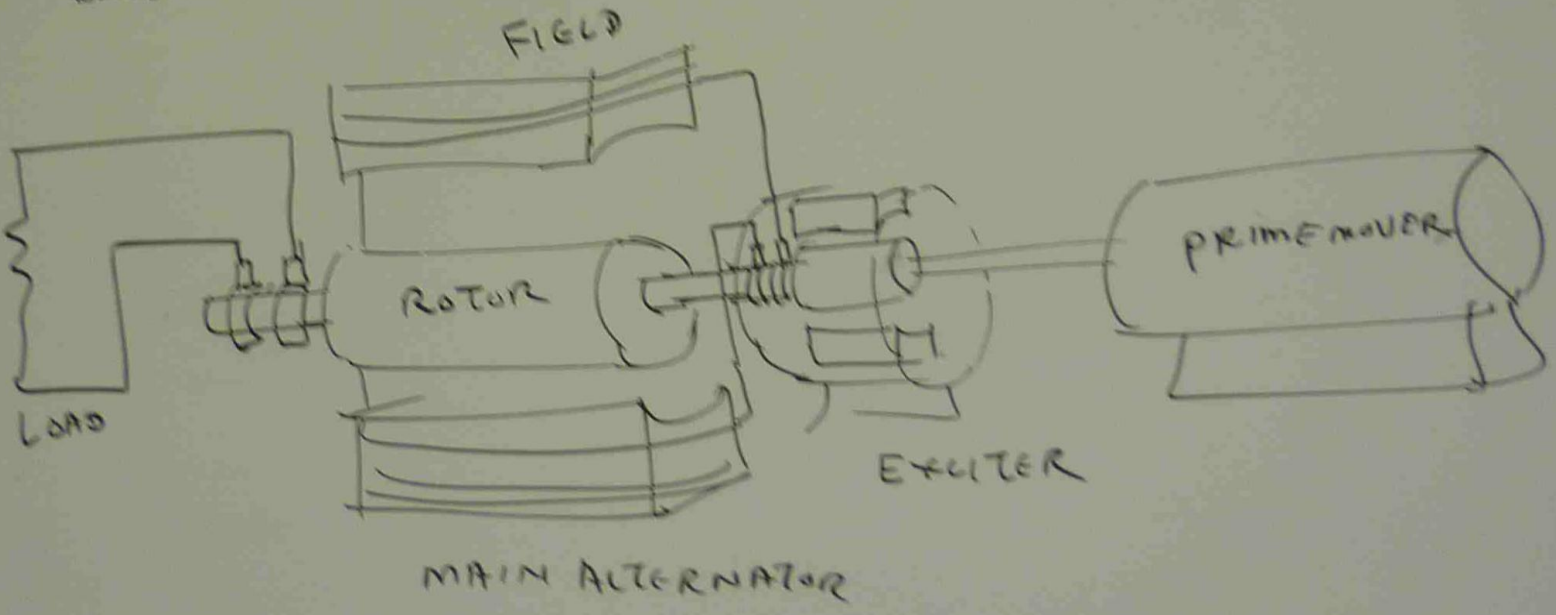
A TYPICAL ELECTRIC GENERATING SYSTEM CONSISTS of A GENERATOR, PRIME MOVER, REGULATION AND CONTROL EQUIPMENT IN ADDITION TO PROTECTION DEVICES.



EXCITER

THE EXCITER SUPPLIES DC EXCITATION CURRENT TO THE FIELD OF A SYNCHRONOUS GENERATOR THERE ARE TWO BASIC KINDS OF EXCITERS, ROTATING AND STATIC.

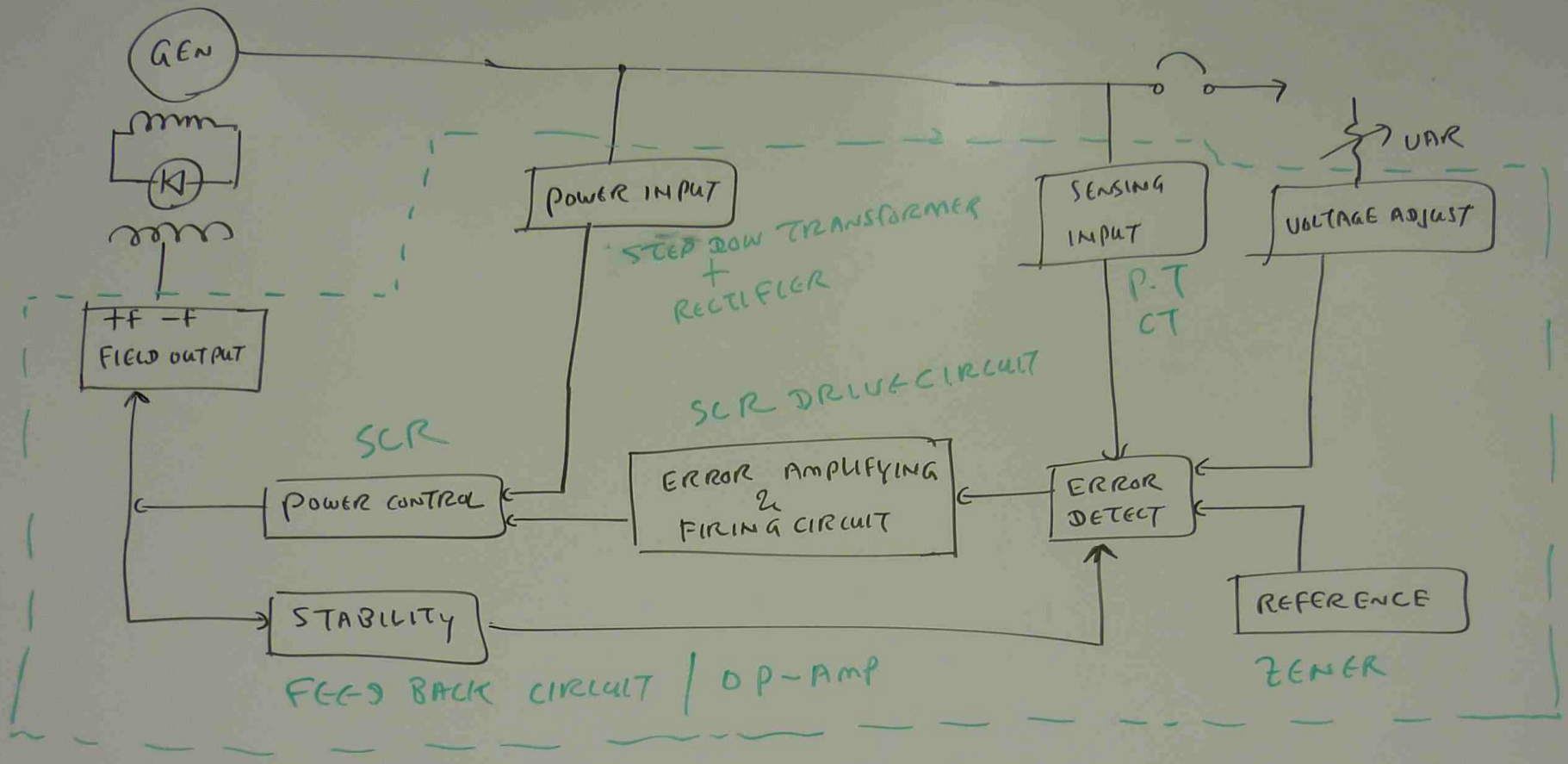
ROTATING EXCITERS ARE FURTHER BROKEN DOWN IN TO TWO CATEGORIES BRUSH AND BRUSHLESS.



VOLTAGE REGULATORS

THE VOLTAGE REGULATOR PROVIDES DC EXCITATION CURRENT TO THE BRUSHLESS EXCITER FIELD POLE WINDINGS. IT NORMALLY TAKES IT'S OPERATING POWER FROM GENERATOR OUTPUT VOLTAGE AND CONVERTS THIS AC POWER TO DC EXCITING CURRENT.

A VOLTAGE REGULATOR THEN REGULATES OR CONTROLS THE AC GENERATOR OUTPUT VOLTAGE BY SENSING THAT VOLTAGE, COMPARING IT TO AN INTERNAL ZENER REFERENCE VOLTAGE AND THEN MAKING ADJUSTMENTS TO ITS OUTPUT WHICH IS SUPPLYING CURRENT TO EXCITER FIELD.



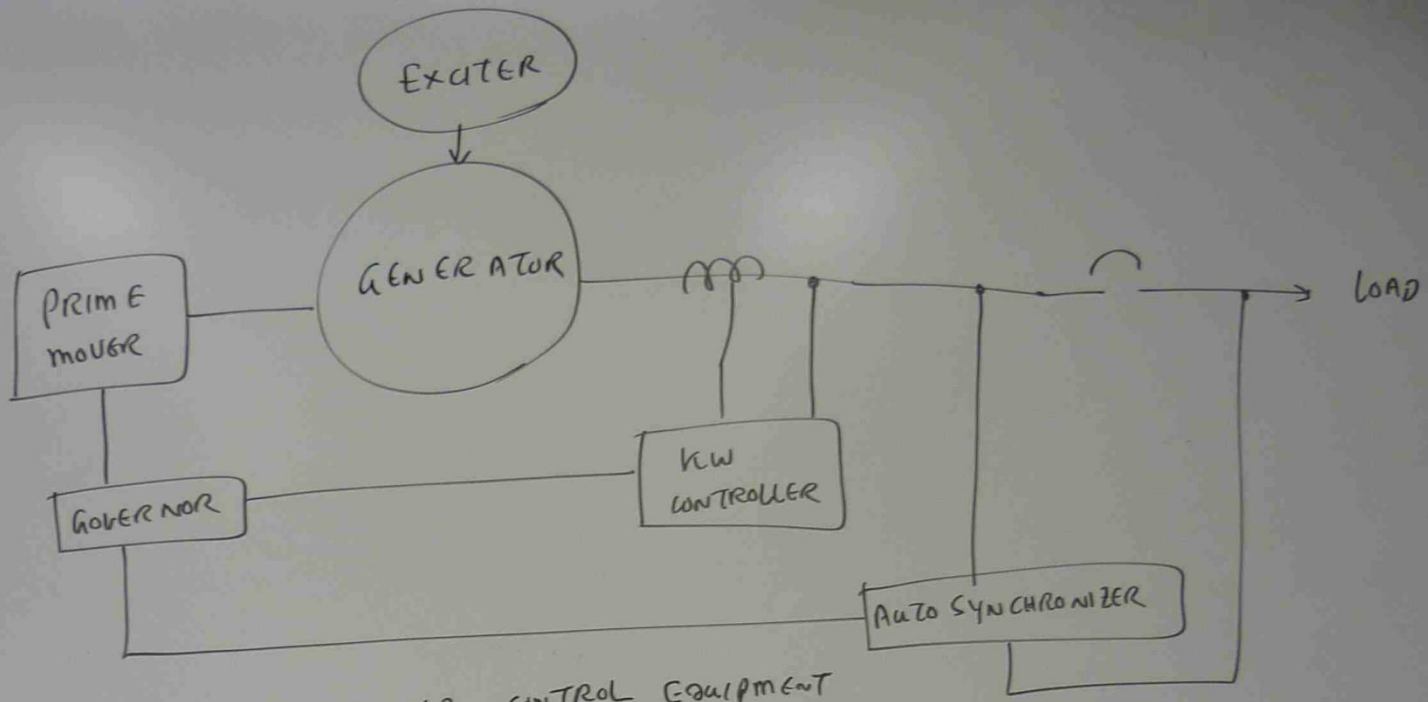
VOLTAGE REGULATOR PROVIDES PRECISE VOLTAGE CONTROL

PRIME MOVER / GOVERNOR

THE PRIME MOVER / GOVERNOR CONTROLS THE ENGINE SPEED PROVIDES THE PRECISE FREQUENCY REGULATION.

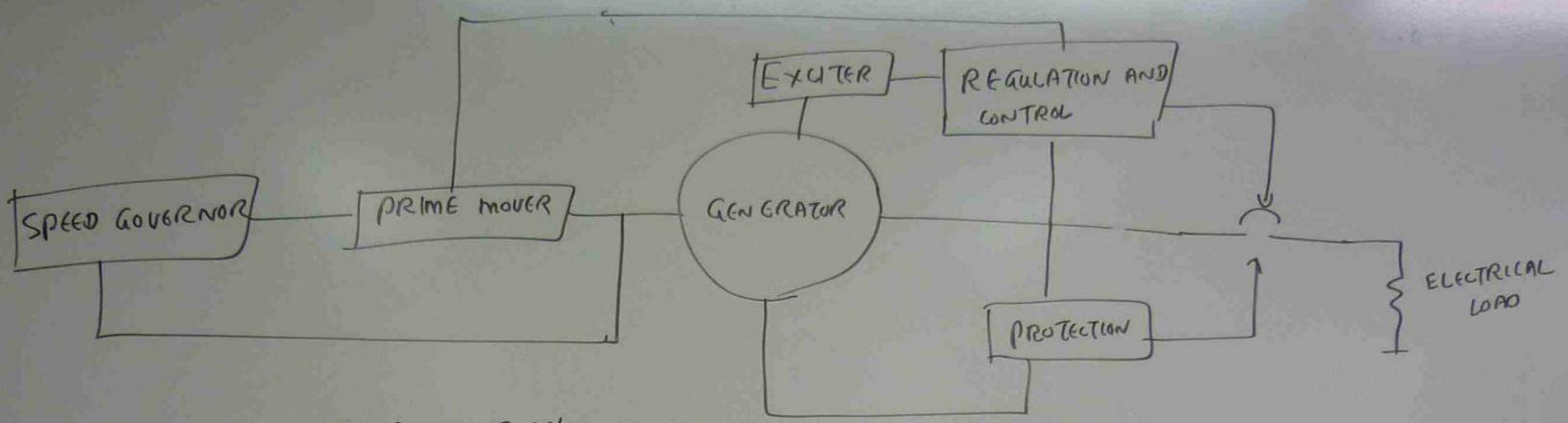
WHEN THE GENERATOR IS CONNECTED IN PARALLEL WITH AN INFINITE BUS SUCH AS UTILITY, THE PRIME MOVER GOVERNOR NO LONGER CONTROLS FREQUENCY. THE FREQUENCY IS DETERMINED BY INFINITE BUS. THE GOVERNOR CONTROLS THE ACTIVE (OR) WATT LOAD.

AUTOMATIC SYNCHRONIZERS CAN BE USED TO GIVE THE FREQUENCY SPEED MATCHING SIGNAL TO THE GOVERNOR AND VOLTAGE REGULATOR VOLTAGE MATCHING SIGNALS FOR ACCURATE INPHASE SYNCHRONIZING OF SYNCHRONOUS MACHINES.

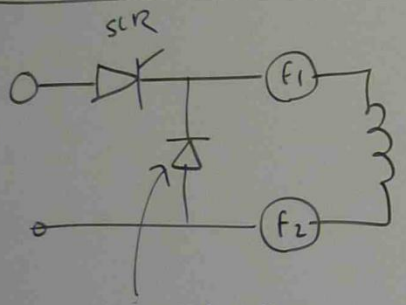


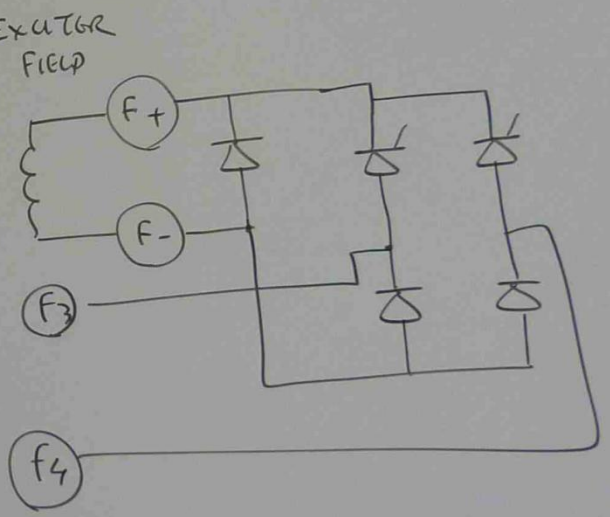
PRIME MOVER CONTROL EQUIPMENT

THE PRIME MOVER GOVERNOR CONTROLS BOTH SYSTEM FREQUENCY AND THE PROPORTIONAL SHARING OF WATT LOAD BETWEEN GENERATORS.



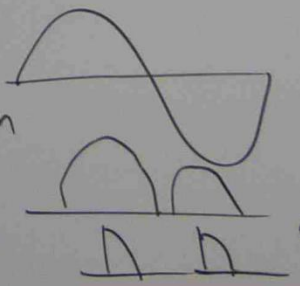
EXCITER FIELD POWER SUPPLY SYSTEM





THE WAVE FORM IS CONTROLLED BY SCR GATING CIRCUIT.

FLY BACK DIODE GIVES A PATH FOR FIELD CURRENT FLOW DURING SCR IS OFF.



STABILITY

THE STABILITY CIRCUIT IS INCLUDED IN FIELD REGULATOR.

TYPES of EXCITATIONS

A : STATIC EXCITATION (SLIP RING)

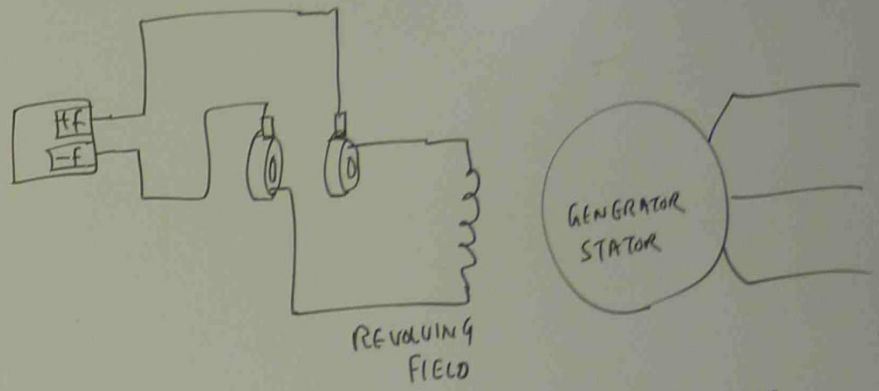
B : ROTARY BRUSH TYPE EXCITATION

C : ROTARY BRUSHLESS EXCITATION.

THE VOLTAGE REGULATOR INFLUENCE ON GENERATOR STABILITY

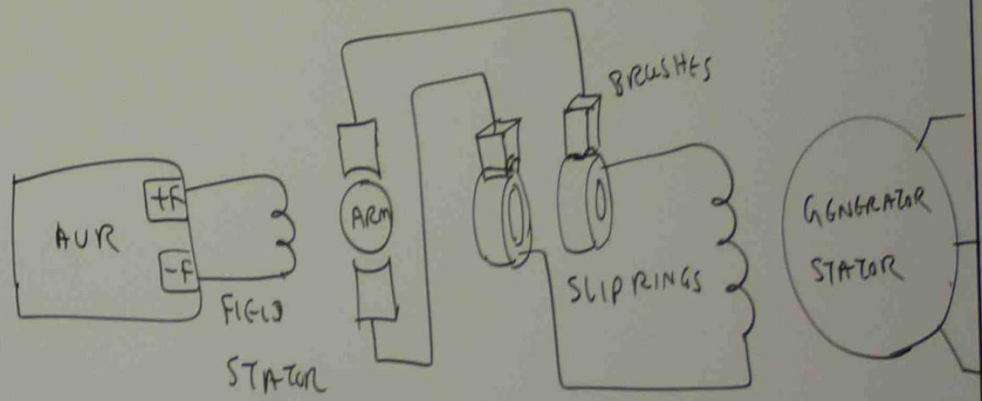
1. RATED GENERATOR KILOWATTS
2. RATED GENERATOR POWER FACTOR
3. RPM OF PRIME MOVER
4. GENERATOR LINE VOLTAGE
5. FIELD REQUIREMENT.

STATIC EXCITATION



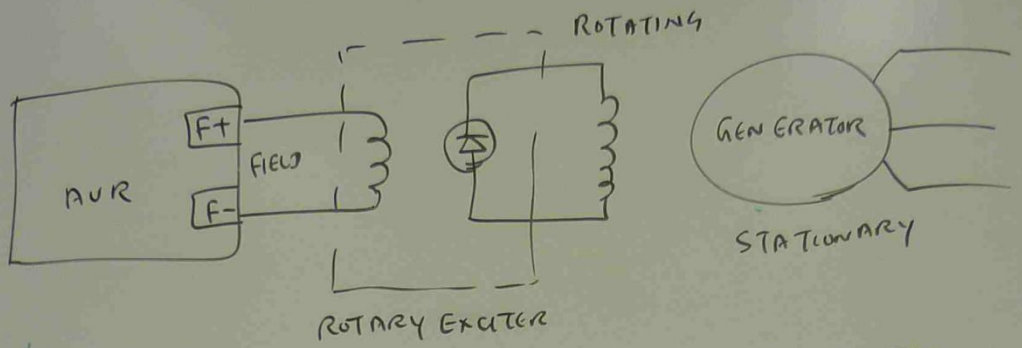
SLIP RING GENERATOR

BRUSH TYPE ROTARY EXCITER

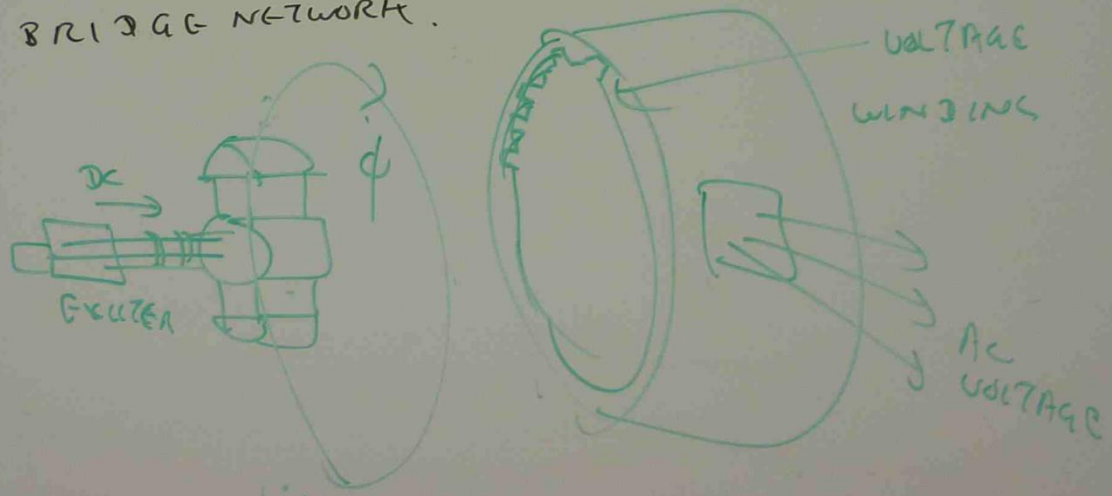


ROTARY EXCITED, BRUSH TYPE GENERATOR

BRUSHLESS ROTARY EXCITER



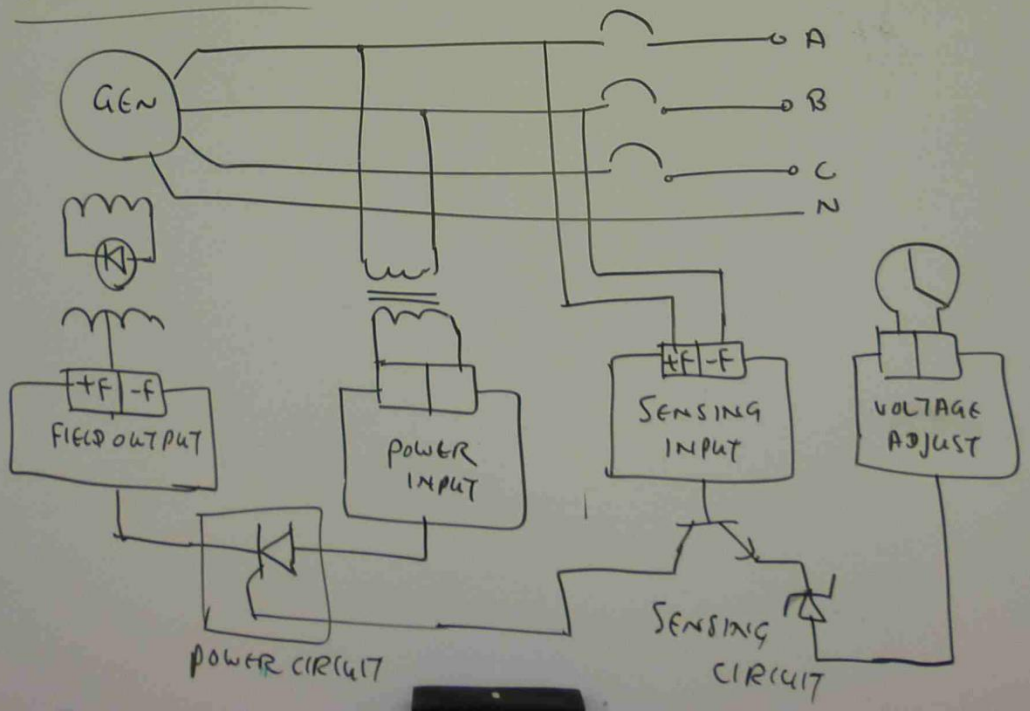
A BRUSHLESS ROTARY EXCITER IS SIMILAR TO THE BRUSH ROTARY EXCITER, BUT INSTEAD OF USING A COMMUTATOR AND BRUSH TO CONVERT THE AC VOLTAGE FROM ROTATING STATOR TO DC, IT USES DIODE BRIDGE NETWORK.



SELECTING THE PROPERLY SIZED REGULATOR

GENERATOR RATING		REGULATOR RATING
FIELD VOLTAGE	<	REGULATOR CONTINUOUS VOLTAGE RATING
FIELD CURRENT	<	REGULATOR CONTINUOUS CURRENT RATING
FIELD RESISTANCE	>	REGULATOR MINIMUM RESISTANCE RATING.

POWER INPUT



OTHER SELECTION CRITERIA

THE FOUR BASIC STEPS FOR THE SELECTION OF THE VOLTAGE REGULATOR HAVE BEEN IDENTIFIED. THESE ARE:

1. GENERATOR TYPE
2. EXCITER RATING
3. POWER INPUT
4. SENSING INPUT.

ADDITIONAL SELECTION CRITERIA

1. TEMPERATURE RANGE
2. VIBRATION AND SHOCK
3. REGULATION ACCURACY
4. THERMAL DRIFT

THREE FACTORS AFFECT VOLTAGE STABILITY OF GENERATOR SYSTEM

GAIN

IN ORDER TO OBTAIN HIGH ACCURACY FOR GOOD VOLTAGE REGULATION, THE EXCITATION SYSTEM MUST BE DESIGNED WITH ELECTRONIC CIRCUIT THAT HAS HIGH GAIN

STABILITY NETWORK

THE AUTOMATIC VOLTAGE REGULATOR UTILIZES A NETWORK THAT IS FREQUENCY SENSITIVE. THIS NETWORK CONSISTS OF LAG AND LEAD CIRCUITS THAT ARE ARRANGED TO PROVIDE A FEEDBACK SIGNAL INTO THE SUMMING POINT OF THE VOLTAGE REGULATOR

FIELD TIME CONSTANT

FIELD TIME CONSTANT $\tau = \frac{L}{R}$ PROVIDES INDUCTIVE TIME LAG. THERE IS ALSO A PHASE SHIFT THAT CAUSES THE FIELD CURRENT TO LAG FIELD VOLTAGE

TYPICAL GENERATOR INSTABILITY PROBLEMS

(1) MATCHING TIME CONSTANTANT OF REGULATOR AND GENERATOR.

A REGULATOR WHICH WORKS WELL WITH 3 MW GENERATOR MAY NOT WORK WELL WITH 10 MW GENERATOR. IT NEEDS TO TUNE TIME CONSTANT

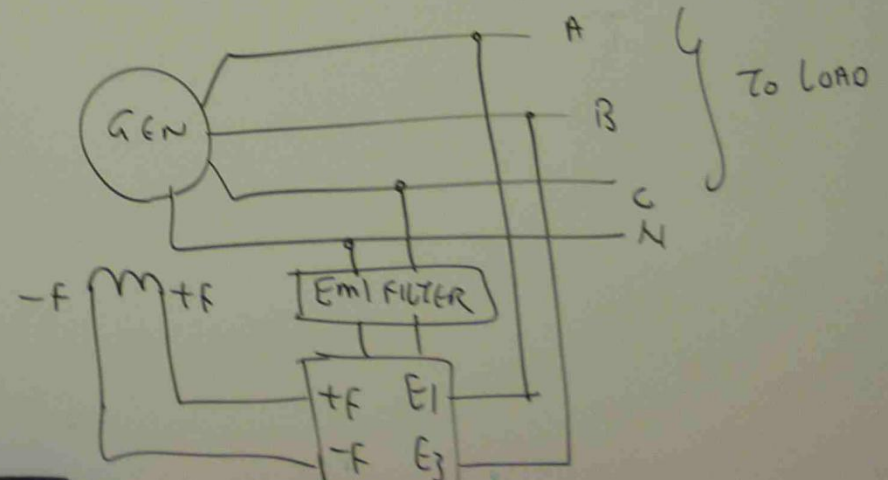
(2) KW FLUCTUATION

LOW FREQUENCY GENERATOR INSTABILITY CAN BE CAUSED BY NATURAL HARMONIC FREQUENCY RESONANCE OF THE TURBINE AND THE PEN STOCK

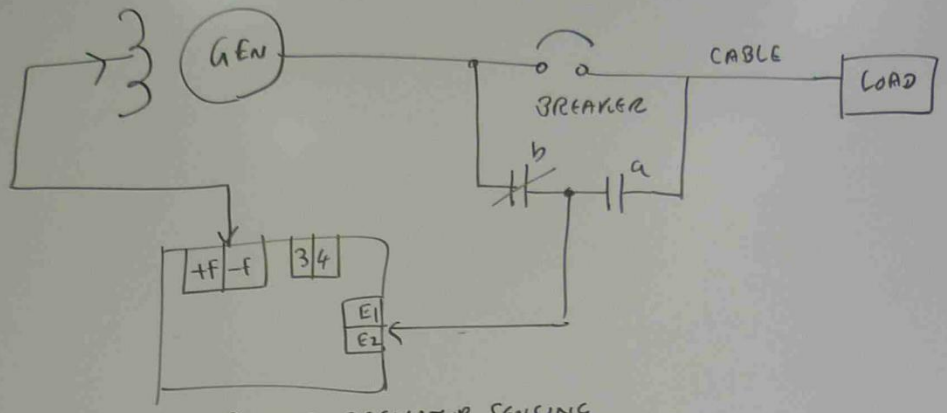
(3) LONG POWER LINE / DISTANCE POWER SOURCE

HIGH IMPEDANCE POWER LINES CONNECTING A GENERATOR TO A DISTANT POWER GRID (OR) POWER SOURCE CAN CAUSE INSTABILITY.

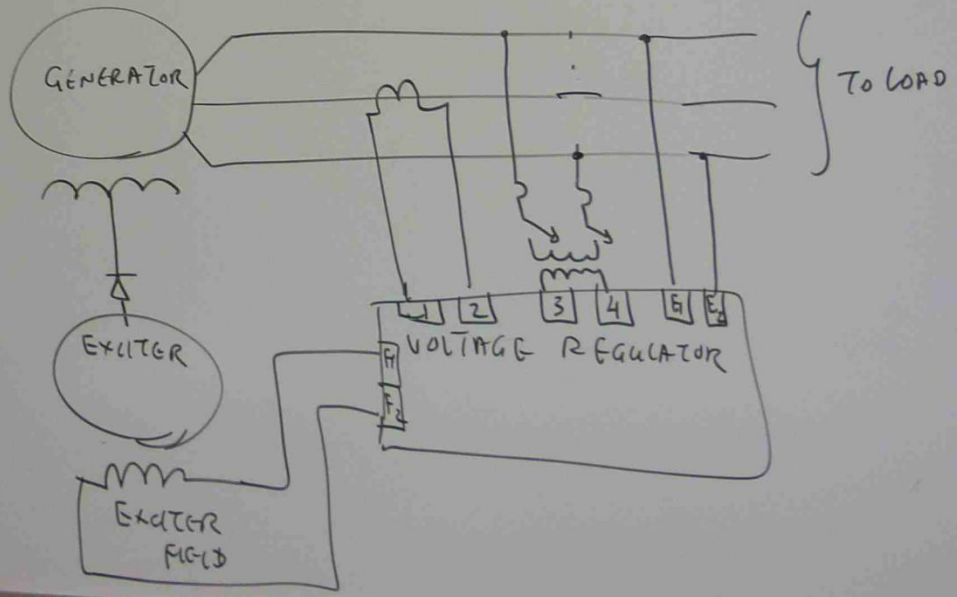
EMI FILTER



REMOTE REGULATOR SENSING



REMOTE REGULATOR SENSING



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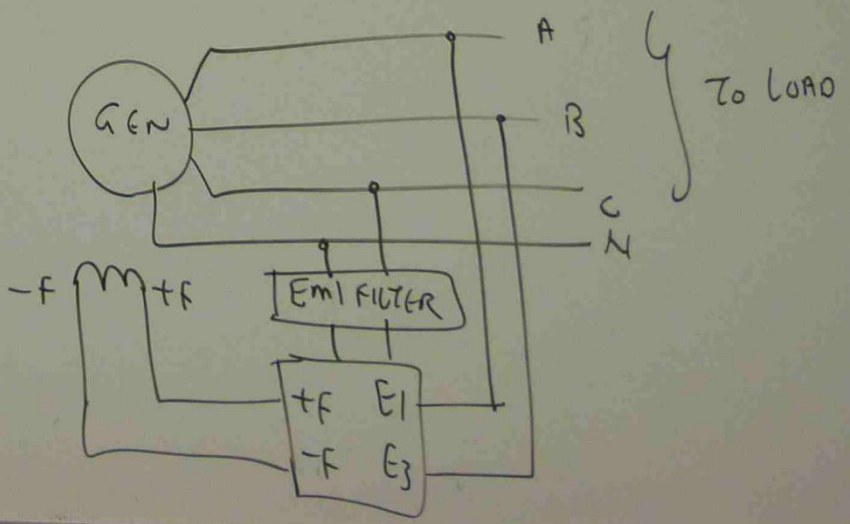
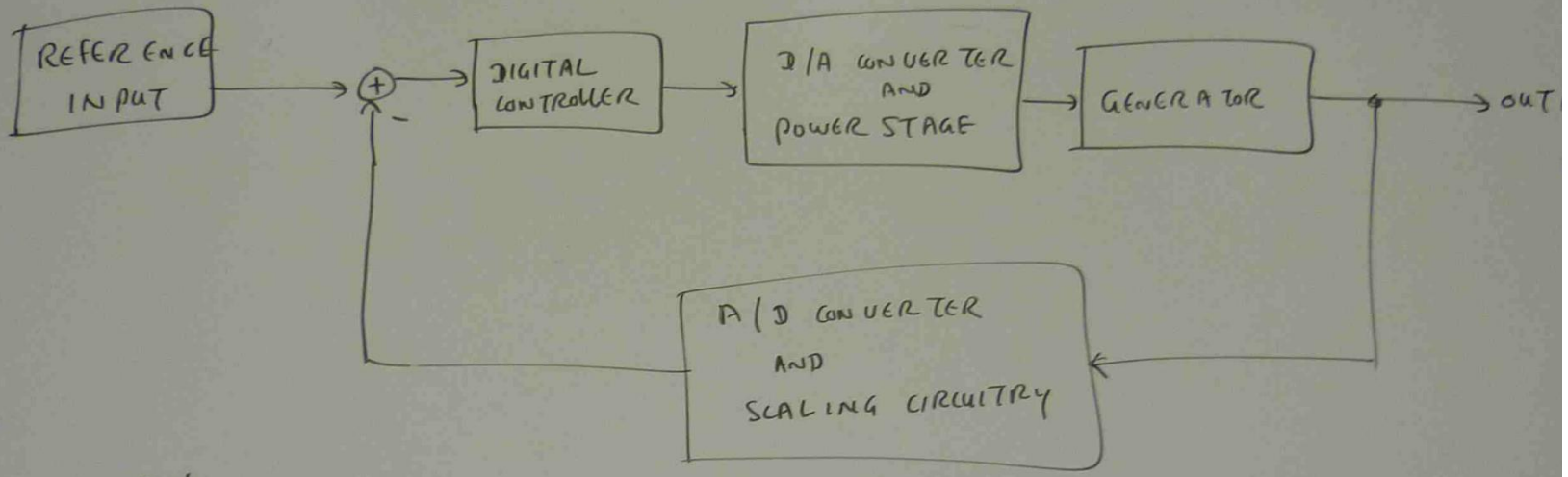
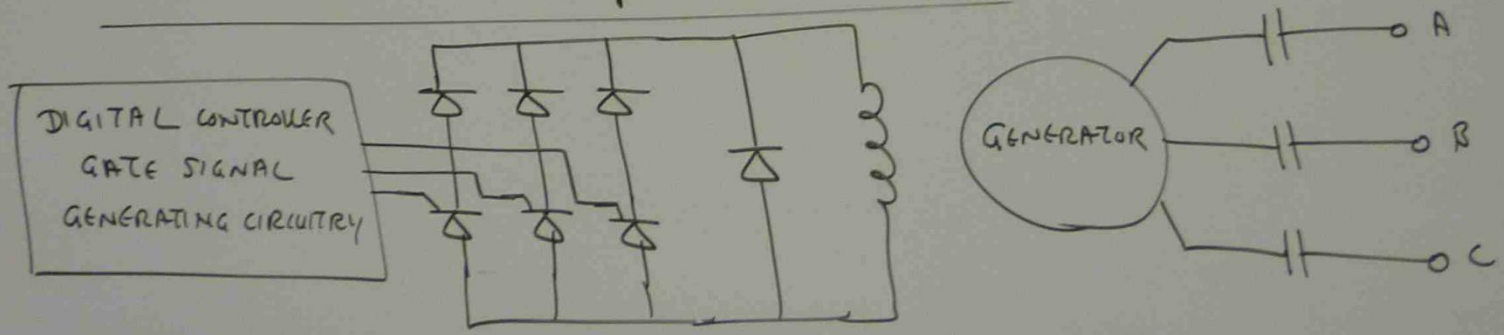


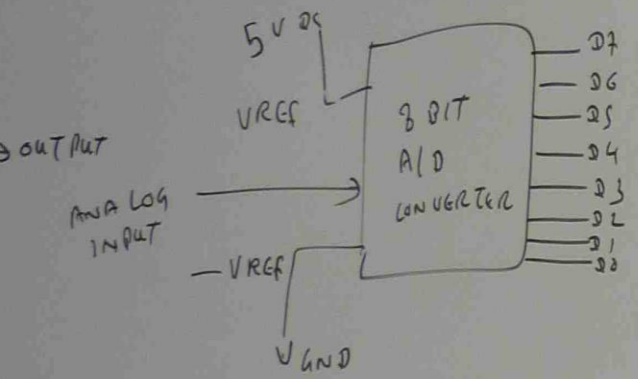
DIGITAL EXCITATION TECHNOLOGY



3ϕ SEMI CONTROLLER POWER BRIDGE

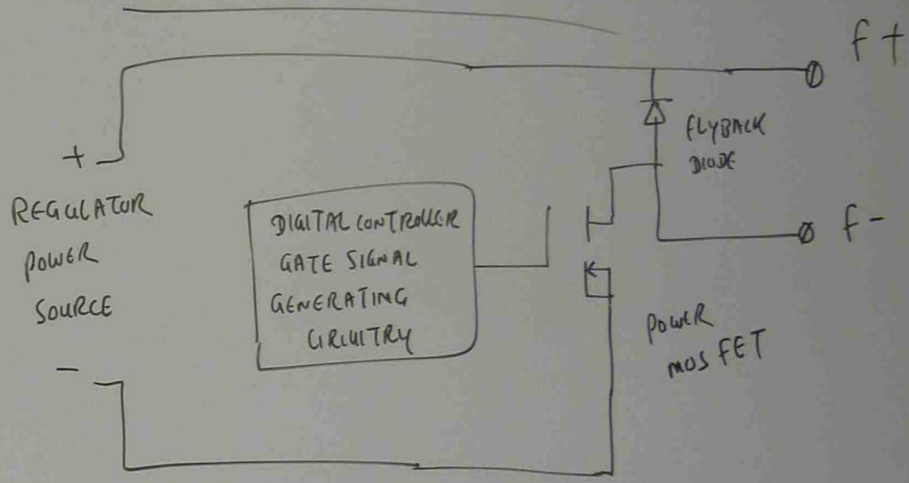


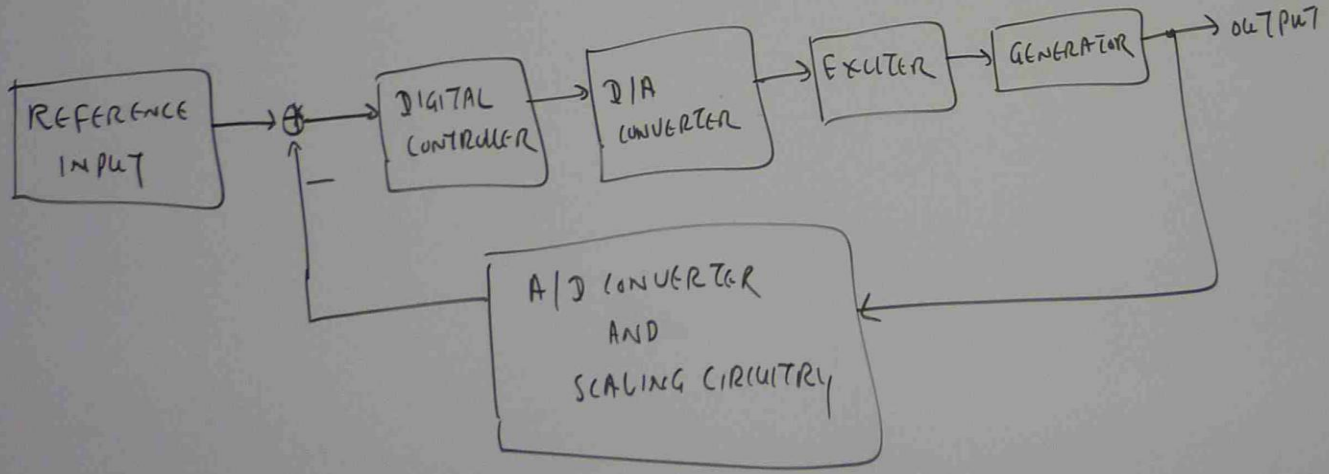
AD CONVERTOR



DIGITAL VOLTAGE REGULATION
BLOCK DIAGRAM

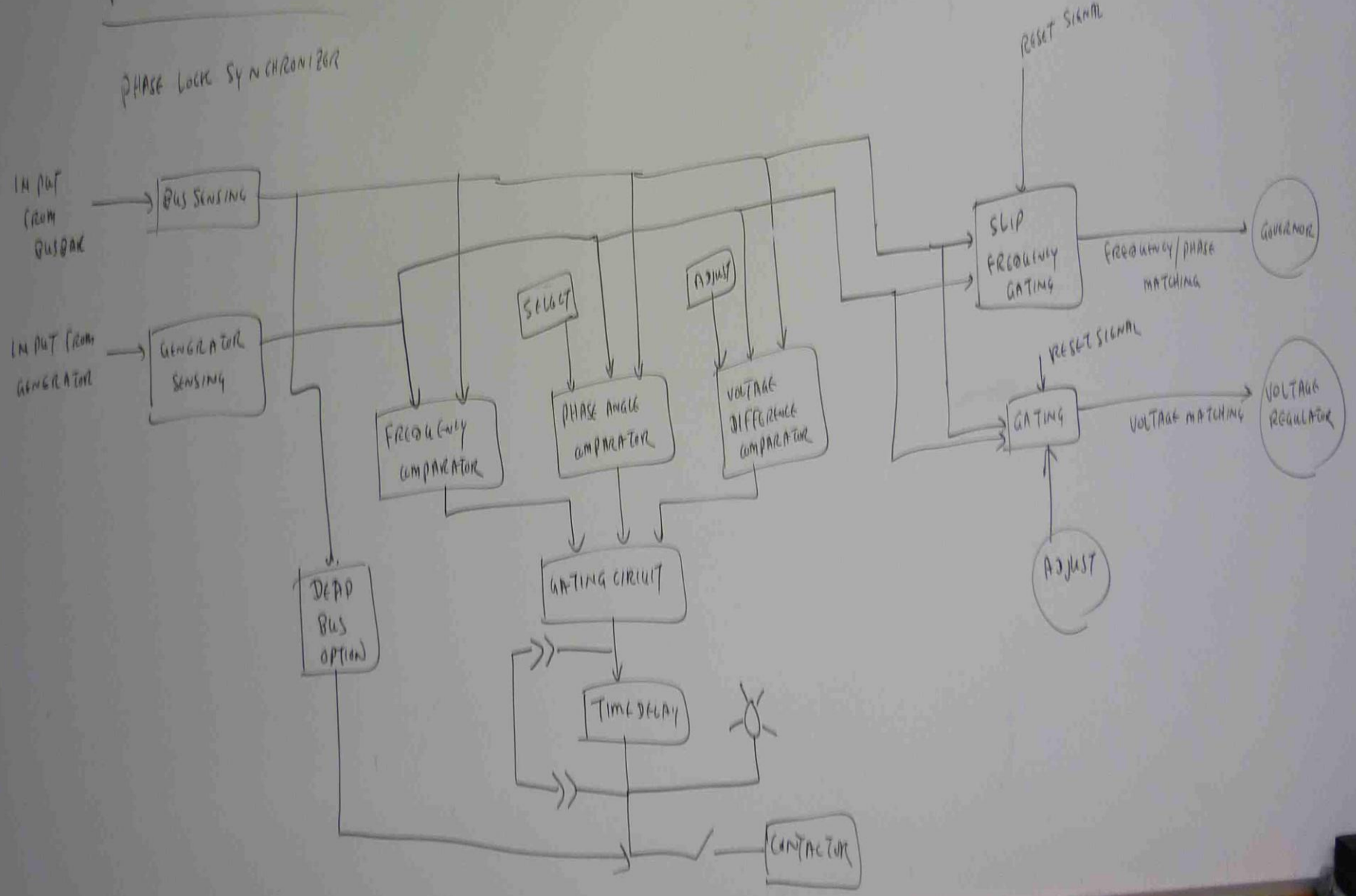
DIGITAL VOLTAGE REGULATION
SYSTEM POWER OUTPUT STAGE





PARALLELING GENERATORS

PHASE LOCK SYNCHRONIZER



PARALLELING GENERATORS

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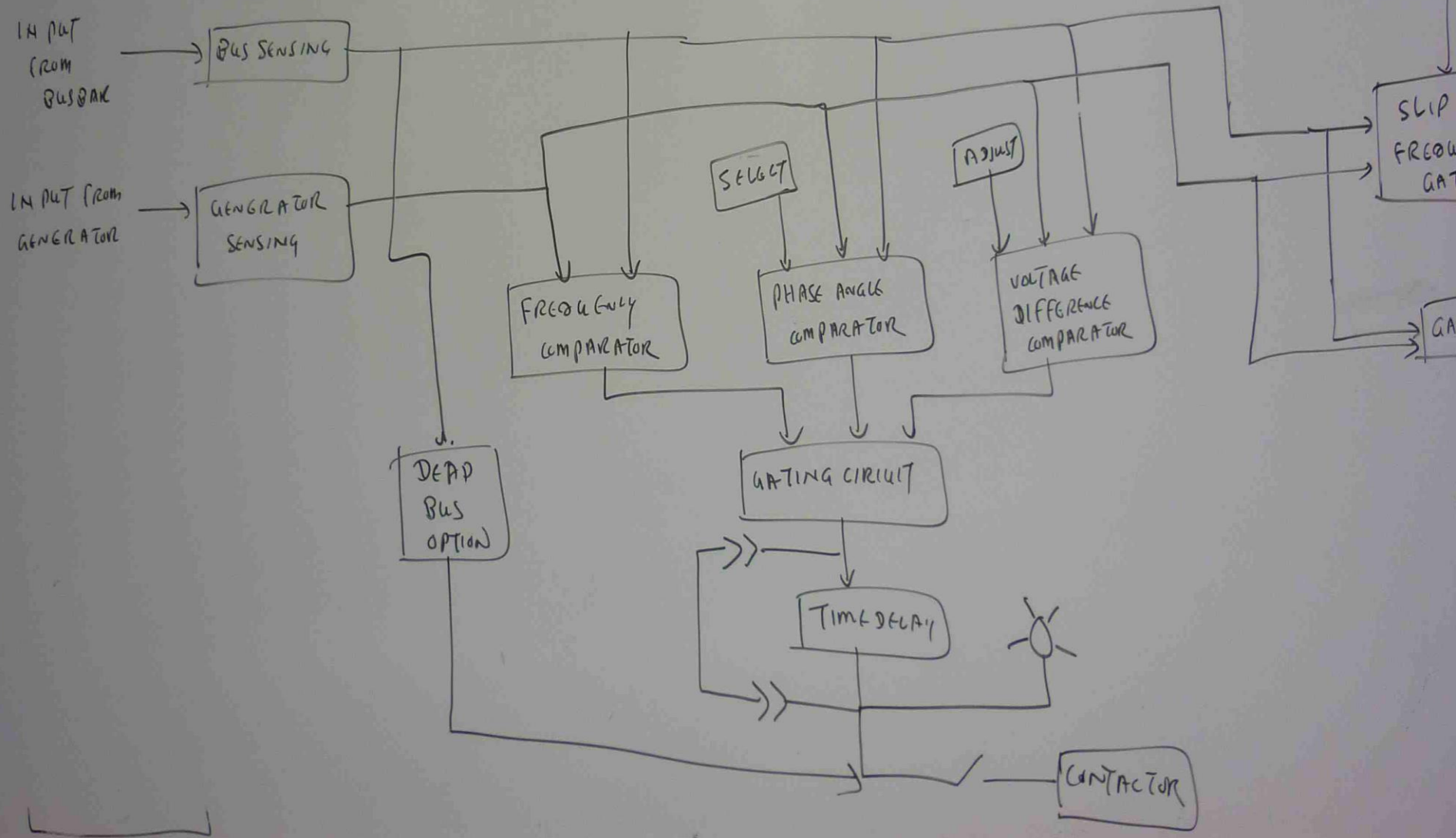
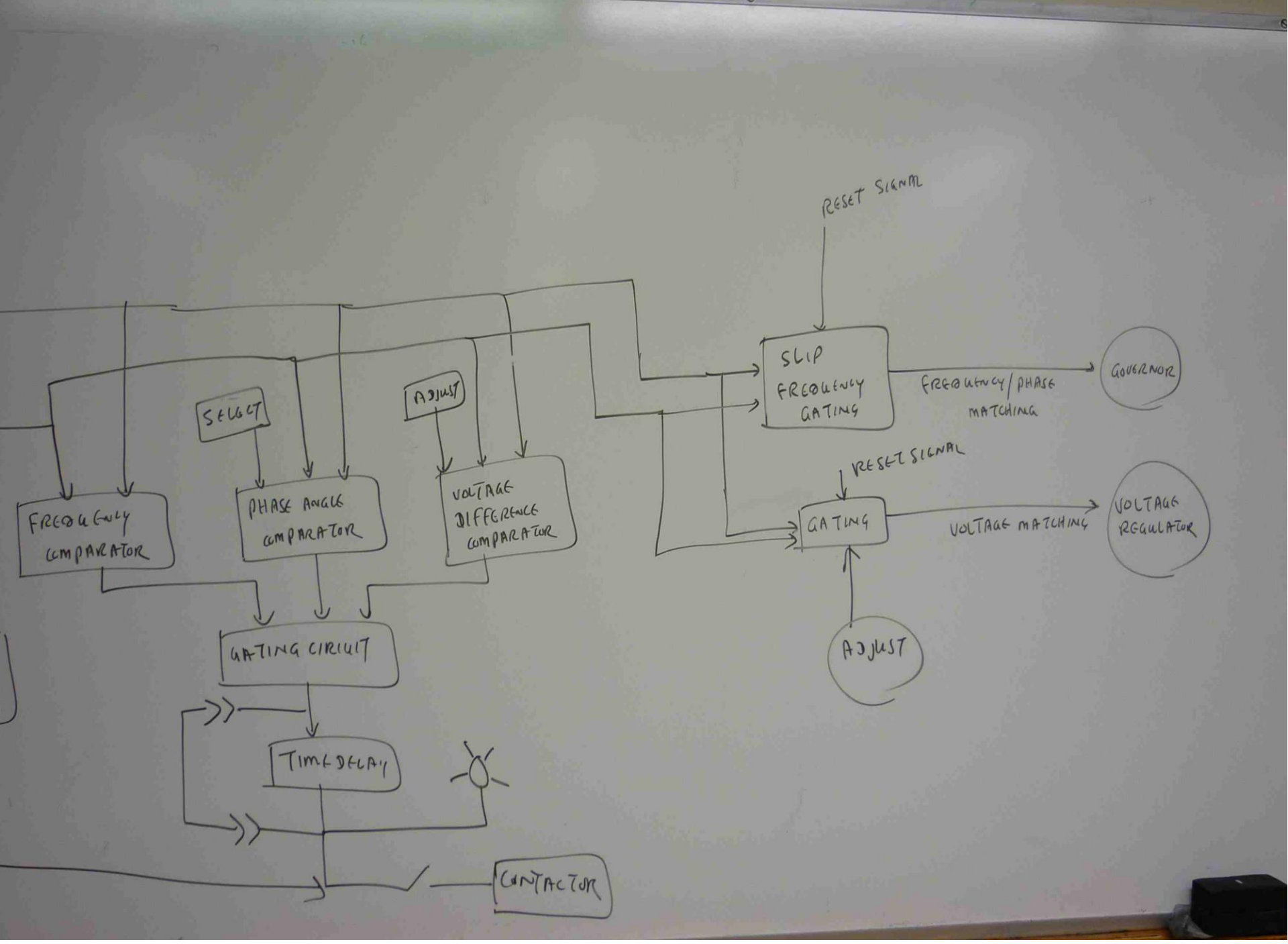
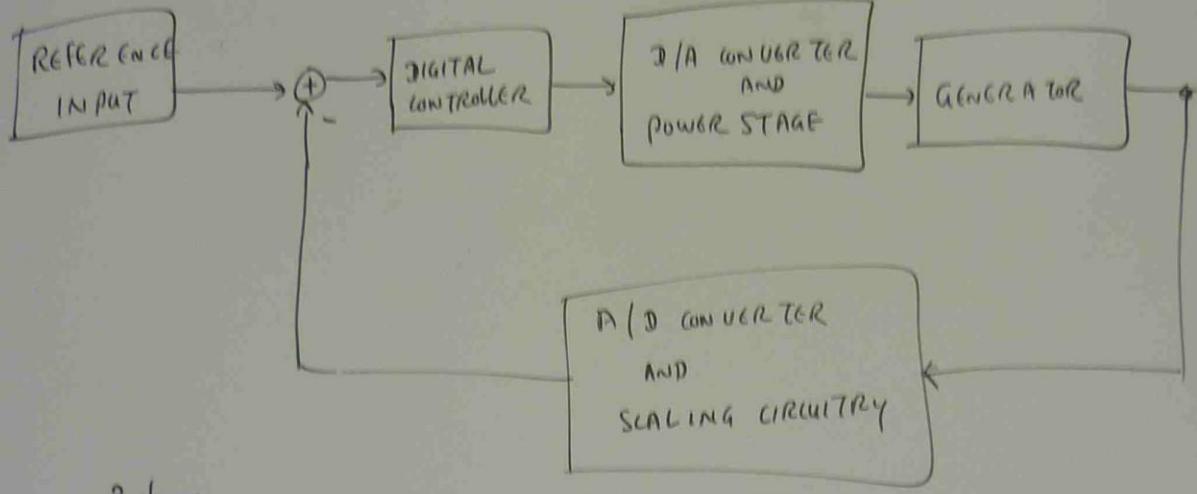
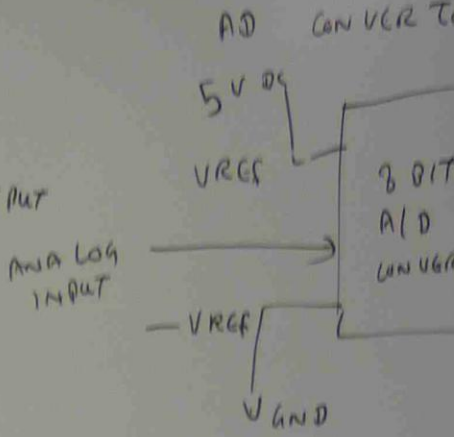



RESET SIGNAL
SLIP FREQUENCY GATING
GOVERNOR
FREQUENCY / PHASE MATCHING
SELECT
ADJUST
FREQUENCY COMPARATOR
PHASE ANGLE COMPARATOR
VOLTAGE DIFFERENCE COMPARATOR
RESET SIGNAL
GATING
VOLTAGE MATCHING
VOLTAGE REGULATOR
ADJUST
GATING CIRCUIT
TIME DELAY
CONTACTOR

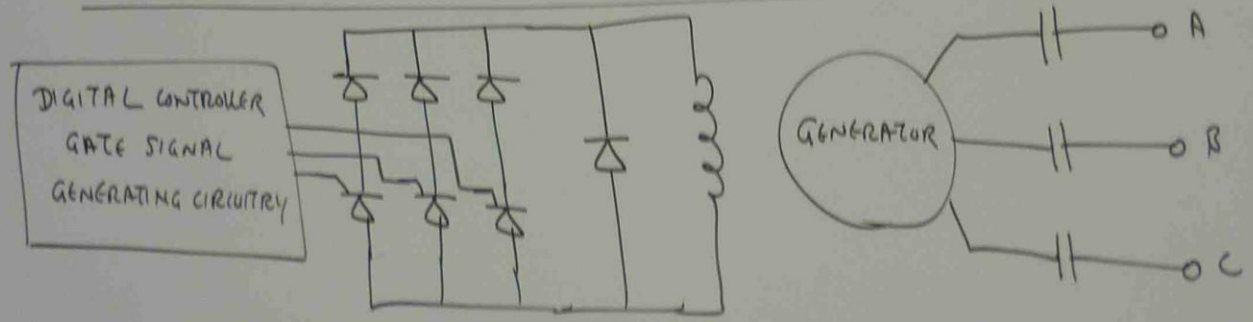
DIGITAL EXCITATION TECHNOLOGY

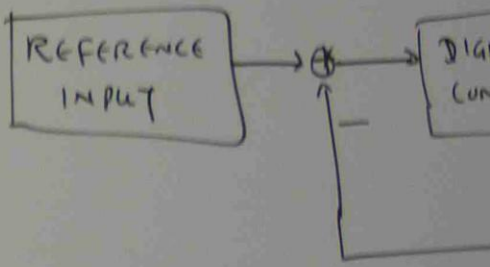


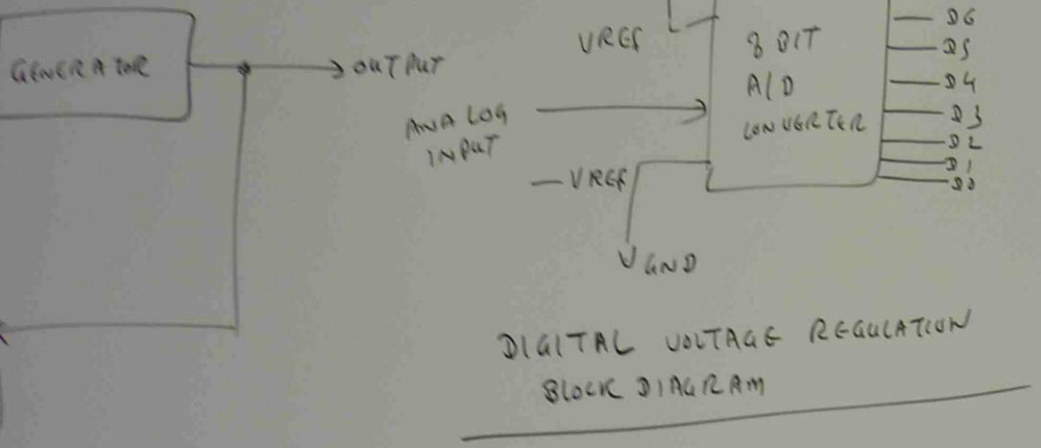


DIGITAL VOLTAGE BLOCK DIAGRAM

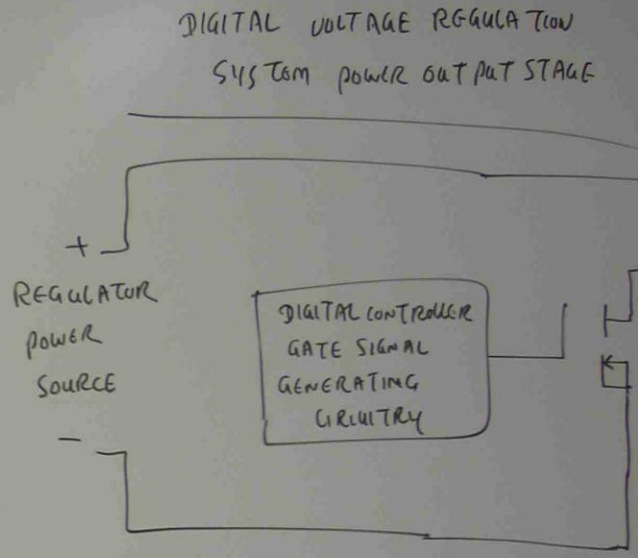
3ϕ SEMI CONTROLLER POWER BRIDGE

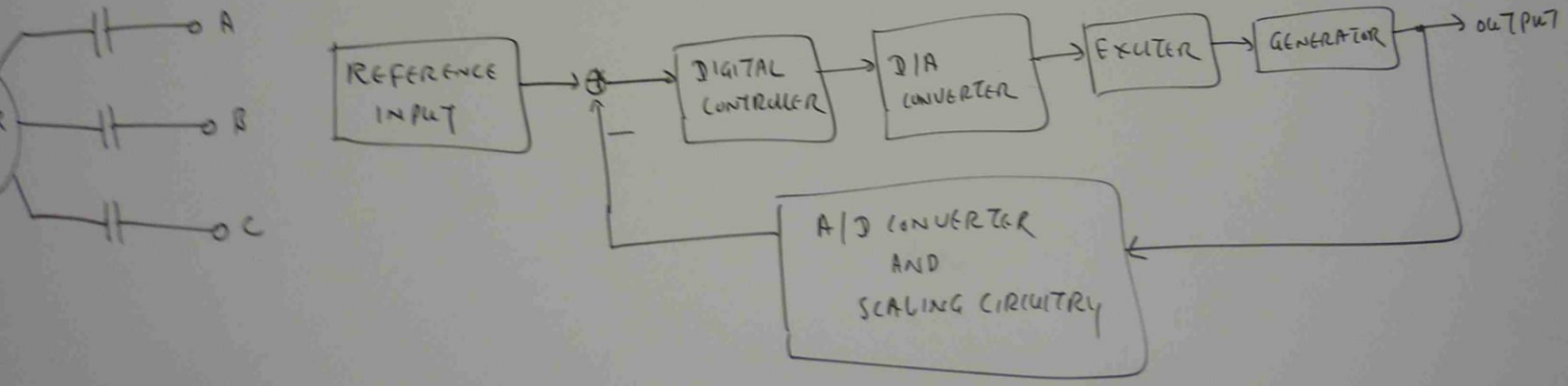




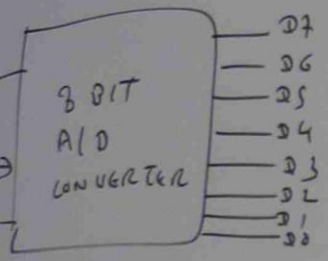


DIGITAL VOLTAGE REGULATION
BLOCK DIAGRAM





CONVERTOR



VOLTAGE REGULATION
RAM

DIGITAL VOLTAGE REGULATION
SYSTEM POWER OUTPUT STAGE