

IGBT based Inverter/ control system of HHP Locomotives

By

**Lecturer(E)
IRIMEE/JMP**

Basics of Traction Control System

Power Electronics



Power:

The static and rotating power equipment for the generation, transmission of electric power.

Electronics:

The solid-state devices and circuits to meet the desired control objectives.

Control :

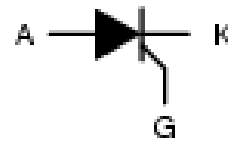
The Micro processor control of closed loop systems.

Semiconductor Devices ?

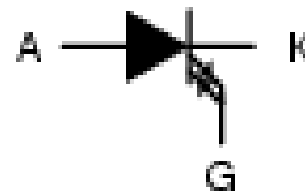
•*Diode*



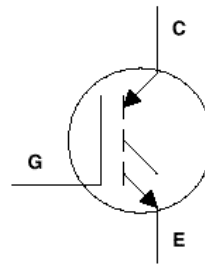
•*Thyristors (SCR)*



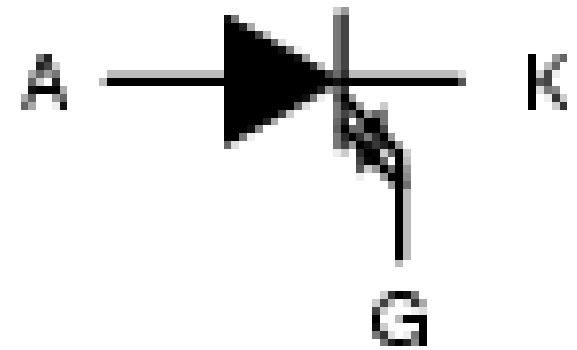
•*GTO*



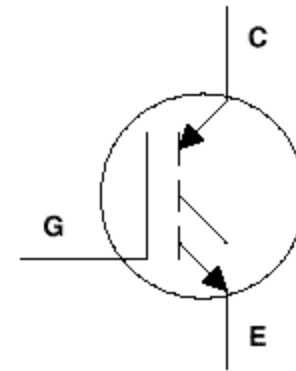
IGBT



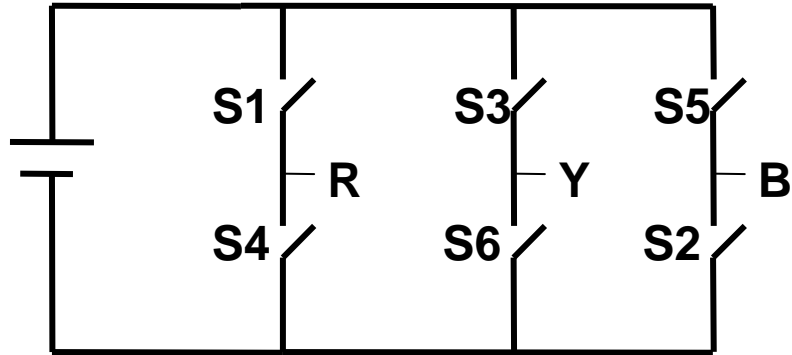
Gate Turn-Off Thyristor (GTO)



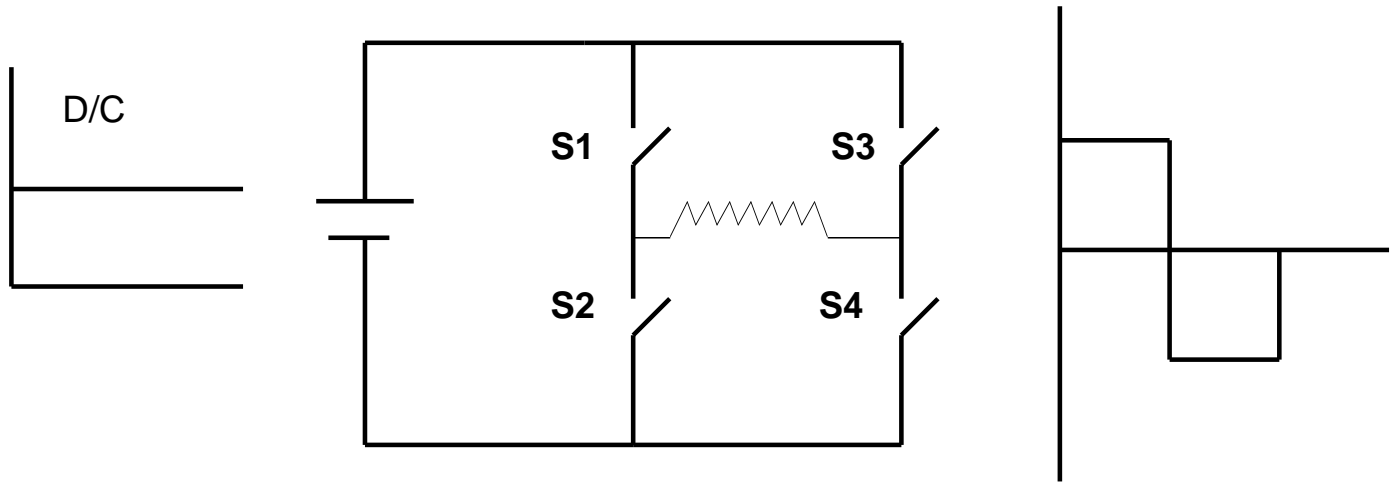
Insulated-gate Bipolar Transistor (IGBT)



3Ø Inverter



1Ø Inverter



Introduction

- **AC- AC Traction system comprises of four cabinets:**
 - ▶ **. Electrical Control Cabinet 1 (ECC#1)**
 - ▶ **. Electrical Control Cabinet 2 (ECC#2)**
 - ▶ **. Electrical Control Cabinet 3 (ECC#3)**
 - ▶ **Traction Control Cabinet (TCC)**

ECC-1

It houses equipments that controls and supplies power to the Locomotive.
This equipment includes principally:

EXTERNAL

- Circuit Breaker Panel
- Engine Control Panel
- Ground Relay Cutout switch and Test panel
- Display Unit

INTERNAL

- Main Control Panel (Relays, Resistors etc.)
- Locomotive Control Computer MLC 691
- ADB 1, 2, 3, 4 and FDB
- Four Braking contactors (B1, B2, B3, B4)
- Silicon Control Rectifier (SCR) Assembly



ECC-2

The Electrical Control Cabinet#2 mounts on the right side of the locomotive, under the locomotive under frame, between the No.1 bogie and the fuel tank. It consists of two interfaces. One is for battery charging and another one is for starting motors circuit. It consists:

Battery Charger

AGAV Sensor

AGAI Sensor

AG Ckt. Breaker

Two starting contactors (ST and STA) with resistors (RE ST1 & RE ST2)

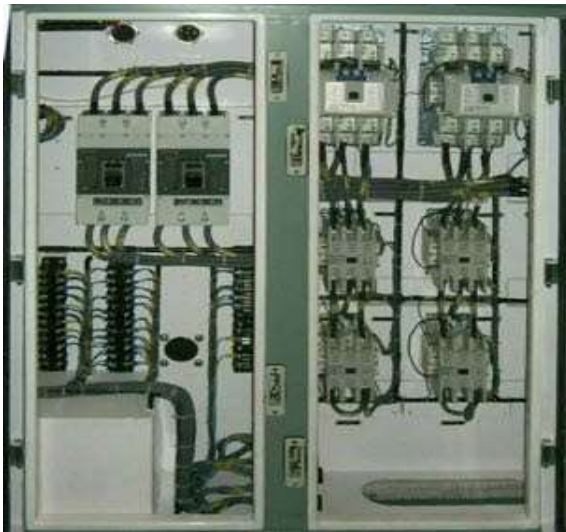


ECC-3

The Electrical Control Cabinet#3 mainly consists of Two Circuit Breakers and 6 contactors to run the radiator Fan Blower Motors either at low speed or at Fast speed to cool the engine.

TCC

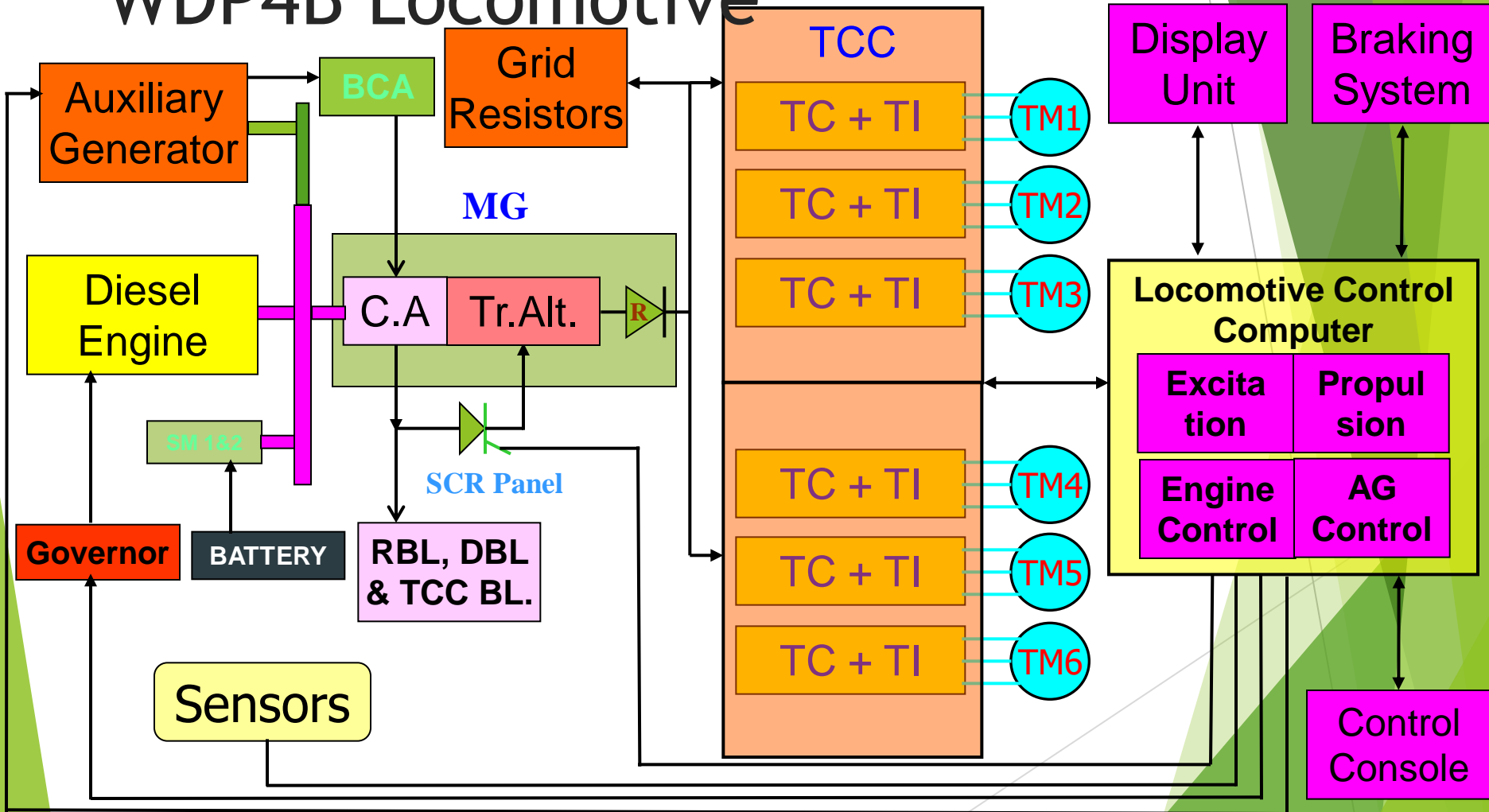
- ◆ 6 Traction inverters including Traction computers, IGBT drives, cooling Blowers and other components.
- ◆ Brake Chopper Resistor Assembly
- ◆ Crowbar Resistor Assembly



ECC 4 in Dual cab Loco

ECC-3

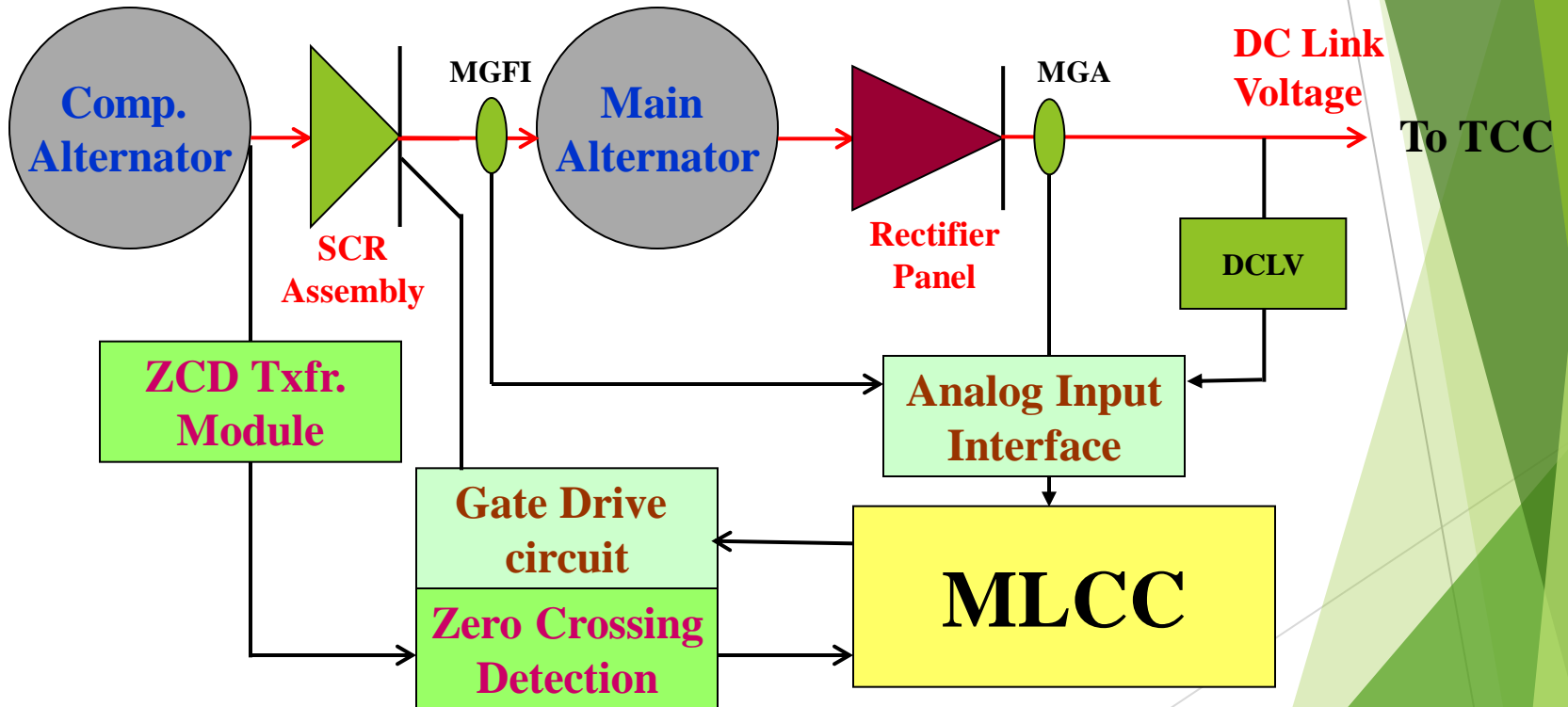
Block Diagram of WDG4 / WDP4B Locomotive



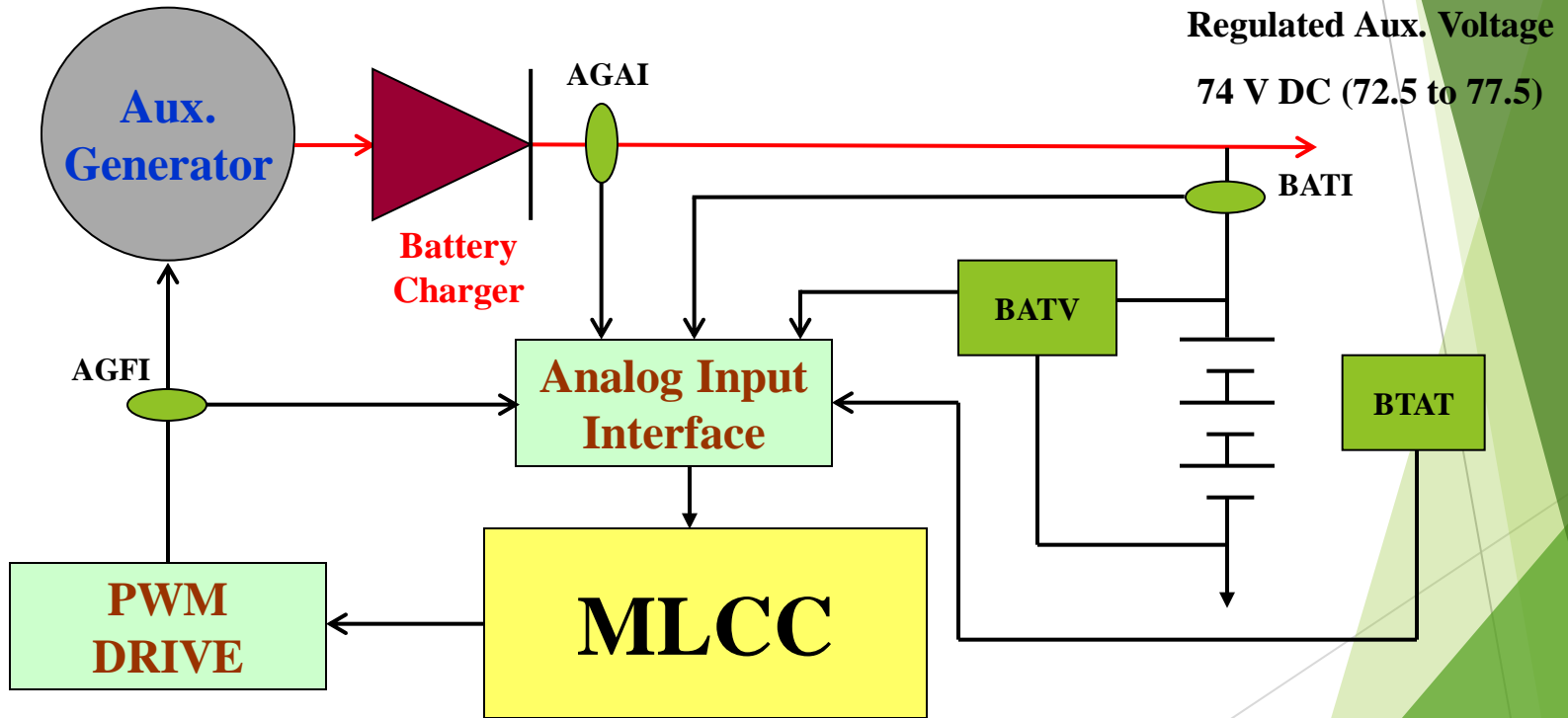
Functionalities

- ◆ Excitation of main generator
- ◆ Auxiliary generator control and battery charging
- ◆ Adhesion and wheel slip control
- ◆ Engine Control
- ◆ GHP Based Control
- ◆ Radiator Fan control
- ◆ Traction Inverters
- ◆ TM Control Philosophy
- ◆ TI Cooling Blowers.

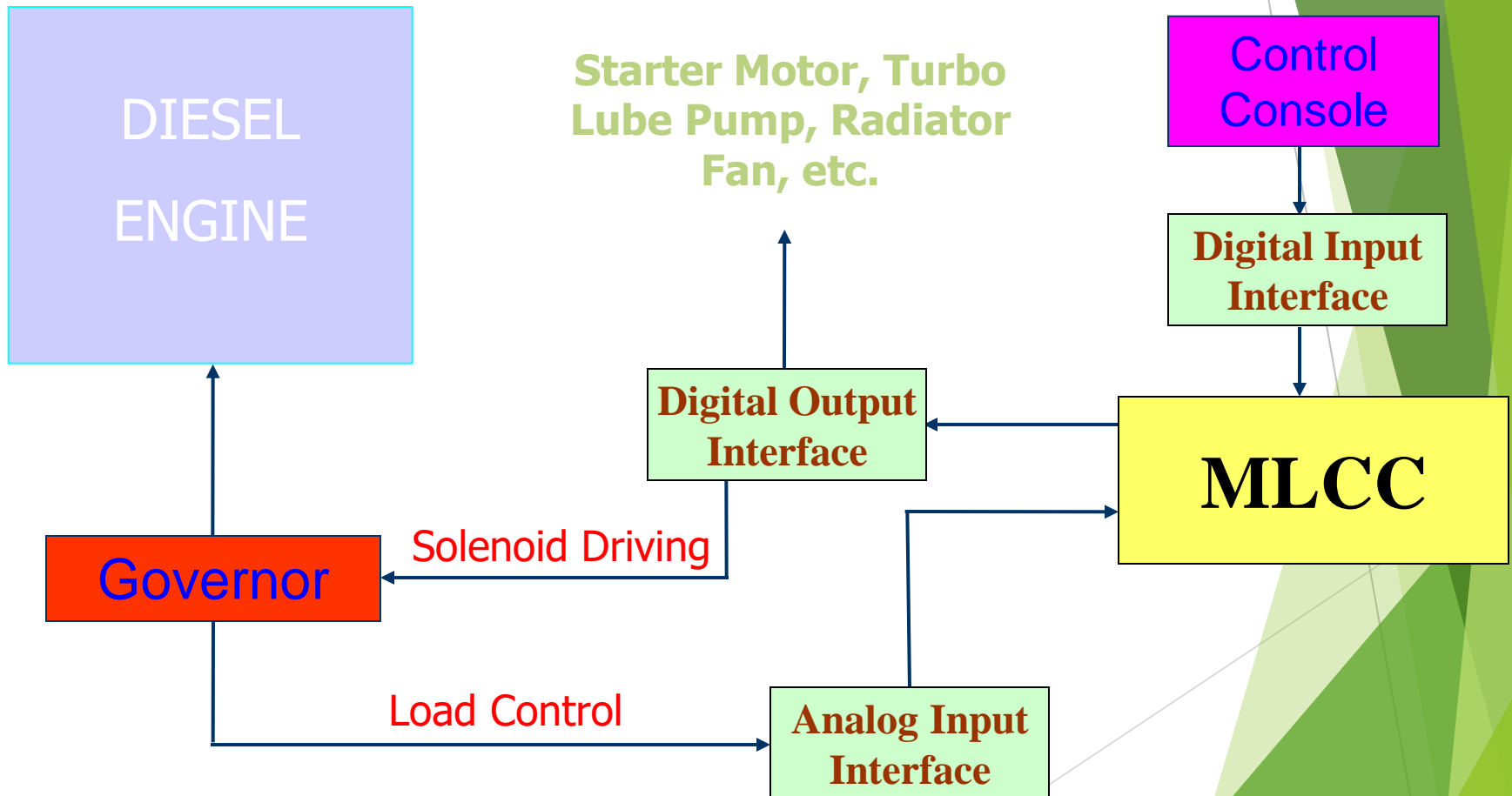
Excitation Control of Main Alternator



Auxiliary Generator Control and Battery Charging (Integrated with LCC)

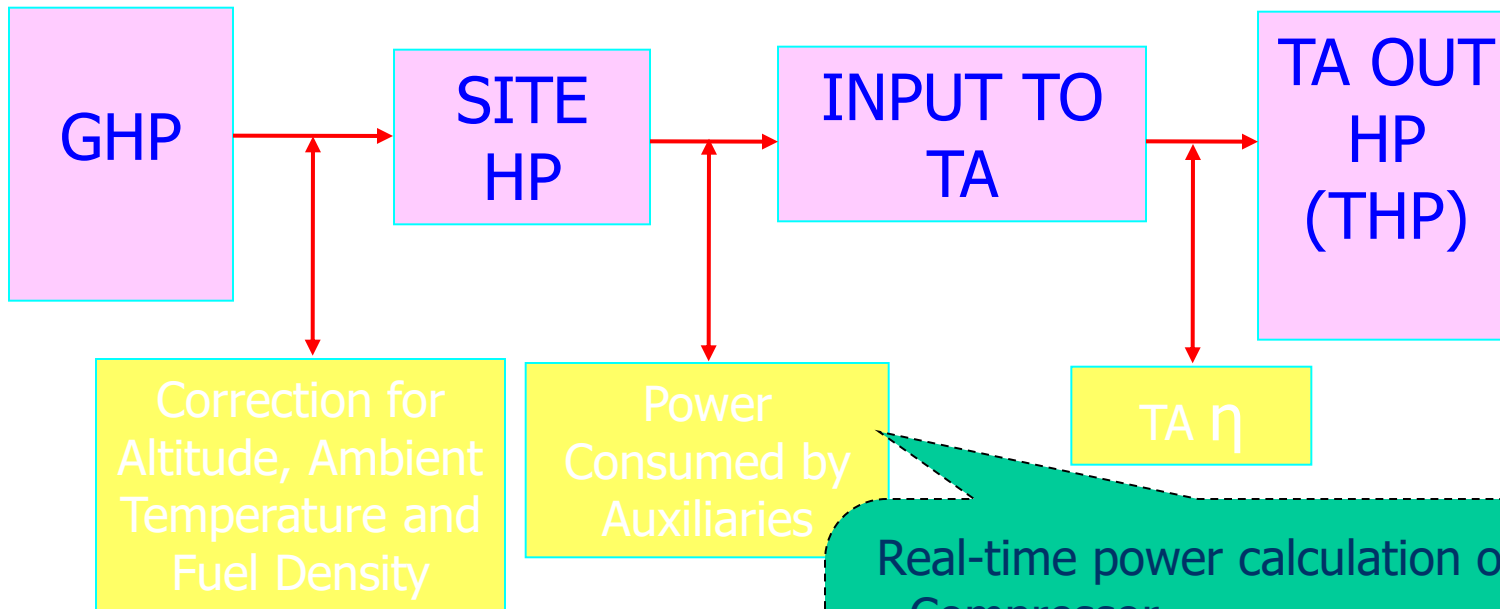


Engine Control through Governor Load Control and Control of Auxiliaries



Constant GHP Control

- GHP control leads to optimal engine loading, while balancing auxiliary power requirement with Traction Power available.



- Real-time power calculation of
- Compressor
 - Radiator fan (OFF, HALF, FULL)
 - Traction Motor Blower
 - Auxiliary Generator
 - Inertial Filter Blower

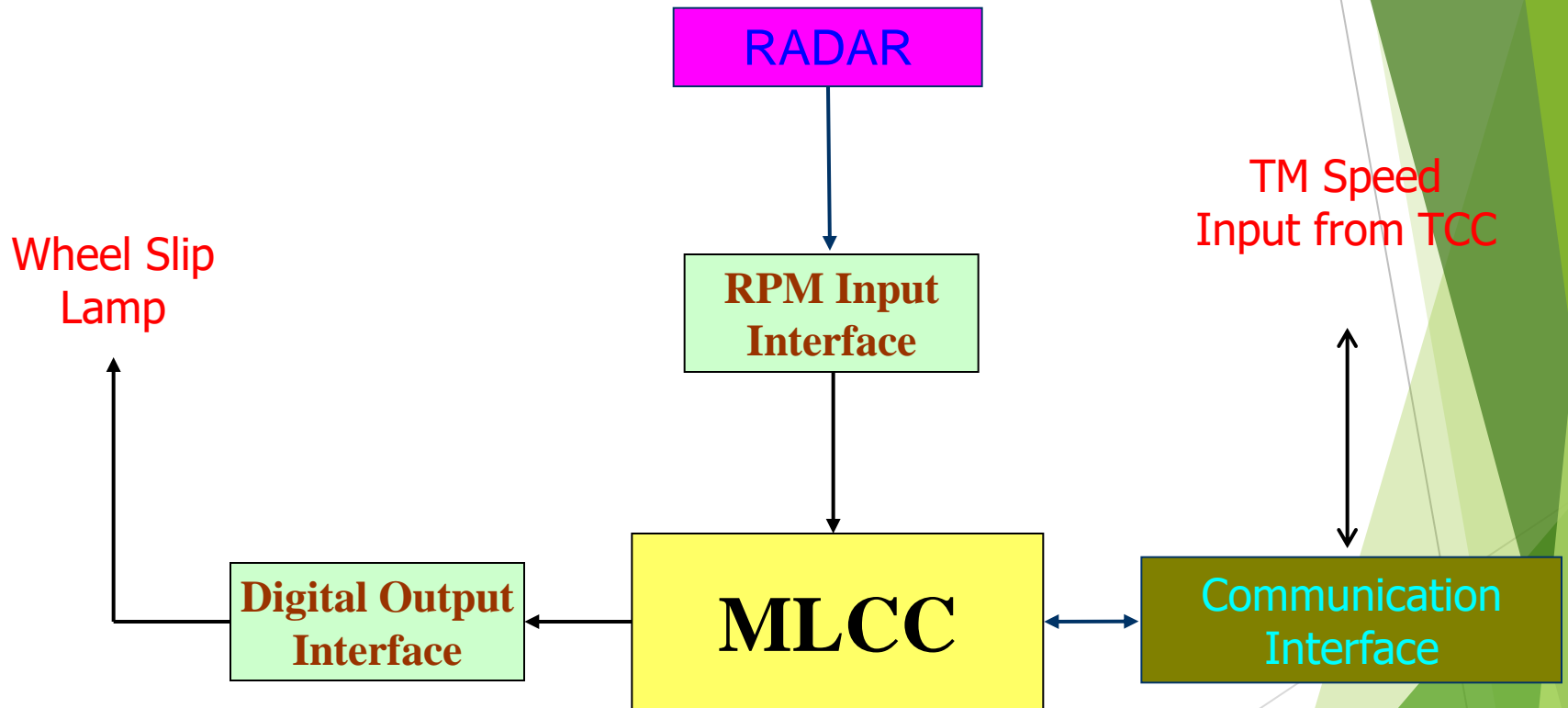
Radiator Fans Control

- Engine temperature monitored by ETP1 & ETP2
- Max of ETP1 & ETP2 (healthy) considered as engine temperature.

Pick up Temp.	System Action	Drop out Temp.	System Action
> 85° C	Fans will be made ON as per Pre defined Logic	< 79 ° C	Fans will be made OFF as per Pre defined Logic
> 96° C	Power limited to 6 th Notch (RPM remains same)	< 90 ° C	No Limitation
> 101° C	Hot Engine Indication (RPM + power limited to 6 th Notch)	< 95 ° C	Power limited to 6 th Notch (RPM remains same)
> 101° C for 5 min	Hot Engine - Extended Time (Engine will come to IDLE)	< 95 ° C	Power limited to 6 th Notch (RPM remains same)
> 79° C (Turbo Cool Down Cycle)	Fans will be made ON as per Pre defined Logic	< 73 ° C (Turbo Cool Down Cycle)	Fans will be made OFF as per Pre defined Logic

- ◆ Whenever TH brought from \geq Notch 6 to $<$ Notch 2, Turbo Cool down cycle would start and remains in Notch 2 rpm for 20 minutes.
- ◆ Fans will be made instant Turn OFF if Engine Temp. reaches $< 66^{\circ}$ C.

Adhesion and Wheel Slip Control



Ground Protection

- ▶ Ground Protection enable / disable through GRNTCO switch with lock provision.
- ▶ PGNDMG Sensor is provided to detect ground in main generator at 800mA.
- ▶ PGNDPI + Sensor is provided in main generator positive half side to detect phase imbalance at 400mA.
- ▶ PGNDPI - Sensor is provided in main generator negative half side to detect phase imbalance at 400mA.



Vigilance Control Device / Alerter

- ▶ VCD feature can be enabled / disabled through display.
- ▶ If Brake Cylinder pressure $> 1.8 \text{ kg/cm}^2$ and loco speed is zero, Alerter cycle will be reset.
- ▶ Any driver activity (changing throttle handle or pressing horn push button etc.) Alerter cycle will be reset.
- ▶ At least driver has to press Alerter reset push button to reset alerter cycle.
- ▶ If any acknowledgment is not received by driver for 60 sec in (T0 Cycle), Alerter lamp will be made ON and OFF for 8 sec (T1 Cycle).
- ▶ If any acknowledgment is not received by driver for 8 sec in (T1 Cycle), Alerter Bell as well as Alerter lamp will be made ON and OFF for 8 sec (T2 Cycle).
- ▶ After T2 cycle LCC intimates CCB to apply penalty brakes (T3 Cycle).
- ▶ To release penalty brakes bring the throttle handle to IDLE, wait for 35 sec (T3 Cycle).
- ▶ After satisfying above conditions, operator has to keep auto handle in Full Service for 10 sec. automatically penalty brakes will release.

Restricted Air Penalty Brake / AEB

- ▶ Selection Switch (RAPB) is provided in ECC#1 with locking mechanism.
- ▶ RAPB apply speed and Release speed are configurable.
- ▶ Whenever the loco speed exceeds “RAPB apply speed” LCC intimates CCB to apply penalty brake.
- ▶ Penalty will be released once Loco speed < “RAPB release speed” & Master Control Handle is in IDLE & AEB reset push button is pressed.

TE Limit Feature

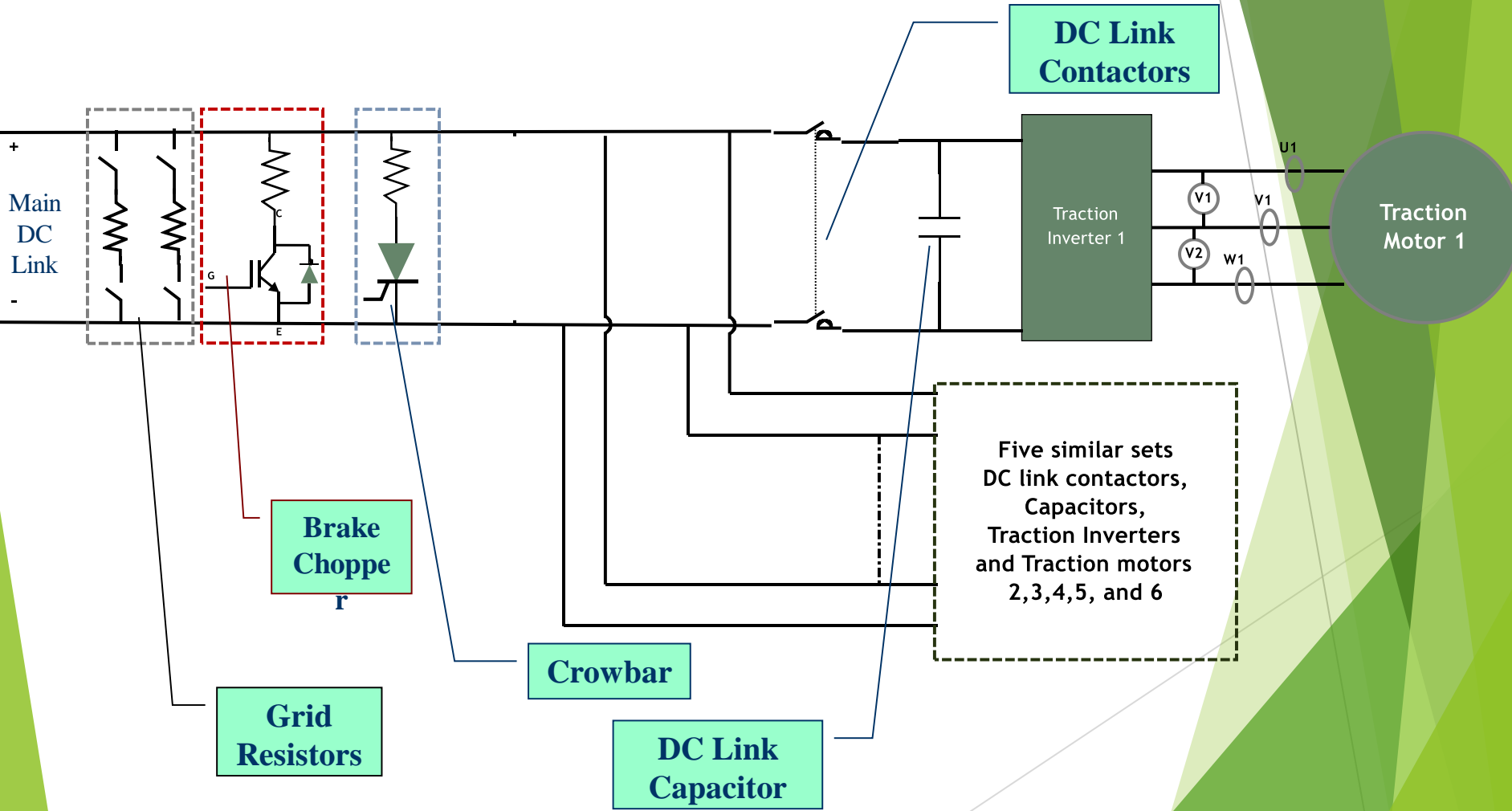
- Selection Switch (TELM) is provided in ECC#1.
- TE Limit Lamp indication on Driver control console.
- Intimation to coupled locomotives through TLI4.
- Maximum Tractive Effort Limited to 294 KN.

Distributed Power Control

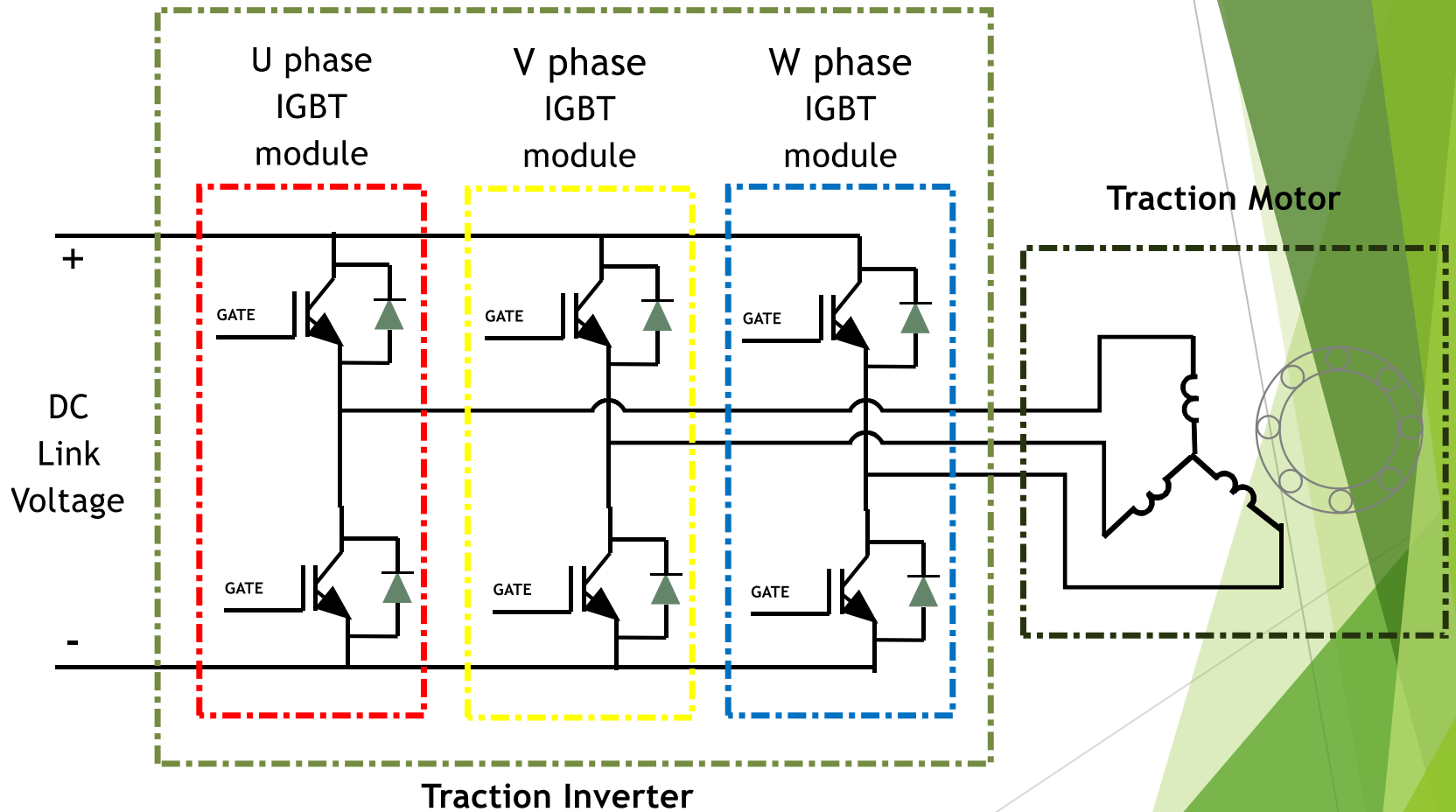


- ◆ Distributed Locomotives - higher Aggregate HP with lesser peak coupler forces
- ◆ Longer Trains imply higher traffic throughput
- ◆ Continuous Brake Pipe with multiple braking locomotives - Shorter Braking Distances.

DC Link Block Diagram



Traction Inverter and Motor



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