→ $T_{st} = 0.4\ T_{FL}$
DOL

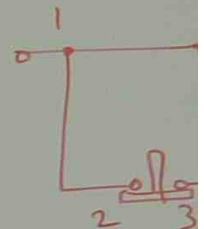
AUTOMATIC REDUCED VOLTAGE STARTERS

PRIMARY RESISTANCE STARTING

IN PRIMARY RESISTANCE STARTING, A RESISTOR IS CONNECTED IN EACH MOTOR LINE TO PRODUCE A VOLTAGE DROP TO THE MOTOR STARTING CURRENT.

A TIMING RELAY SHORTS OUT THE RESISTORS AFTER THE MOTOR HAS ACCELERATED.

THE MOTOR IS STARTED AT REDUCED VOLTAGE BUT OPERATES AT LINE VOLTAGE



STOP

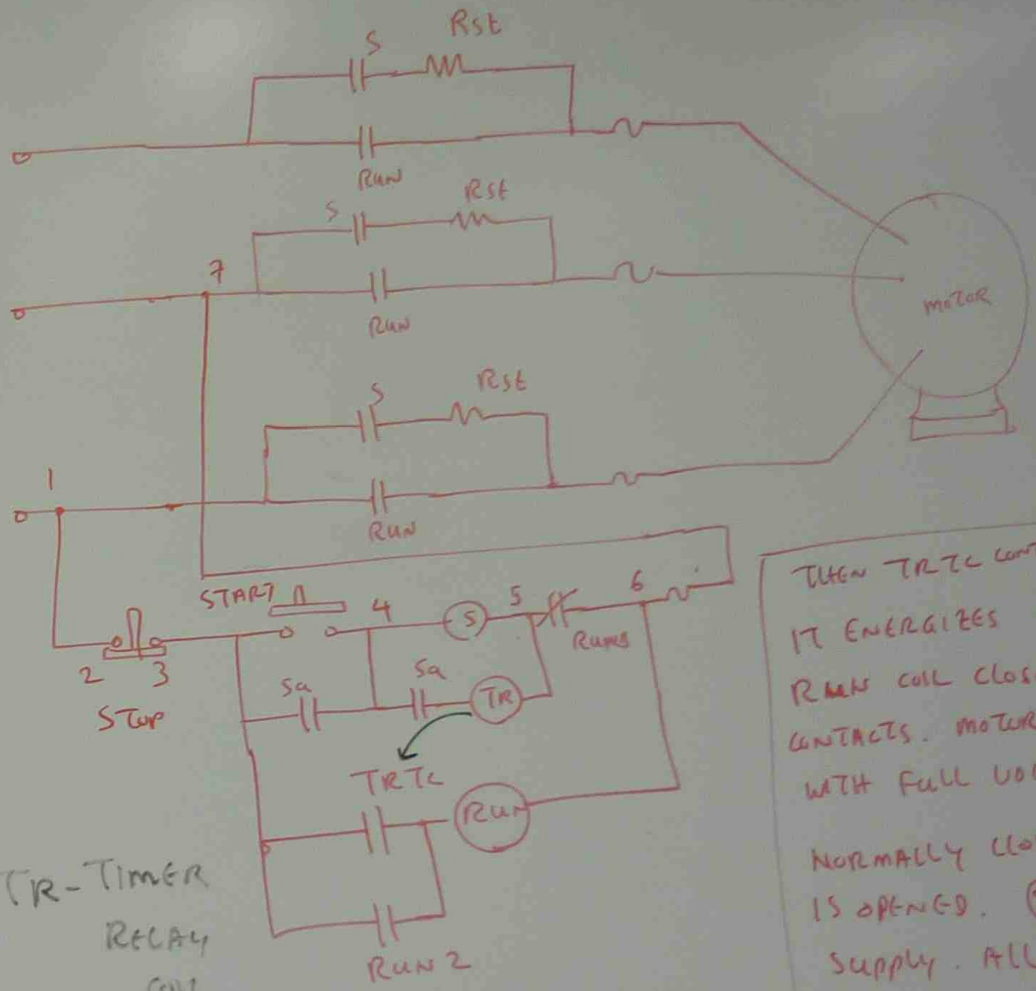
TR-Time
REL
TRTC-
REDUCED

OPERATION WHEN START IS PRESSED, THE CURRENT FLOWS 1, 2, 3, 4, 5, 6, 7

(S) COIL IS ENERGIZED, 5 CONTACTORS ARE CLOSED, MOTOR STARTS WITH SERIES RESISTANCE.

(TR) COIL IS ALSO ENERGIZED. (TR) COIL TRIES TO CLOSE TRTC.

BUT TRTC CONTACT DOES NOT CLOSE IMMEDIATELY. IT WAITS FOR SOME TIME. DURING THIS TIME, MOTOR STARTING CURRENT IS



TR - TIMER RELAY COIL

TRTc - TIMER RELAY TIMING CONTACT

REDUCED

THEN TRTc CONTACT IS CLOSED. IT ENERGIZES RUN COIL. RUN COIL CLOSE ALL RUN CONTACTS. MOTOR IS SUPPLIED WITH FULL VOLTAGE.

NORMALLY CLOSED RUN CONTACT IS OPENED. (S) COIL LOSES THE SUPPLY. ALL (S) CONTACTS ARE OPENED.

RUN 2 CONTACT ALSO CLOSES AND TRTc CONTACT IS THEN BYPASSED.

STAR-DELTA STARTER

AT STARTING, MOTOR WINDING MUST BE CONNECTED IN STAR TO START WITH REDUCED VOLTAGE.

AT THE RUNNING, MOTOR WINDING MUST BE CONNECTED IN DELTA TO RUN WITH FULL VOLTAGE.

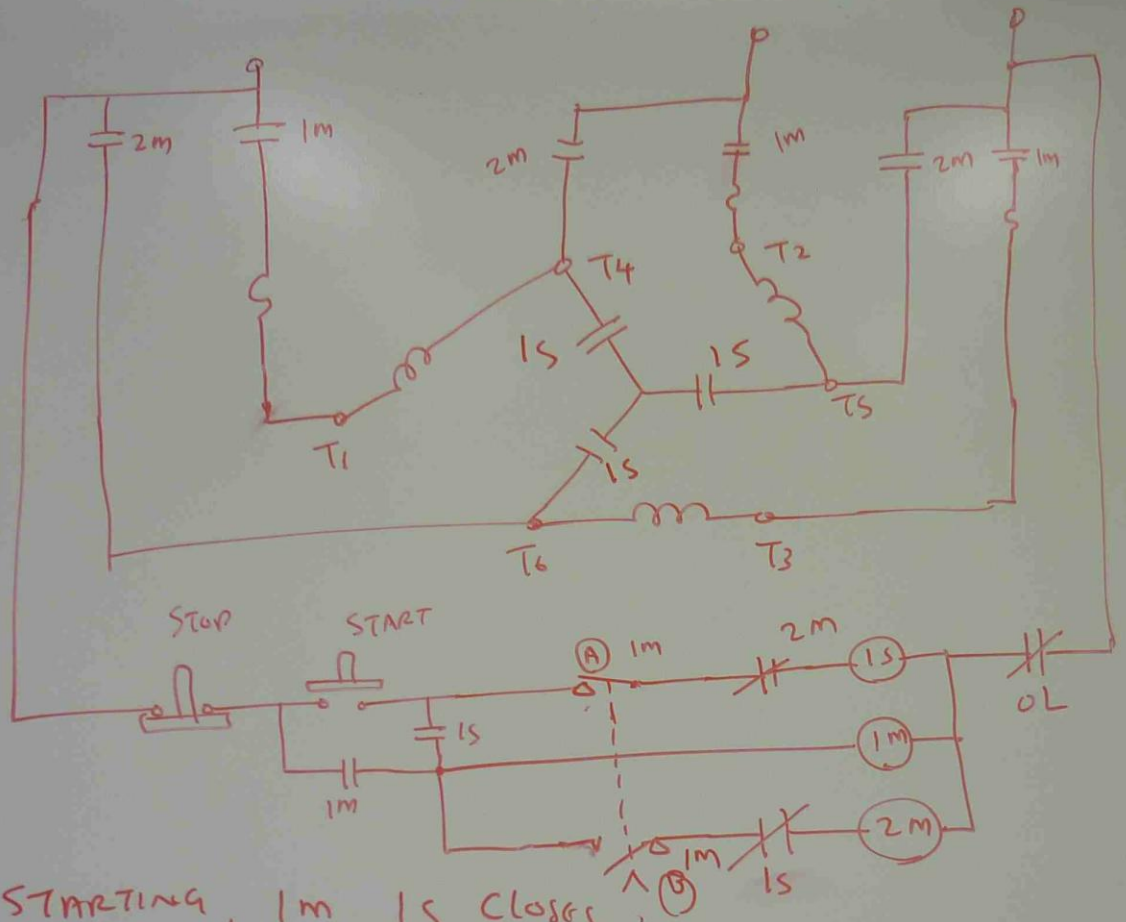
THE SWITCH WHICH CAN OPERATE NORMALLY CLOSED & NORMALLY OPEN CONTACTS IS REQUIRED FOR STAR HOLDING COIL AND DELTA HOLDING COIL SO THAT STAR CONTACTS AND DELTA CONTACTS WILL NOT CLOSE AT THE SAME TIME.

OPERATION

- WHEN THE START SWITCH IS PRESSED, THE CURRENT WILL FLOW THROUGH STOP, START, (A) 1M, 2M, (1S) COIL.
- ALL 1S CONTACTS ARE CLOSED. THE CURRENT ALSO PASSES THROUGH (1M) COIL. ALL 1M CONTACTS ARE ALSO CLOSED. MOTOR STARTS WITH Y CONNECTION.
- (1M) COIL TRIES TO OPEN A 1M CONTACT BUT IT IS CLOSED AFTER SOME TIME. WHEN A 1M IS OPEN, B 1M IS CLOSED.

STARTI

RUNNI



STARTING, 1M, 1S CLOSES.

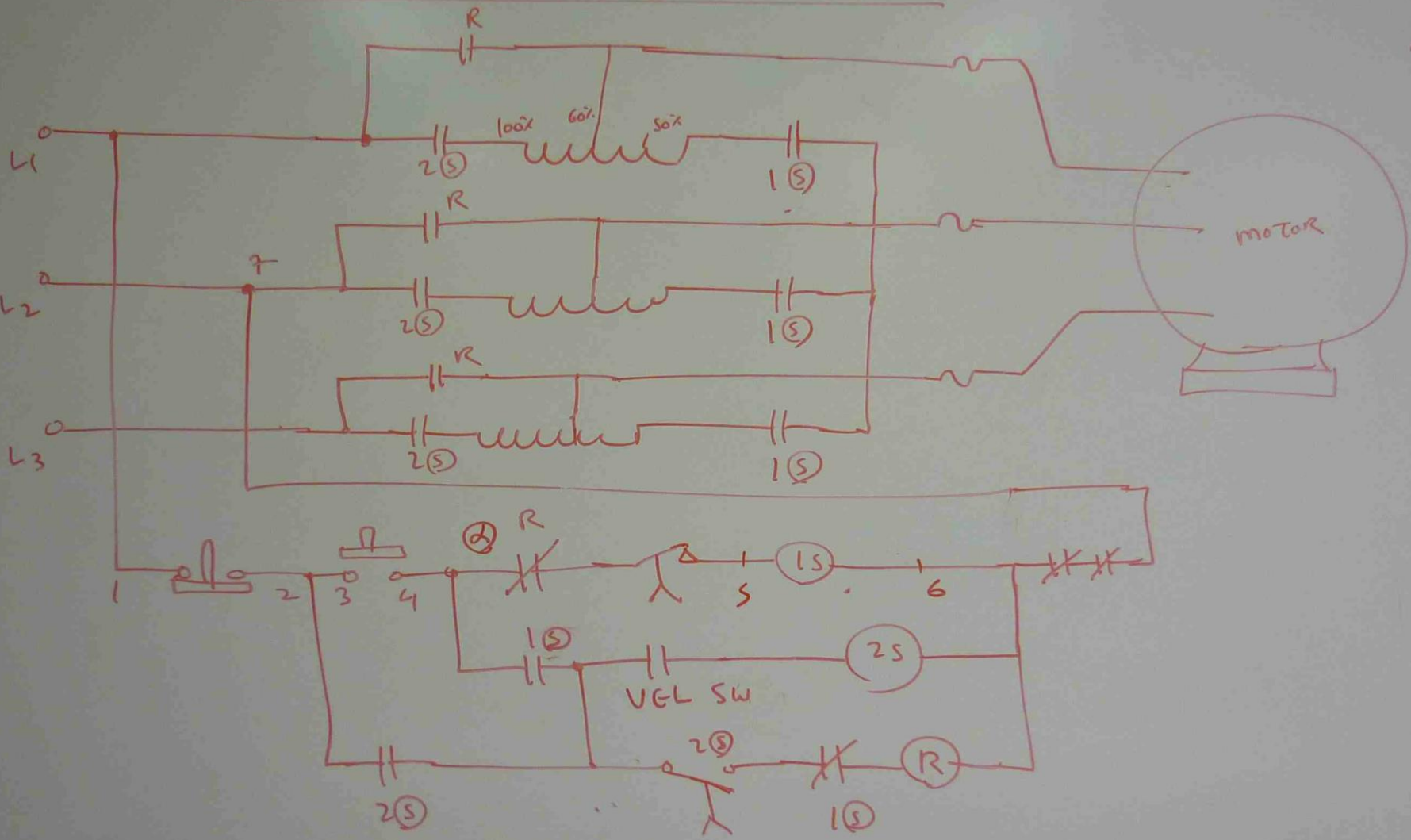
RUNNING 1M, 2M CLOSES, 1S OPEN

THUS (2M) COIL IS ENERGIZED AND 2M CONTACTS ARE CLOSED. MOTOR RUNS AT DELTA

(2M) COIL ALSO OPEN THE NORMALLY CLOSED 2M CONTACTOR.

(1S) COIL IS DE-ENERGIZED ALL 1S CONTACTS ARE OPEN.

AUTOMATIC AUTO TRANSFORMER STARTER



- WHEN START BUTTON IS PRESSED, CURRENT FLOWS FROM 1-2-3-4-5-6 AND ENDS AT 7.

- (1S) COIL IS ENERGIZED. IT CLOSES ALL 1S CONTACTS. THEN (2S) COIL IS ENERGIZED. 2(S) CONTACTS ARE CLOSED

- CLOSING OF 1(S), 2(S) CONTACTS ENERGIZES TRANSFORMER WINDING.

- % VOLTAGE IS APPLIED TO MOTOR TERMINAL. MOTOR STARTS WITH REDUCED VOLTAGE.

- 2(S) COIL CLOSES TIME DELAY CONTACT 2(S). THEN (R) COIL IS ENERGIZED.

R CONTACTS ARE CLOSED. MOTOR RUNS AT FULL VOLTAGE.

NORMALLY CONTACT R POINT (4) IS OPEN

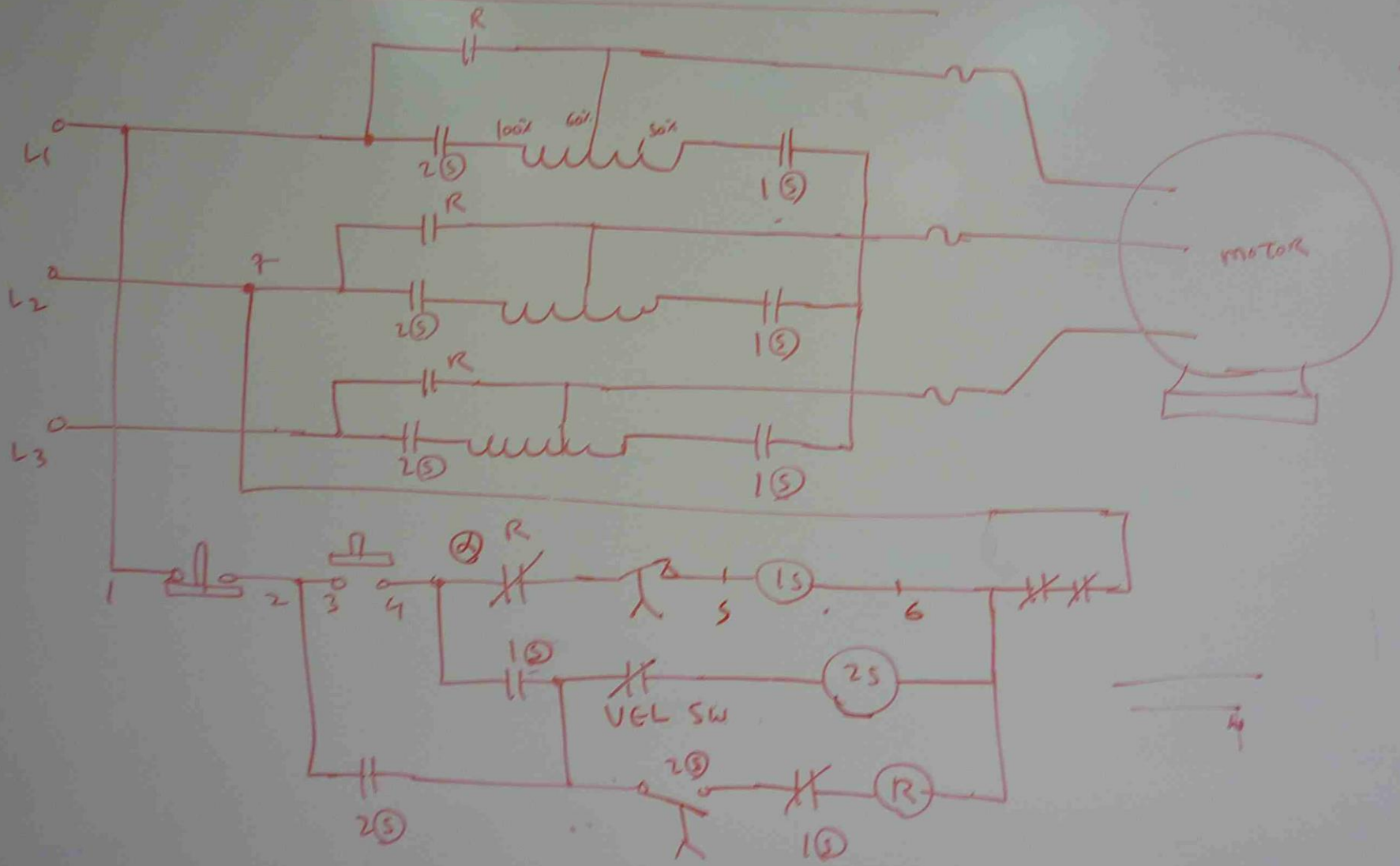
(1S) COIL IS DE-ENERGIZED AND IT OPENS

1(S), 2(S) CONTACTS.

- TRANSFORMER IS REMOVED FROM SUPPLY

- VEL SW IS ATTACHED TO MOTOR SHAFT. IT IS CLOSED ONLY MOTOR RUNNING TIME. BY THIS WAY MOTOR WINDING WILL NOT GET FULL VOLTAGE WITHOUT RUNNING.

AUTOMATIC AUTO TRANSFORMER STARTER



- WHEN START BUTTON IS PRESSED, CURRENT FLOWS FROM 1-2-3-4-5-6 AND ENDS AT 7.

- (1S) COIL IS ENERGIZED. IT CLOSES ALL 1S CONTACTS. THEN (2S) COIL IS ENERGIZED. 2(S) CONTACTS ARE CLOSED

- CLOSING OF 1(S), 2(S) CONTACTS ENERGIZES TRANSFORMER WINDING.

- % VOLTAGE IS APPLIED TO MOTOR TERMINAL. MOTOR STARTS WITH REDUCED VOLTAGE.

- 2(S) COIL CLOSES TIME DELAY CONTACT 2(S). THEN (R) COIL IS ENERGIZED. R CONTACTS ARE CLOSED. MOTOR RUNS AT FULL VOLTAGE.

NORMALLY CONTACT R POINT (4) IS OPEN

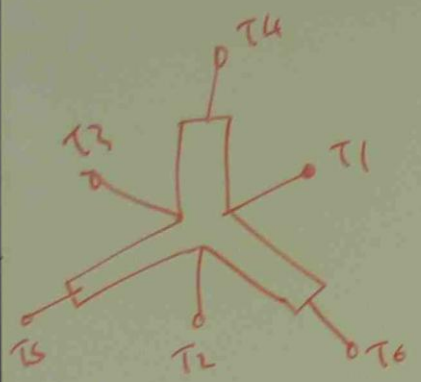
(1S) COIL IS DE-ENERGIZED AND IT OPENS

1(S), 2(S) CONTACTS.

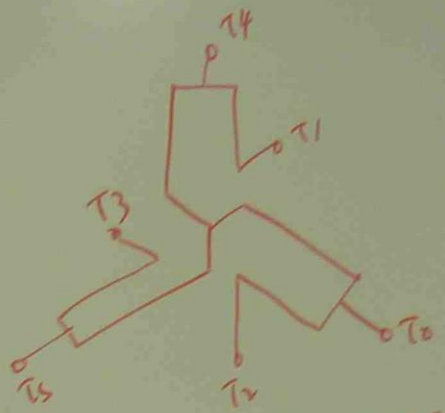
- TRANSFORMER IS REMOVED FROM SUPPLY

- VEL SW IS ATTACHED TO MOTOR SHAFT. IT IS CLOSED ONLY MOTOR RUNNING TIME. BY THIS WAY MOTOR WINDING WILL NOT GET FULL VOLTAGE WITHOUT RUNNING.

CONSEQUENT POLE STARTER



CONSTANT TORQUE



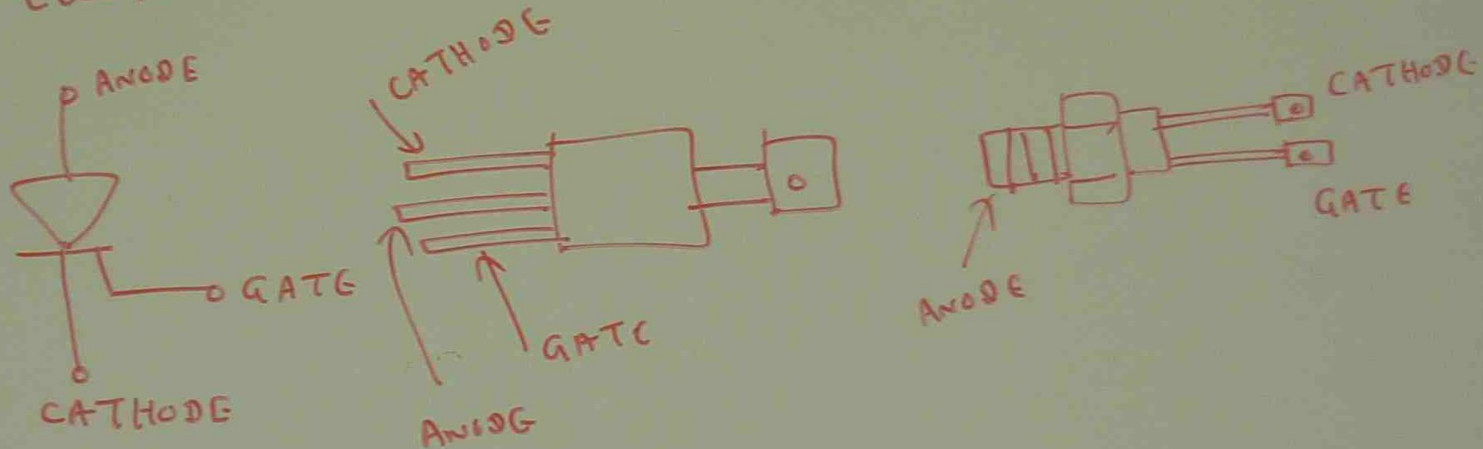
VARIABLE TORQUE

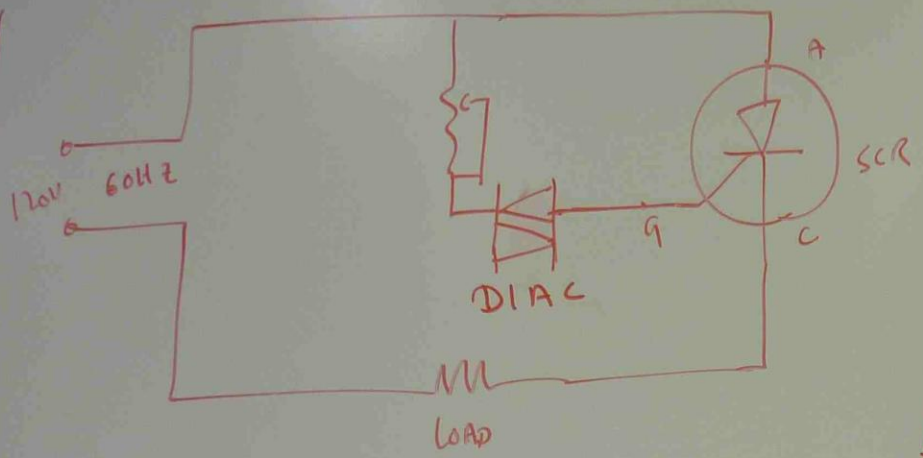
SPEED	SUPPLY LINE L_1 L_2 L_3	OPEN	TOGETHER
LOW	T_1 T_2 T_3	$T_4T_5T_6$	NONE
HIGH	T_6 T_4 T_5	NONE	$T_1T_2T_3$

SOLID STATE REDUCED VOLTAGE STARTER

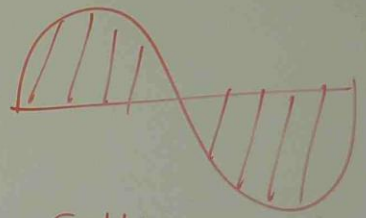
SILICON CONTROLLED RECTIFIER (SCR)

THE SILICON CONTROLLED RECTIFIER (SCR | THYRISTOR) IS THE DEVICE USED MOST OFTEN TO CONTROL THE ELECTRIC MOTORS



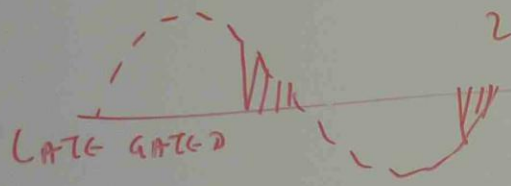


DEPENDING ON TIME TO APPLY THE PULSE, GATE CONDUCTION VARIES MOTOR SPEED IS CONTROLLED BY GATE CONDUCTION.



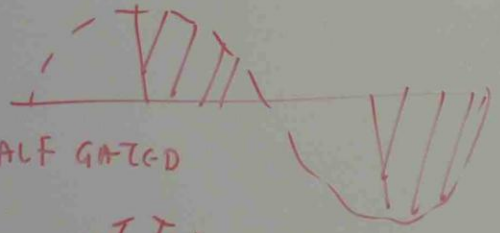
FULL VOLTAGE

FULLY GATED



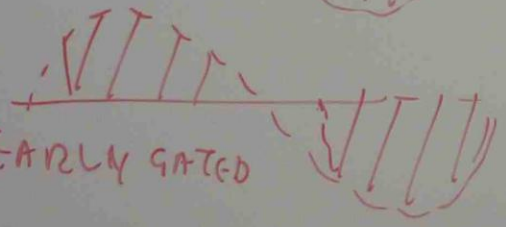
25% OUTPUT

LATE GATED



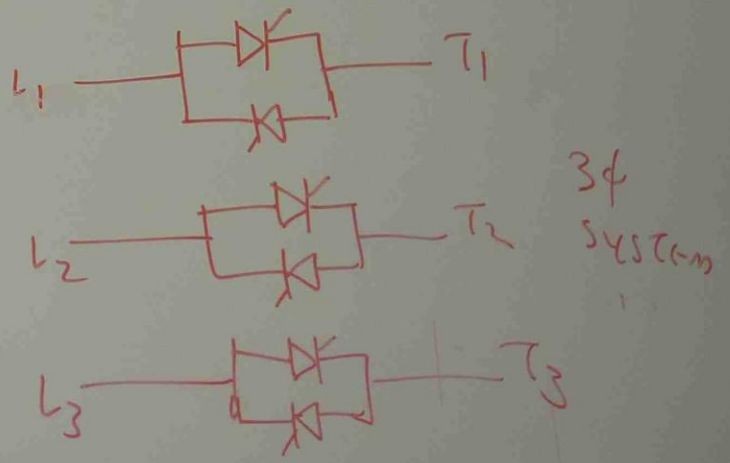
50% OUTPUT

HALF GATED



75% OUTPUT

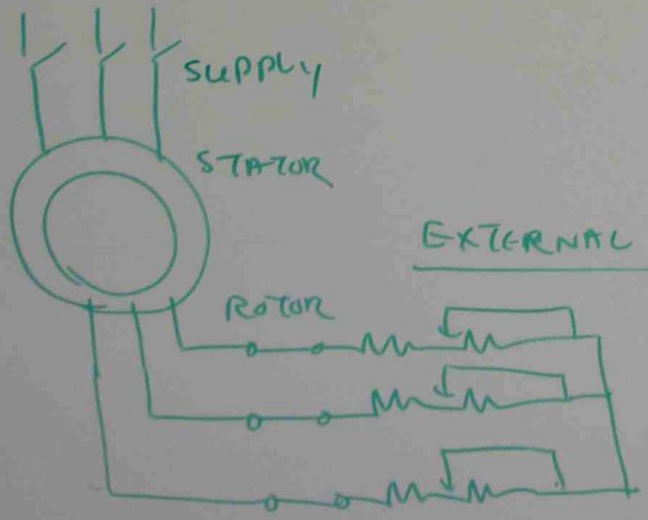
EARLY GATED



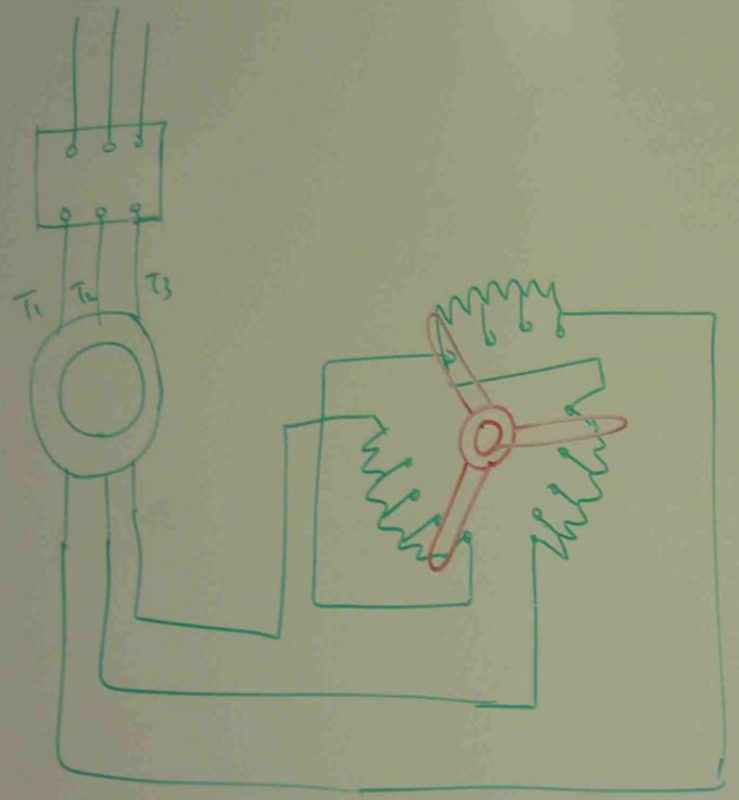
WOUND ROTOR MOTOR

THE WOUND ROTOR MOTOR IS DIFFERENT FROM THE SQUIRREL CAGE MOTOR IT HAS THE WIRE COIL WINDINGS IN IT'S ROTOR INSTEAD OF A SERIES OF CONDUCTING BARS IN ROTOR. INSERTING THE EXTERNAL RESISTANCE IN THE MOTOR CIRCUIT WHEN THE STARTING WILL DEVELOP A HIGH TORQUE WITH A COMPARATIVELY LOW STARTING CURRENT.

AS THE MOTOR COMES UP TO SPEED, THE RESISTANCE IS GRADUALLY REMOVED. AT THE FULL SPEED, THE ROTOR IS SHORT CIRCUITED. SPEED CAN BE REGULATED WITHIN THE SPEED BY VARYING THE AMOUNT OF RESISTANCE



STARTER CONTROLLER WITH WOUND ROTOR MOTOR



DRUM CONTROLLER

SPEED REGULATION BY RESISTANCE

RESISTORS CAN BE USED TO REGULATE THE SPEED IF THEY ARE OF PROPER SIZE TO PREVENT THE OVERHEATING FROM CONSTANT USE.

THE RESISTORS USED IN THE STARTING PERIOD ARE USED ONLY FOR A SHORT TIME. BUT THOSE USED FOR CONTINUOUS MOTOR SPEED REDUCTION ARE IN USE FOR LONGER PERIOD OF TIME.

- BY PLACING A HIGH RESISTANCE IN THE ROTOR CIRCUIT, IT IS POSSIBLE TO START THE MOTOR AND PRODUCE HIGH STARTING TORQUE WITH LOW STARTING CURRENT.

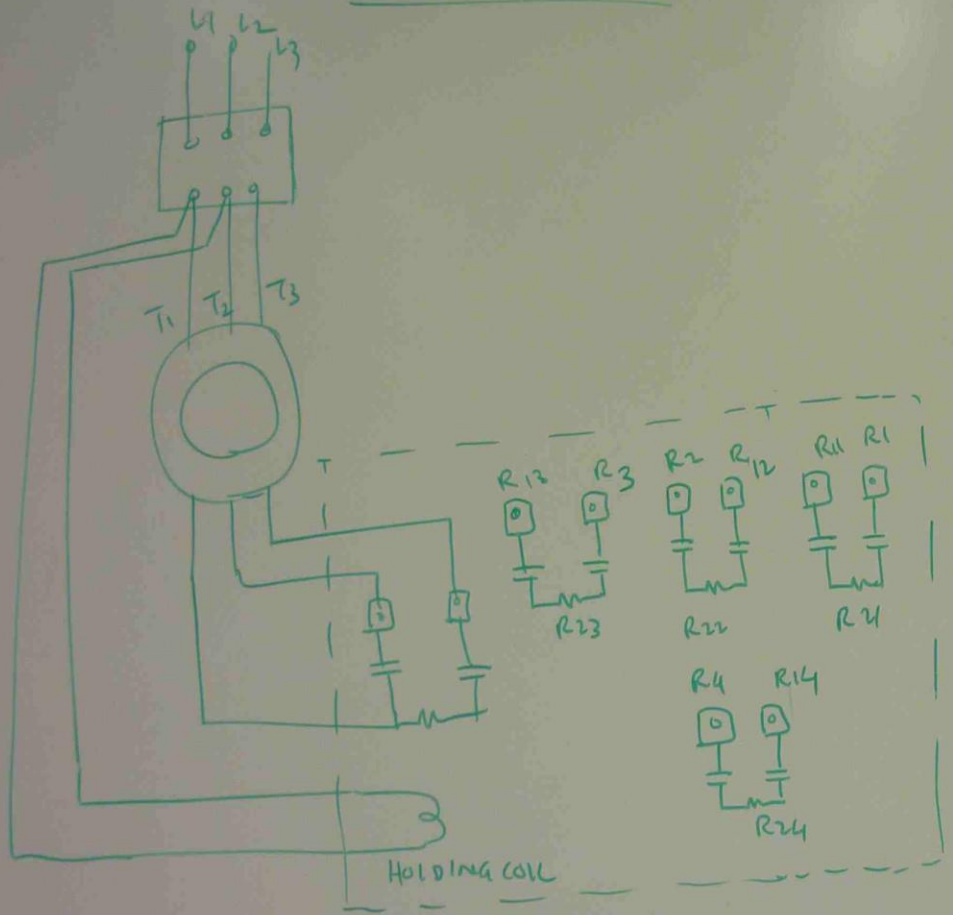
TYPE OF STARTERS

MULTI SWITCH STARTER

DRUM CONTROLLER

MAGNETIC STARTER

MULTI SWITCH STARTER



- THIS TYPE OF STARTER IS USED IN THE SECONDARY CIRCUIT OF LARGE WOUND ROTOR INDUCTION MOTOR UP TO 2000 HP WITH ROTOR CURRENT UP TO 1000 Amp.
- CONTACT LEVERS (DOUBLE POLE) ARE CLOSED IN A PREDETERMINED SEQUENCE MECHANICALLY.
- WHEN THE FINAL SWITCH HAS BEEN CLOSED, IT IS HELD IN A PLACE BY A MAGNETIC COIL.

DRUM CONTROLLERS

DRUM CONTROLLERS CAN BE USED FOR STARTING AND FOR SPEED CONTROL OF THE WOUND ROTOR MOTOR.
THEY ARE MADE TO HANDLE BOTH STATOR AND ROTOR CIRCUITS.

APPLICATION of SLIP RING MOTORS

USE WITH MOTOR DRIVEN CONTROLLERS IN LARGE AIR CONDITIONING PLANTS, BLOWERS STOCKER.

WOUND ROTOR MOTOR CAN BE STARTED WITH A LOAD AND WITHOUT DRAWING TOO MUCH CURRENT. THEY CAN BE USED FOR SUCH LOADS AS THOSE BACK PRESSURE SETUP BY FLUIDS AND GASES. THEY ARE ALSO USED IN ELEVATORS AND CRANES. THEY CAN ALSO BE USED FOR THE PLACE WHERE SPEED RANGE IS SMALL (COMPRESSOR / CONVEYER)

DISADVANTAGE

- HIGHER INITIAL COST
- SLIP RINGS AND BRUSHES NEED MAINTENANCE FROM TIME TO TIME
- RESISTORS AND SWITCHING ARRANGEMENT REQUIRE PERIODIC INSPECTION & MAINTENANCE.

ADVANTAGE OF SQUIRREL CAGE INDUCTION MOTOR

EXCELLENT PROPERTIES FOR SPEED ABOVE 600 RPM

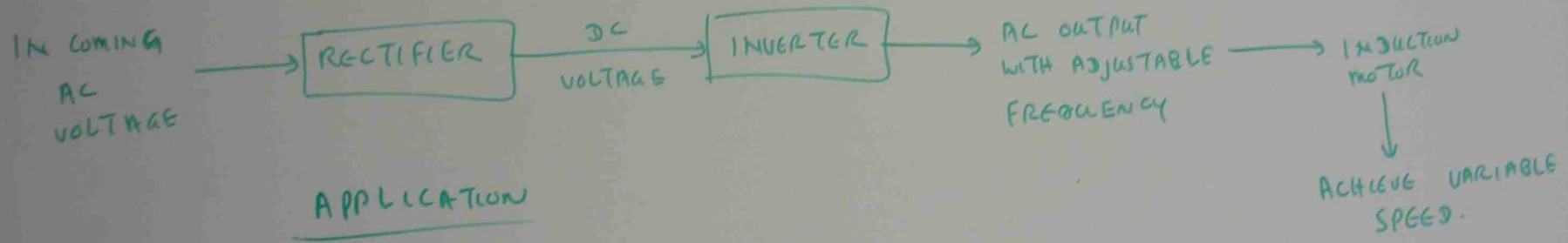
DISADVANTAGE

- SPEED CONTROL IS DIFFICULT
- ADDITIONAL REDUCED CURRENT | VOLTAGE STARTING IS REQUIRED

- AT LOWER SPEED, THEY CAN BE HEAVY, COSTLY, LOW PERFORMANCE
- LOW EFFICIENCY.

FREQUENCY / SPEED CONTROL

SOLID STATE AC MOTOR CONTROL IS ACCOMPLISHED BY CHANGING THE FREQUENCY OF THE POWER SOURCE. MOTOR SPEED IS ADJUSTED BY CONTROLLING THE OUT PUT VOLTAGE AND FREQUENCY OF THE UNIT.



APPLICATION

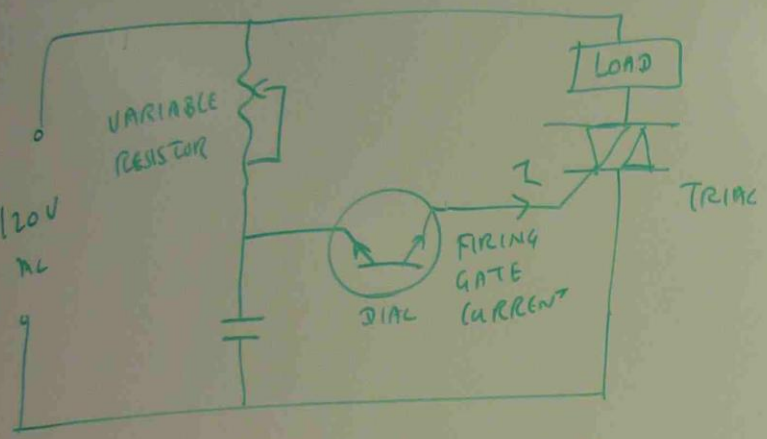
FOOD PACKING PLANT

PAPER MILL

CEMENT PLANT

CENTRIFUGAL PUMP

BLOWERS.



VARIABLE FIRING GATE CURRENT IS CONTROLLED BY VARIABLE RESISTOR.

MULTI SPEED STARTERS

AUTOMATIC CONTROL OF THE SPEEDS.

- LOW SPEED COMPELLING RELAY
- AUTOMATIC SEQUENCE ACCELERATING RELAY
- AUTOMATIC SEQUENCE DECELERATING RELAY

MOTOR PROTECTION

PROTECTION AGAINST LOW VOLTAGE

TIME DELAY PROTECTION

LIGHTNING PROTECTION

SURGE SUPPRESSOR

WHEN SOLID STATE CONTROLS ARE UTILIZED IN CIRCUITS THAT HAVE ELECTROMAGNETIC DEVICES, THERE ARE PROBLEMS WITH THE POWER SOURCE.

SURGE SUPPRESSORS ARE UTILIZED TO LIMIT THE VOLTAGE TRANSIENTS FOR APPLICATIONS REQUIRING INTERFACE WITH SOLID STATE COMPONENTS.

LIGHTNING PROTECTION

SURGE ARRESTERS

1500A AT 2200V

5000A AT 2900V

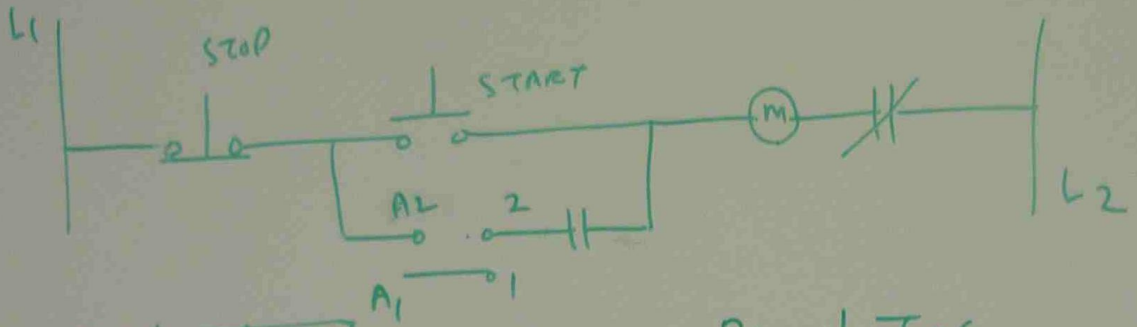
10,000A AT 3400V

20,000A AT 4000V

JOGGING, PLUGGING, BRAKING

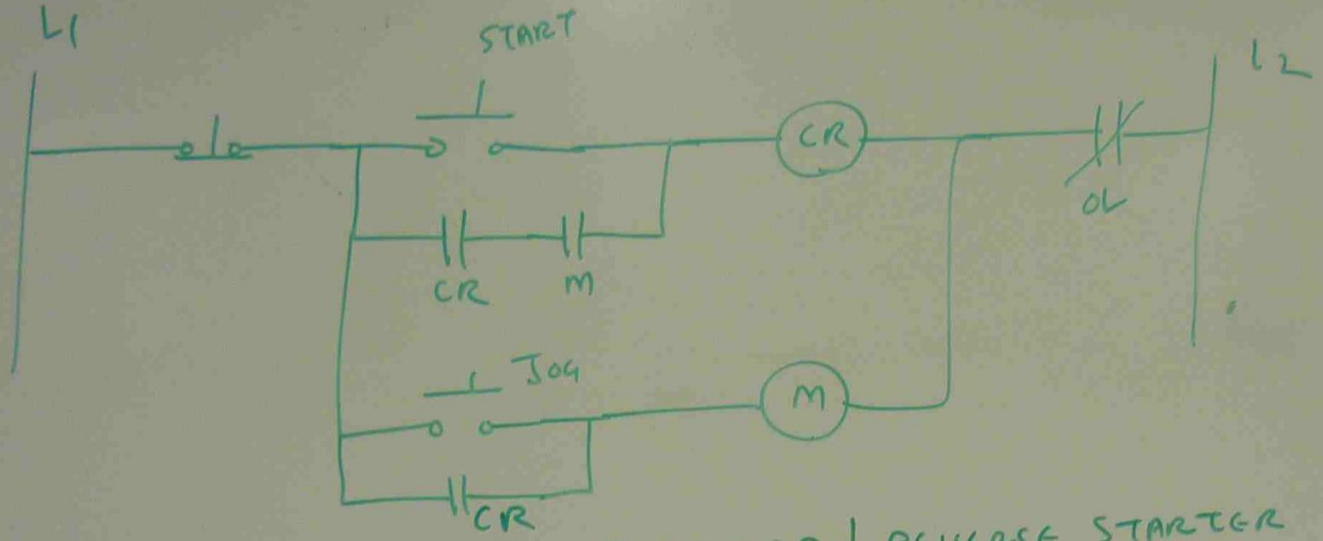
JOGGING

MOMENTARY OPERATION OF A MOTOR FROM REST FOR THE PURPOSE OF ACCOMPLISHING SMALL MOVEMENT OF DRIVEN MACHINE.

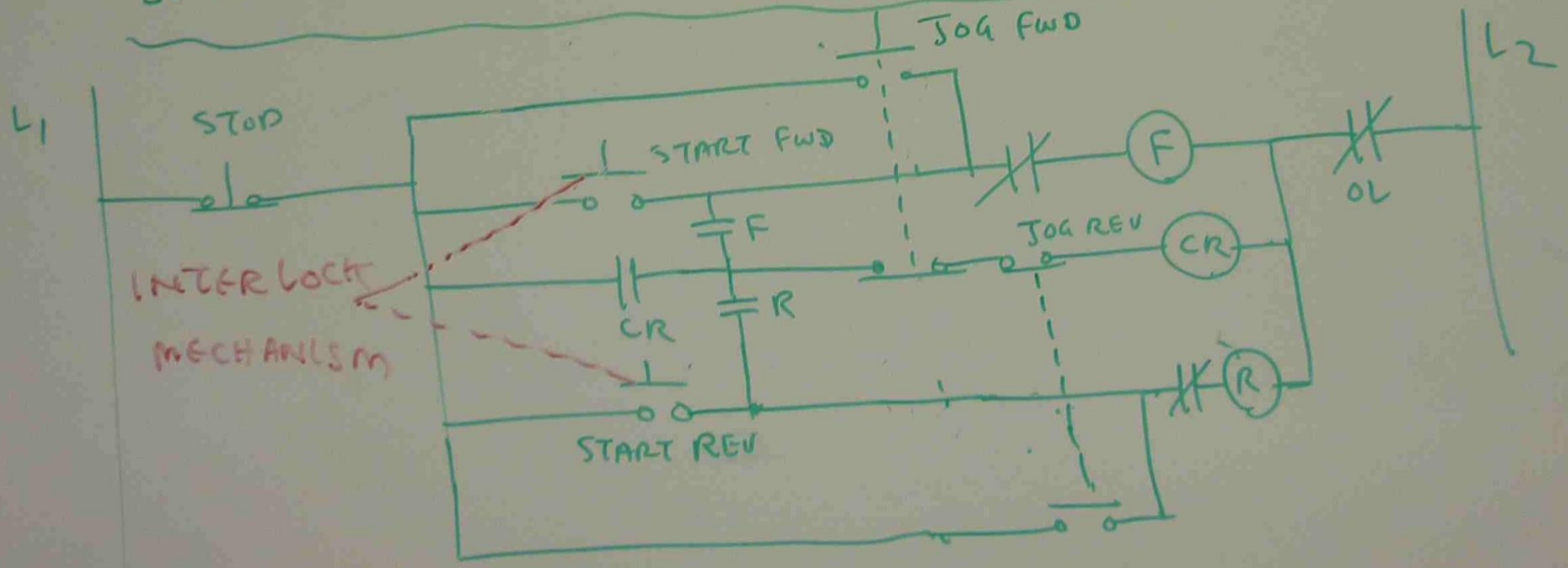


A_1	1	
A_2		1
	JOG	RUN

RUN | JOG



JOGGING USING A FORWARD | REVERSE STARTER

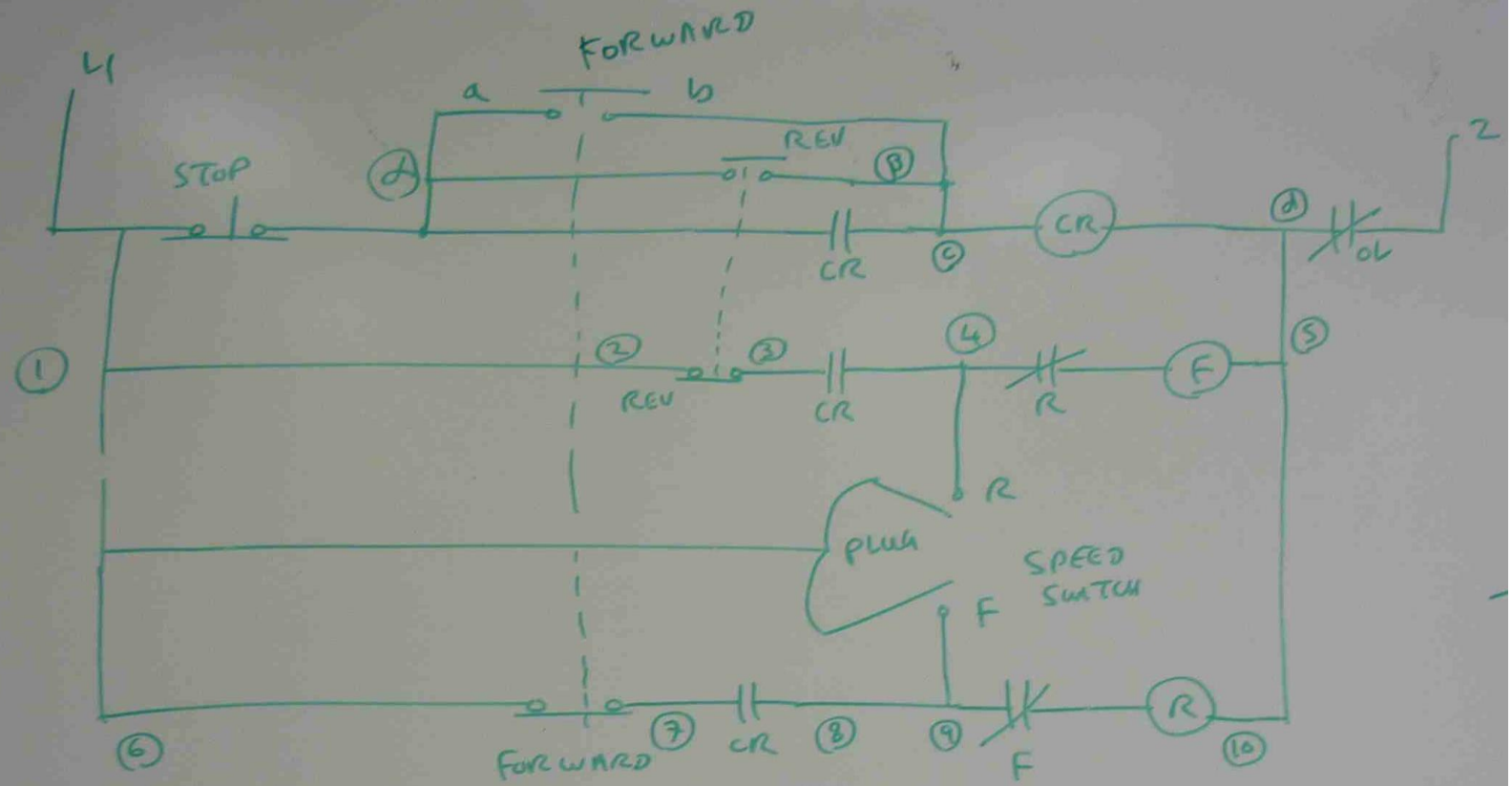


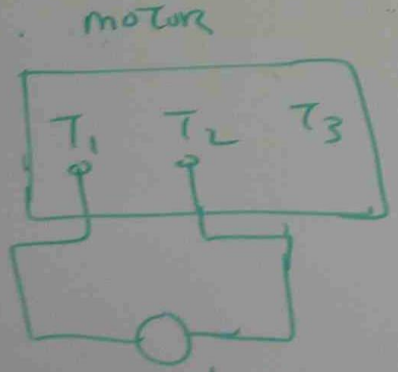
PLUGGING

A SYSTEM OF BRAKING IN WHICH THE MOTOR CONNECTIONS ARE REVERSED SO THAT THE MOTOR DEVELOPS A COUNTER TORQUE.

MOTOR IS RUN IN ONE DIRECTION ONLY AND MUST COME TO COMPLETE A STOP WHEN THE STOP BUTTON IS PRESSED.

REVERSE CONTACTOR OF THE REVERSING SWITCH IS USED ONLY FOR PLUG STOPPING AND NOT FOR RUNNING IN REVERSE.


L1
FORWARD
a
b
REV
STOP
A
B
CR
C
CR
d
OL
2
1
2
3
4
5
REV
CR
R
F
R
PLUG
SPEED SWITCH
F
6
7
8
9
10
FORWARD
CR
F
R


MOTOR
T1
T2
T3
LOCK OUT SOLENOID

2

FORWARD RUNNING

- PRESS FORWARD SWITCH
- CURRENT FLOWS a, b, c, d AND (CR) IS ENERGIZED

CR CONTACTS ARE CLOSED.

THEN THE CURRENT FLOWS ① ② ③ ④ ⑤

(F) COIL IS ENERGIZED ⫽F IS OPEN.

MOTOR RUN WITH FORWARD

OPENING OF ⫽F PREVENTS (R) COIL TO BE ENERGIZED.

REVERSE RUNNING

PRESS REVERSE SWITCH

CURRENT FLOWS α, β, c, d AND (CR) IS ENERGIZED.

CR CONTACTS ARE CLOSED

CURRENT FLOWS ⑥ ⑦ ⑧ ⑨ ⑩ AND (R) COIL IS ENERGIZED.

⫽R IN SERIES WITH (F) IS OPEN

MOTOR RUNS IN REVERSE

OPENING OF ⫽R PREVENTS (F) COIL TO BE ENERGIZED

REVERSE RUNNING

PRESS REVERSE SWITCH

CURRENT FLOWS α, β, C, d AND (CR) IS ENERGIZED.

CR CONTACTS ARE CLOSED

CURRENT FLOWS (6) (7) (8) (9) (10) AND (R) COIL IS ENERGIZED.

$\not{H}_R$ IN SERIES WITH (F) IS OPEN

MOTOR RUNS IN REVERSE

OPENING OF $\not{H}_R$ PREVENTS (F) COIL TO BE ENERGIZED

TO STOP IMMEDIATELY WHILE RUNNING FORWARD

PRESS STOP AND F-PLUG SWITCH

(R) COIL WILL BE ENERGIZED AND TRIES TO TURN THE MOTOR IN OPPOSITE DIRECTION

AS SOON AS MOTOR STOPS, LOCK OUT SOLENOID DEACTIVATES PLUG SWITCH

TO STOP IMMEDIATELY, WHILE RUNNING REVERSE

PRESS STOP AND R-PLUG SWITCH

(F) COIL WILL BE ENERGIZED AND TRIES TO RUN MOTOR IN OPPOSITE DIRECTION.

THEN MOTOR WILL STOP IMMEDIATELY

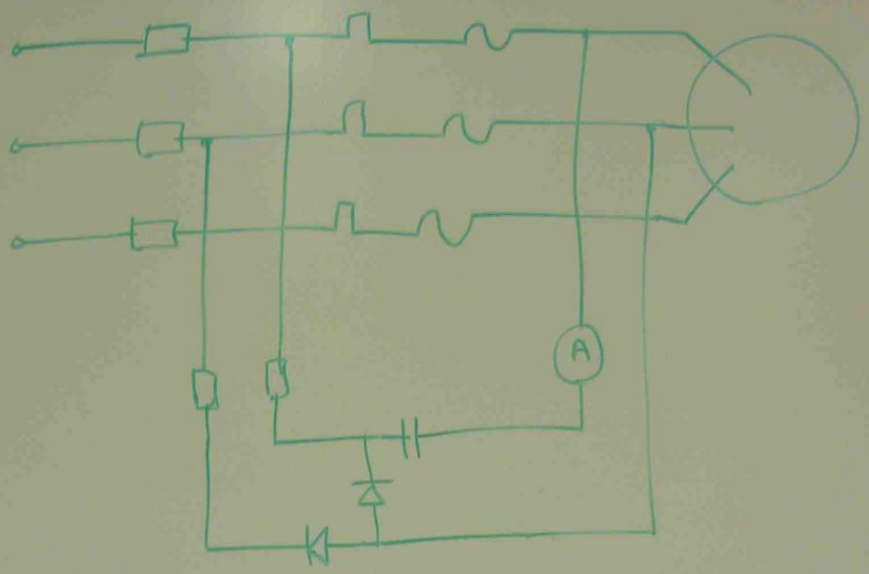
BRAKING

ELECTRIC MOTORS CAN BE BROUGHT TO STOP OR BRAKED BOTH ELECTRICALLY AND MECHANICALLY.

DYNAMIC BRAKING

DYNAMIC BRAKING OF AN AC INDUCTION MOTOR IS GENERALLY ACCOMPLISHED BY EXCITING IT'S STATOR WINDING WITH DC CURRENT. THE AMOUNT OF BRAKING TORQUE IS DIRECTLY PROPORTIONAL TO DC CURRENT PASSING THROUGH THE STATOR WINDING OF THE MOTOR.

EX MOTOR
LL STOP
MMEDIATELY



ADVANTAGE

NO FRICTION / WEAR / MAINTENANCE

ADJUSTABLE / SOFT START CAPACITY

- DISADVANTAGE

ELECTRIC MOTOR BRAKE WILL NOT STOP THE MOTOR IF POWER IS LOST OR DISCONNECTED.

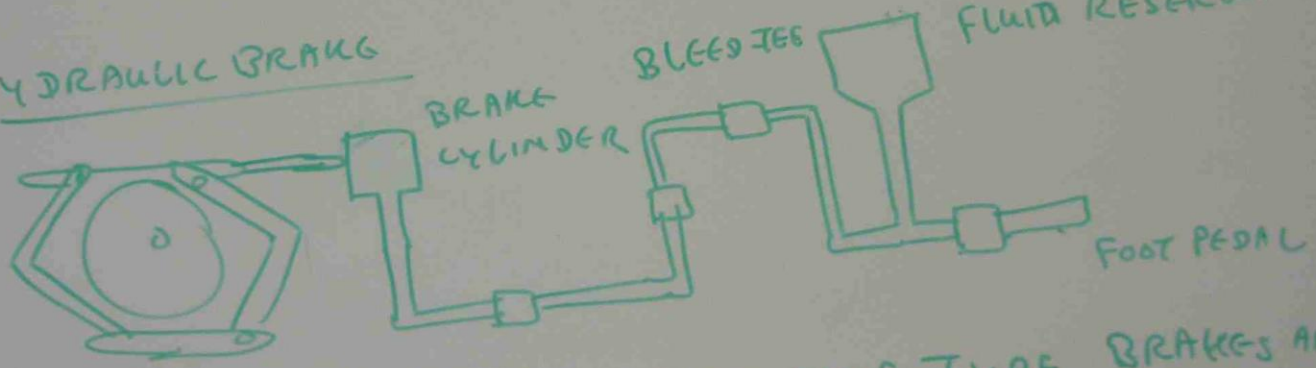
MECHANICAL BRAKING

ELECTROMAGNET HOLDS THE BRAKE SHOE AWAY FROM THE MOTOR SHAFT WHENEVER THE MOTOR IS ENERGIZED

MAGNETIC BRAKE

$$\text{REQUIRED TORQUE TO STOP THE MOTOR (BRAKE TORQUE)} = \frac{\text{RATED HP} \times 5252}{\text{RATED RPM}}$$

HYDRAULIC BRAKE



- HYDRAULICALLY APPLIED SHOE TYPE BRAKES ARE USED
- USED FOR CRANE, TRAVEL DEVICE, MILL MACHINE, CONVEYORS.