SR Drive System Circuit Description

Section 06-03-04

Komatsu has made every effort to make this manual as accurate as possible based on the information available at the time of publication and printing. Continuous improvement and advancement of product design may cause changes to machines which may not have been included in this publication. Komatsu reserves the right to make changes and improvements at any time. To ensure the most current information, please contact your service center.

Table of Contents

List of Figures

This Page Intentionally Left Blank

Safety

This publication contains special instructions that pertain to safety, operation, maintenance, and repair of the machine. Listed below are the signal words and symbols that precede these instructions and their meanings:

DANGER

- **The danger label indicates a hazardous situation which, if not avoided, will result in death or serious injury.**

WARNING

- **The warning label indicates a hazardous situation which, if not avoided, could result in death or serious injury.**

CAUTION

- **The caution label, used with the safety alert symbol indicates a hazardous situation which, if not avoided, could result in minor or moderate injury (includes the safety alert symbol).**

CAUTION

- **The caution label (without safety alert symbol) is used to address practices not related to personal injury – only equipment damage.**

NOTICE

- **The NOTICE graphic is to indicate areas of importance to the reader that are not related to personal injury or machine damage.**

This Page Intentionally Left Blank

SR Circuits

Figure 1. Power flow

Key Points

- All drives report bus voltage over the CAN bus. The bus voltage can be monitored through the use of the operator interface in the operator's cabin.
- A visual LED indicator array is mounted on the control board of each converter panel. This LED array will be illuminated if there is bus voltage of greater than 24V present on that panel.
- All converter panels should have the same voltage since they are all on a common bus.
- If a converter panel has more or less voltage, it may have blown DC bus fuses.
- Both positive and negative buses are fused at each converter panel.
- When a converter panel is powered (24V ignition), it will charge the bus to 15V.
- The isolation monitor works at 15V, and much of the diagnosis of a ground fault can be done with the engine off.
- The IGBT modules on the converter panels are cooled by a dedicated liquid cooling circuit.
- The capacitors on the converter panels are air convection cooled.
- Unlike earlier P&H wheel loader models, this machine has no 'hill hold'. The drive system increases gain near zero speed (with zero pedal input) making the machine very responsive to differences between actual and commanded speed.
- Propel is disabled when service brakes are applied beyond a predetermined threshold.
- All drive faults are Amber warnings or lower, some warnings will occur in conjunction with the disabling of the particular converter panel.
- Some drive faults, such as a generator fault, will remove the ability to propel the machine.
- Motors can be isolated
- Converter panels can be isolated

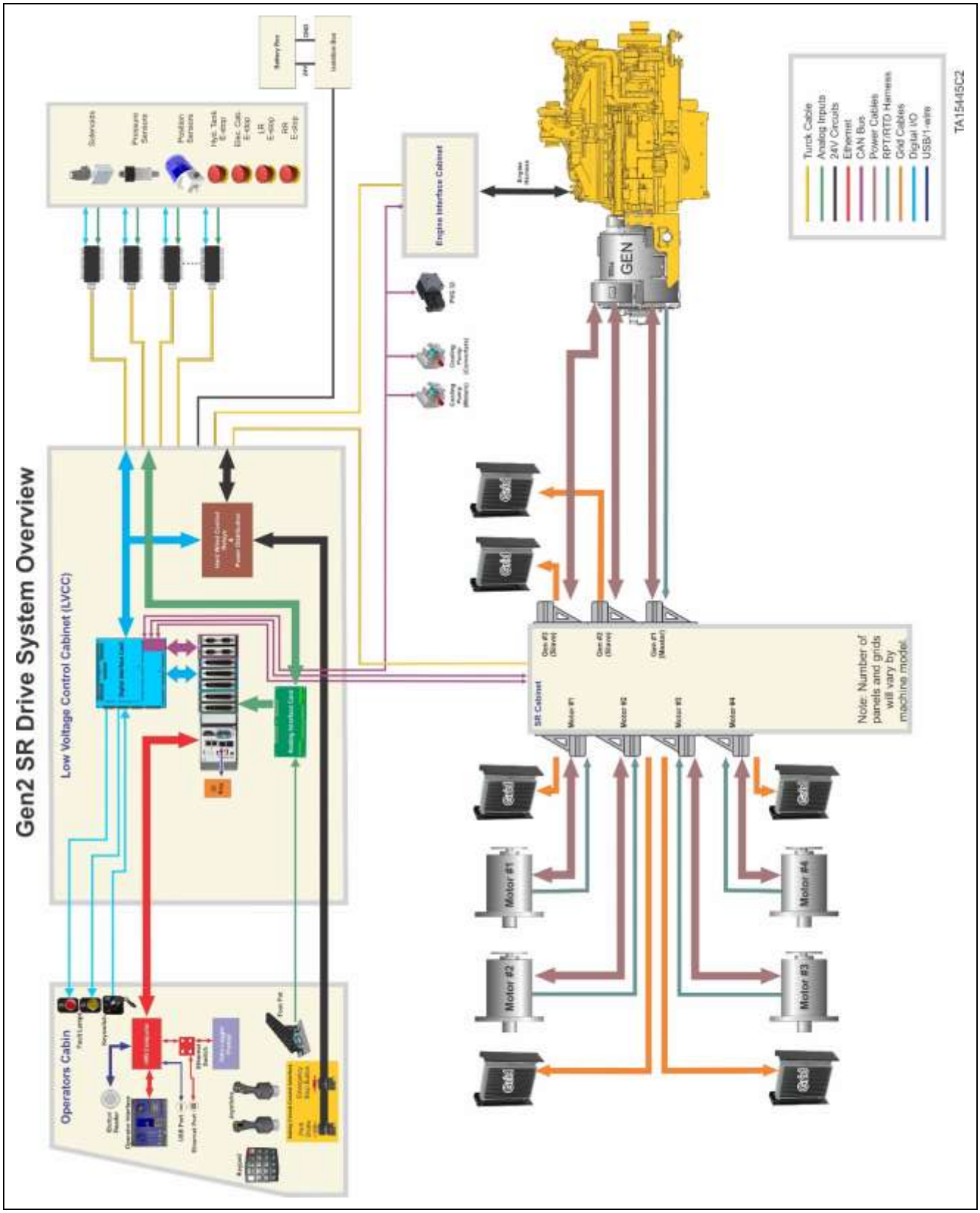


Figure 2. LINCS II circuit layout

LINCS II Booted

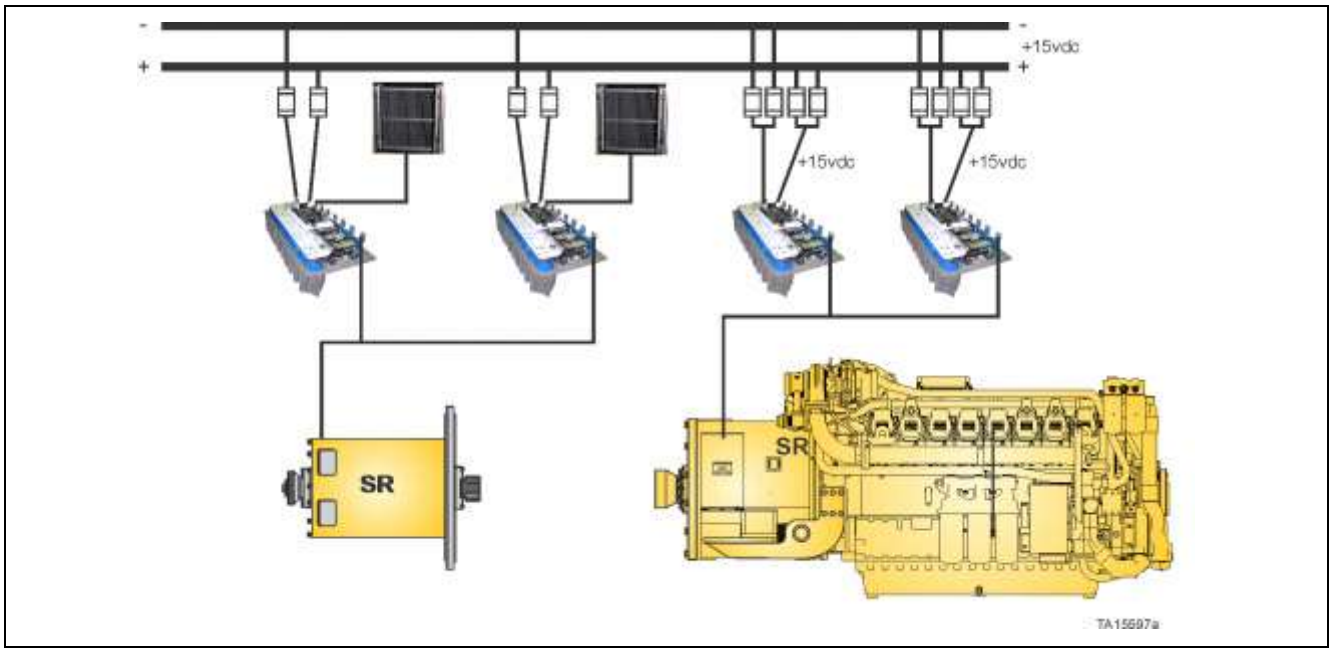


Figure 3. LINCS II booted (L-1150 depicted)

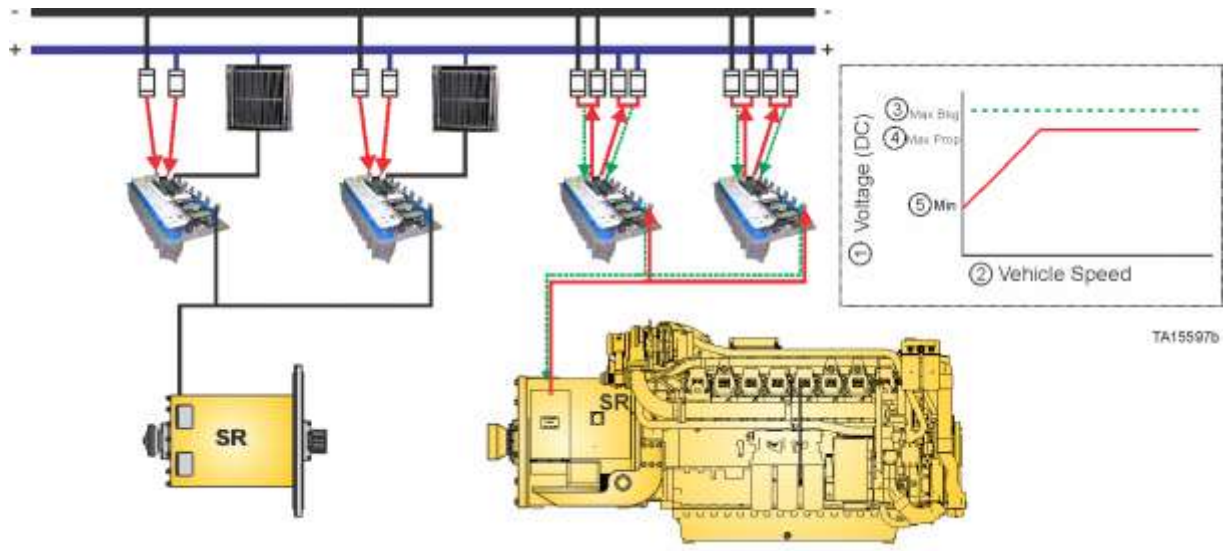
With the key switch on and LINCS II booted, the converter panels supply +15VDC to the DC BUS. As the isolation monitor works at 15V, if there is an isolation monitor alarm, much of the isolation fault diagnosis can be done in this condition.

NOTICE

The generator converter panels have more fuses to handle the higher current requirements.

This Page Intentionally Left Blank

Prime Generator – Drive System Enabled



1) Voltage (DC), **2)** Vehicle Speed, **3)** Maximum braking, **4)** Maximum propulsion, **5)** Minimum

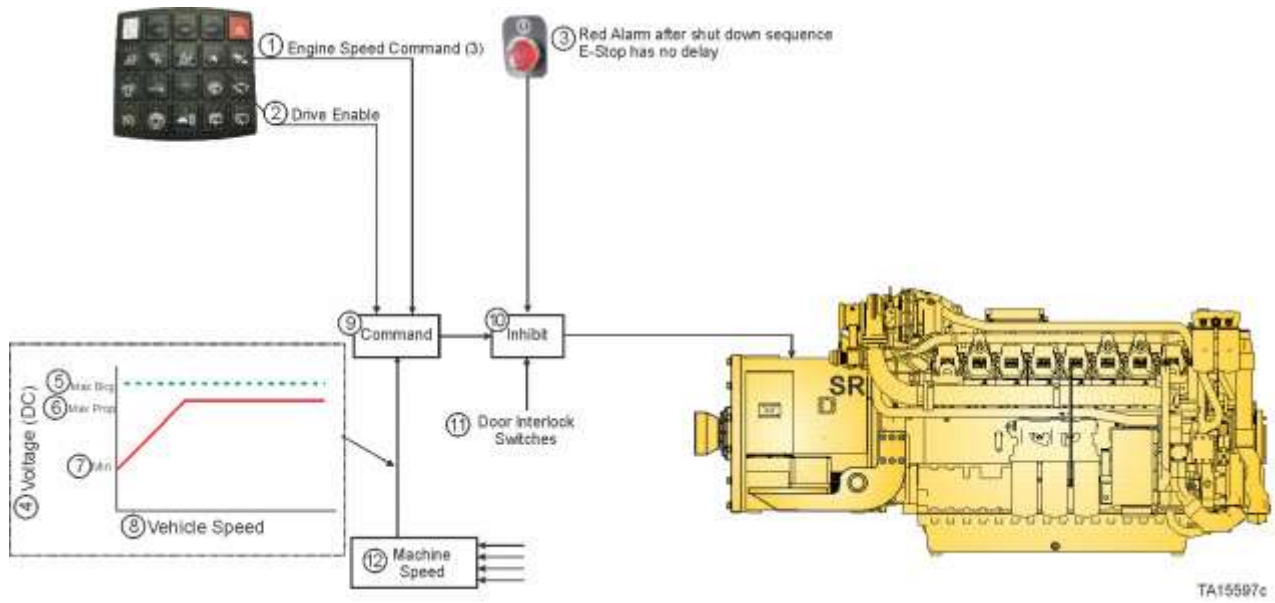
Figure 4. Generator enabled

When the drive system is enabled, the +15V is used to initially energize the generator coils so that the generator, as its rotor is rotated, can produce voltage. Voltage on the DC bus will increase to 500VDC, charging the capacitors on each panel. When the machine is commanded to move, the bus voltage increases from 500VDC to 700VDC as speed increases.

When the machine speed decreases below a set speed, bus voltage returns to 500VDC.

NOTICE

The generator can produce voltage at any throttle speed selection as long as the drive enable button is active.

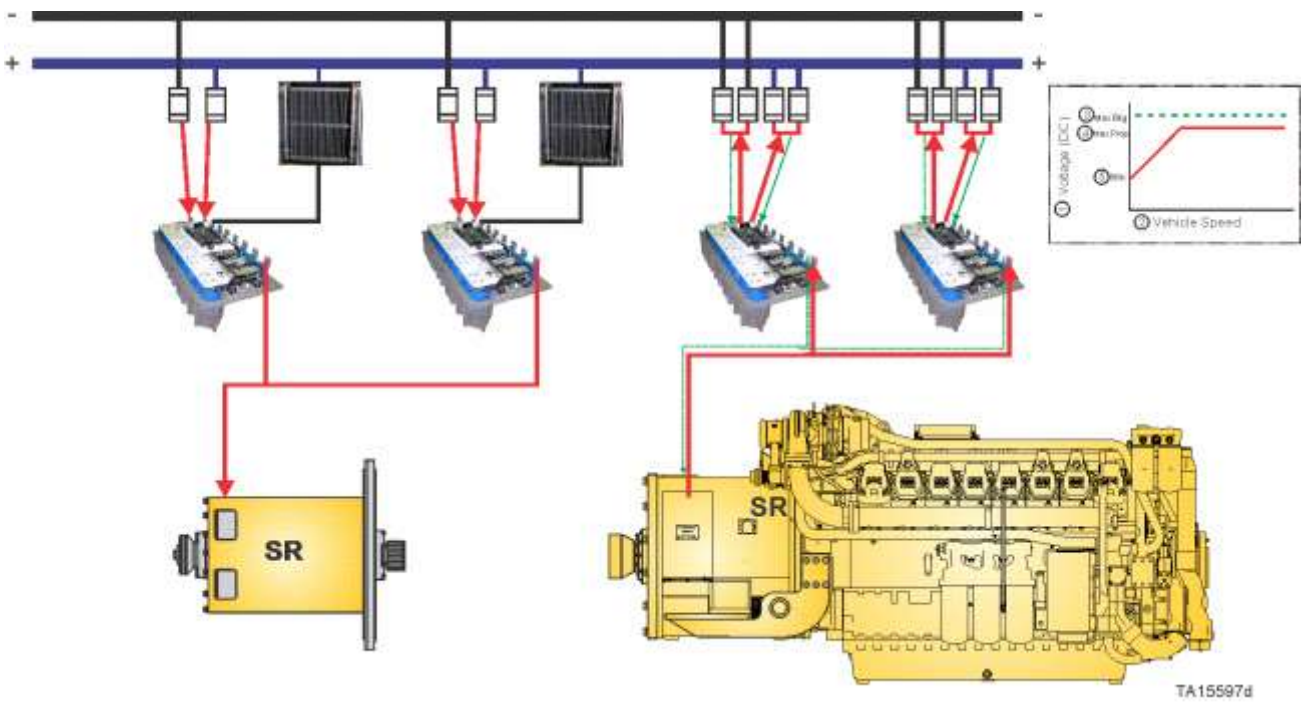


1) Engine speed command (3), **2)** Drive enable, **3)** Red alarm after shut down sequence E-stop has no delay, **4)** Voltage DC, **5)** Maximum braking, **6)** Maximum propulsion, **7)** Minimum, **8)** Vehicle speed, **9)** Command, **10)** Inhibit, **11)** Door interlock switches, **12)** Machine speed

Figure 5. Basic generator logic

The engine speed command is selected through the Throttle Switch. There are three selections, LO (default 800 RPM), L2 (1100 RPM), and HI (1800 RPM). The drive enable switch will allow the generator to produce voltage at LO throttle. Any inhibit such as electrical converter cabinet door interlock, E-Stop, etc. will prevent the generator from enabling.

Propel



1) Voltage (DC), **2)** Vehicle Speed, **3)** Maximum braking, **4)** Maximum propulsion, **5)** Minimum

Figure 6. Propel

In propel, current flows from the DC bus through the motor IGBT's to energize the motor coils to create propel torque. The maximum speed and torque is adjustable within LINCS.

NOTICE

An alternate machine speed and torque can be selected by the operator.

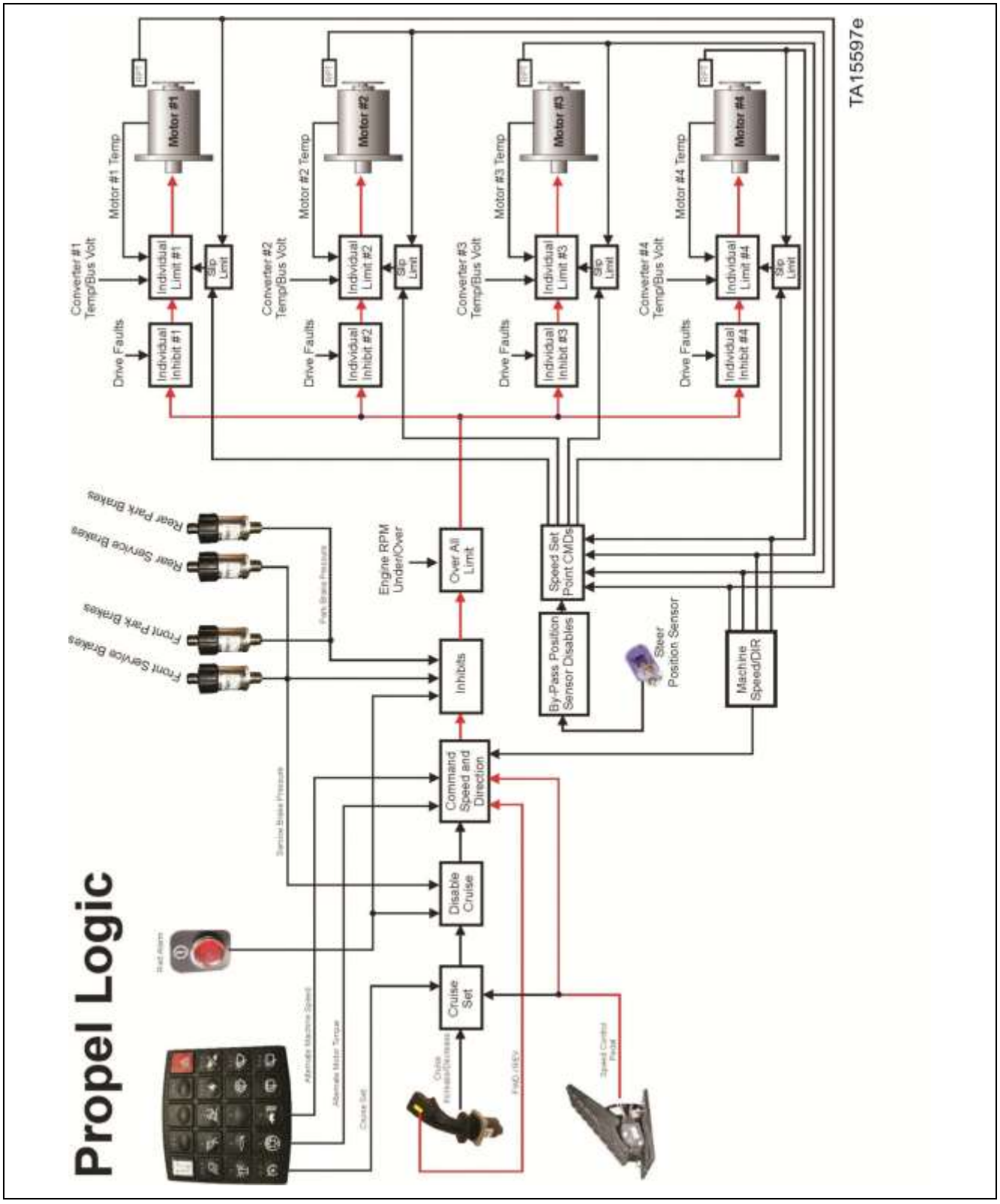
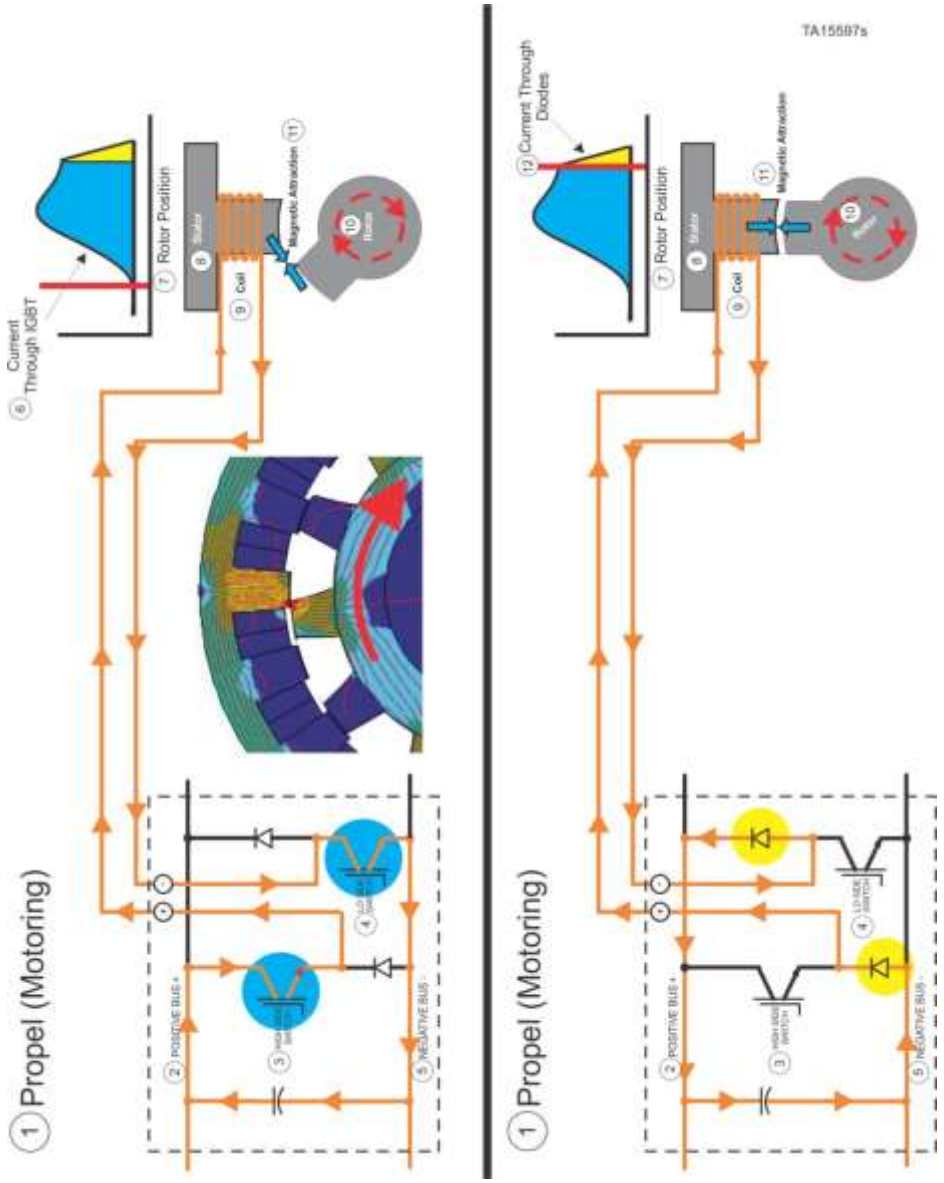


Figure 7. Propel logic

Motor Operation (Propel)



1) Propel (Motoring), **2)** Positive Bus +, **3)** High Side Switch, **4)** LO Side Switch, **5)** Negative Bus - , **6)** Current Through IGBT, **7)** Rotor Position, **8)** Stator, **9)** Coil, **10)** Rotor, **11)** Magnetic Attraction, **12)** Current Through Diodes

NOTICE

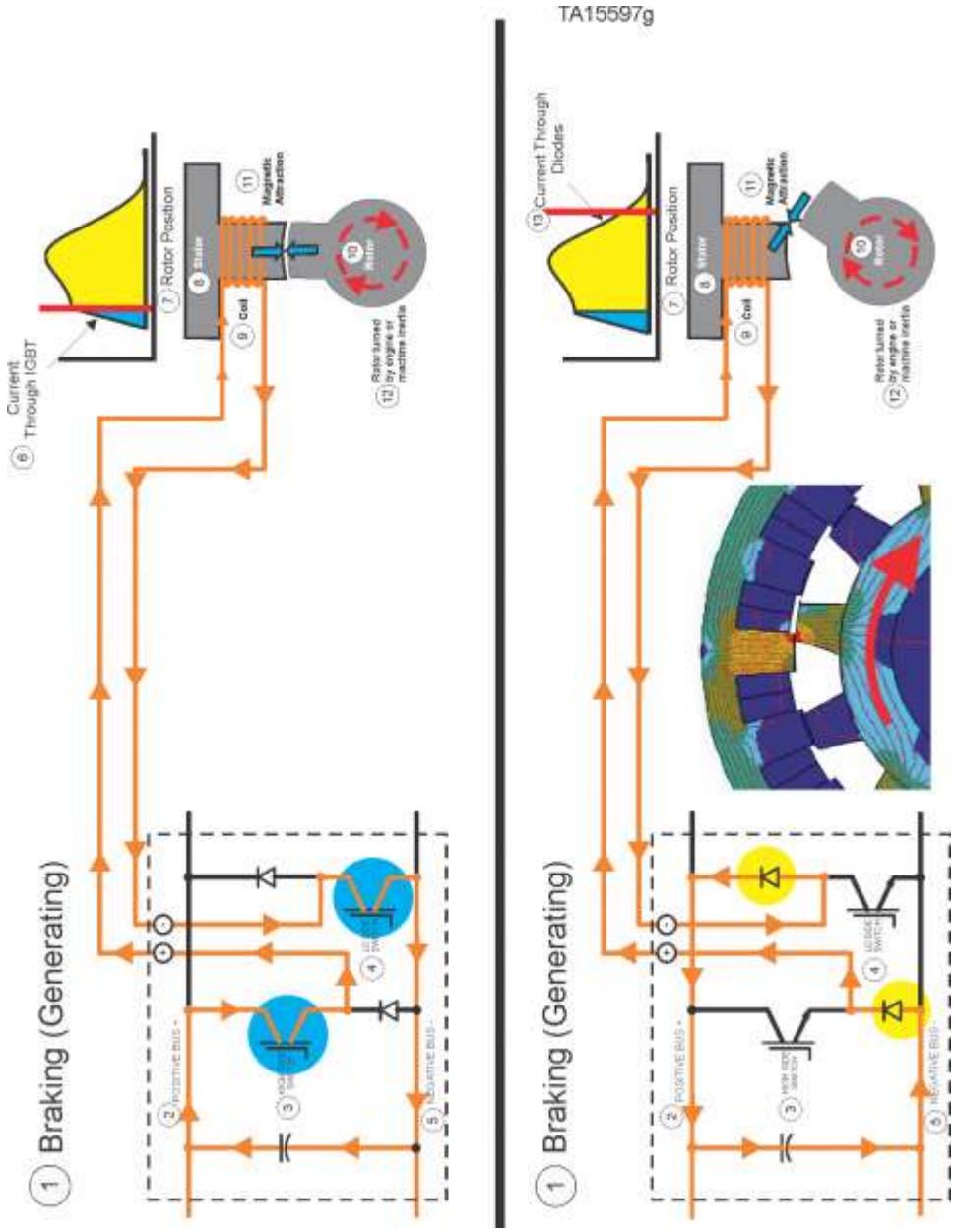
- **Current flows through the IGBTs and winding**
- **Rotor position results in motoring torque**
- **Since most of the energy is converted to torque only a small amount of current returns through the diodes to the bus.**

Figure 8. Motor operation (propel)

In propel, the IGBT turns on as the rotor approaches the pole. The resulting magnetism pulls the rotor toward the pole. When the rotor reaches the pole, the IGBT is switched off. As the magnetic field of the coil collapses, a small amount of energy is created and fed back through the diodes to the DC bus, which is used by the next set of coils to pull the rotor to the next position.

This Page Intentionally Left Blank

Braking



1) Braking (generating), **2)** Positivie bus+, **3)** High side switch, **4)** Low side switch, **5)** Negative bus, **6)** Current through IGBT, **7)** Rotor position, **8)** Stator, **9)** Coil, **10)** Rotor, **11)** Magnetic attraction, **12)** Rotor turned by engine or machine inertia, **13)** Current through diodes

NOTICE

- **Current flows through the IGBTs and winding.**
- **Rotor position results in motoring torque.**
- **Since most of the energy is converted to torque, only a small amount of current returns through the diodes to the bus.**

Figure 9. Braking

In the traction motor, when the rotor is under the corresponding pole, the IGBT will be commanded to turn on for a short period of time. As the rotor pulls away from the magnetic field, it induces energy back into the coil which is then passed through the diodes and onto the DC bus.

Energy Recovery

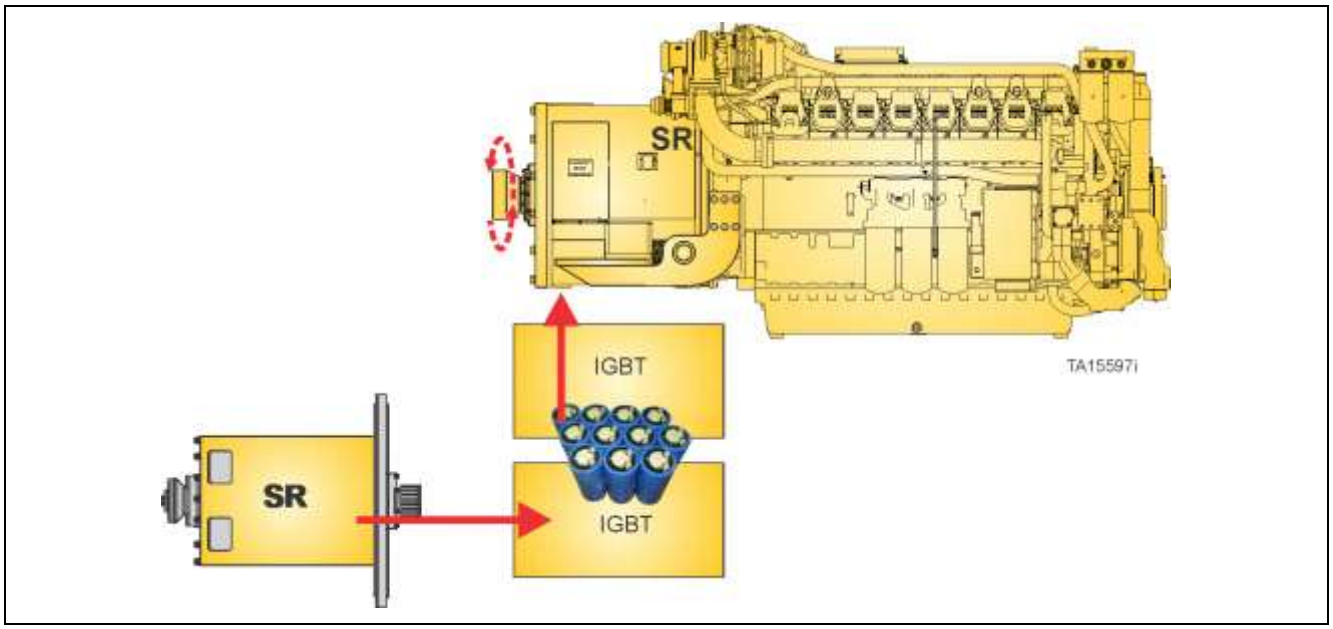


Figure 10. Energy recovery

During braking:

- Motors become generators.
- Generator becomes a motor.
- Braking energy transfers from motors to the generator.

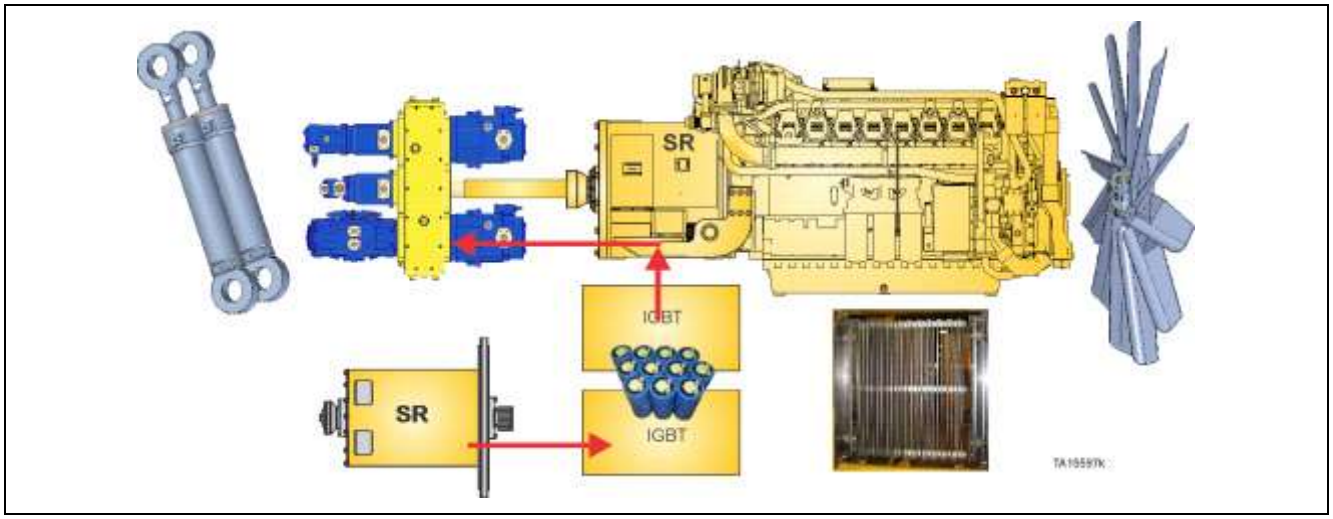


Figure 11. No engine load (1 of 4)

The initial step in energy recovery is to satisfy hydraulic parasitic's, engine losses, and shut the fuel supply off.

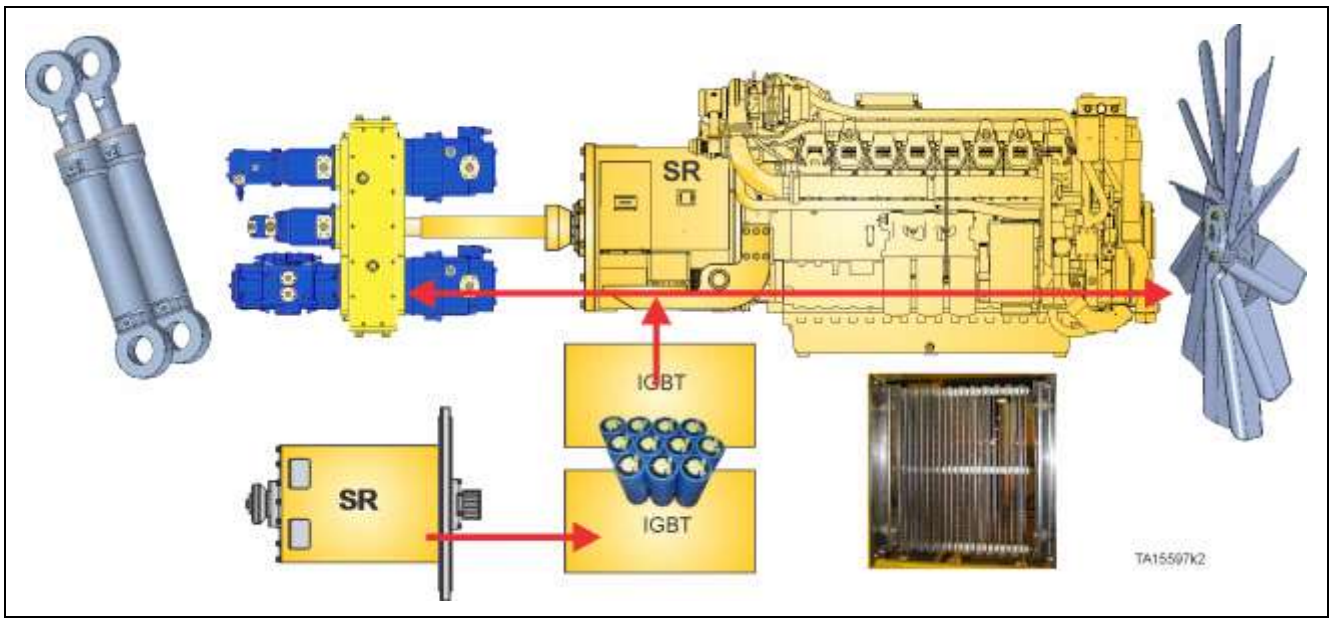


Figure 12. No engine load (2 of 4)

Energy is then available to drive functions such as hoist, and engine fan, functions the engine would normally have to drive.

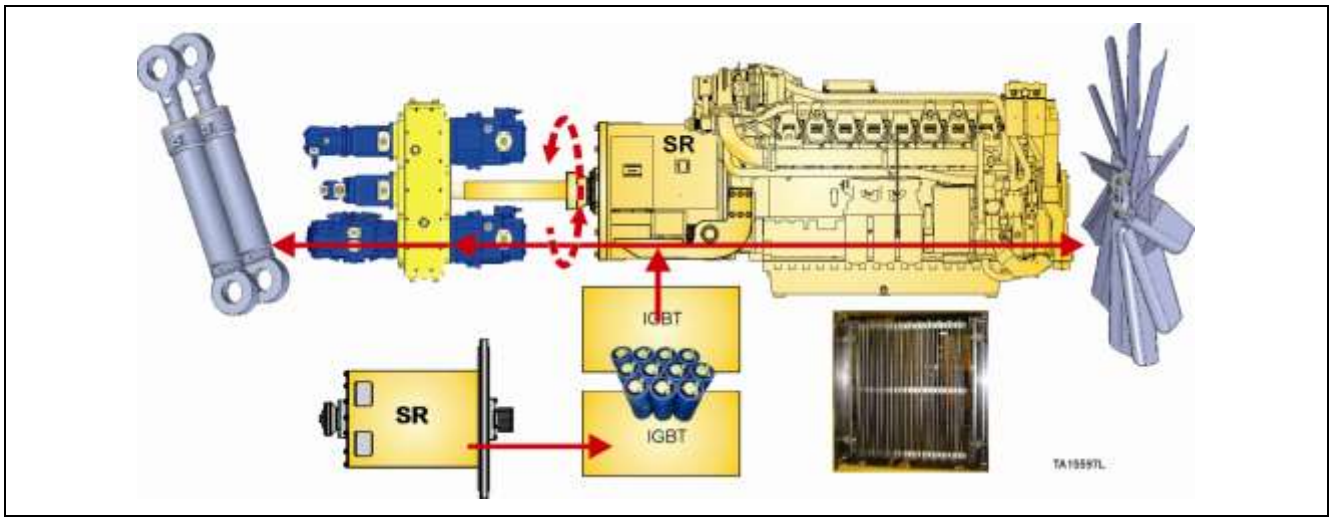


Figure 13. No engine load (3 of 4)

After all devices, both parasitic and functional, are being powered by recovered braking energy, energy can then be stored for later use in the driveline's significant inertia. Increasing driveline speed stores enough energy that the engine fuel can be left off up to a half second after the loader has completely stopped.

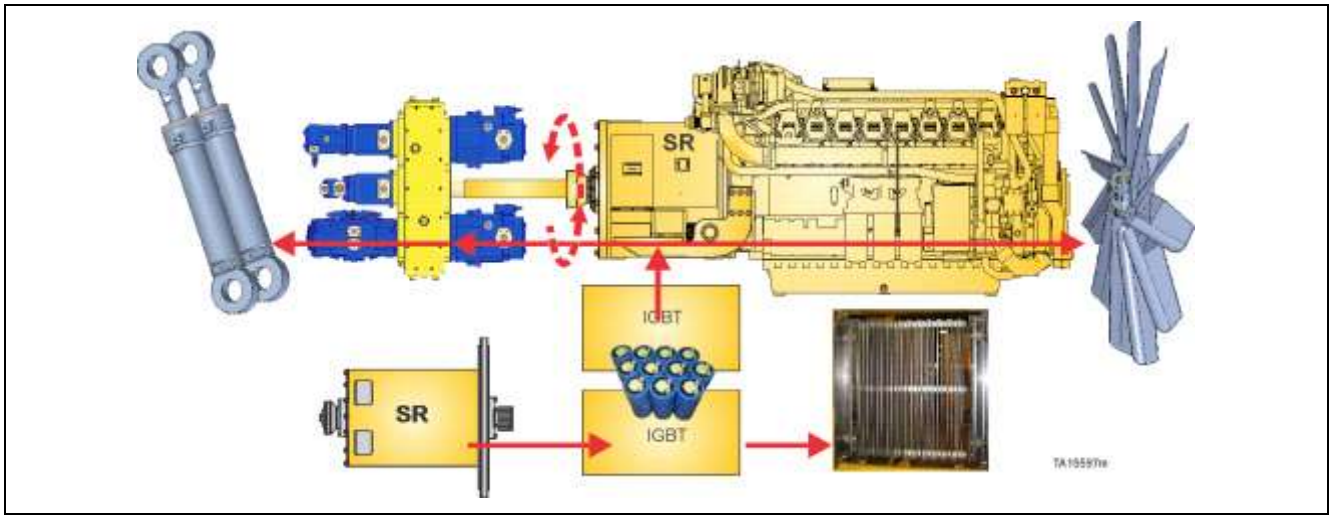


Figure 14. No engine load (4 of 4)

Any additional unused energy is dissipated through the braking grids. This is referred to as “extended braking”.

Extended Braking

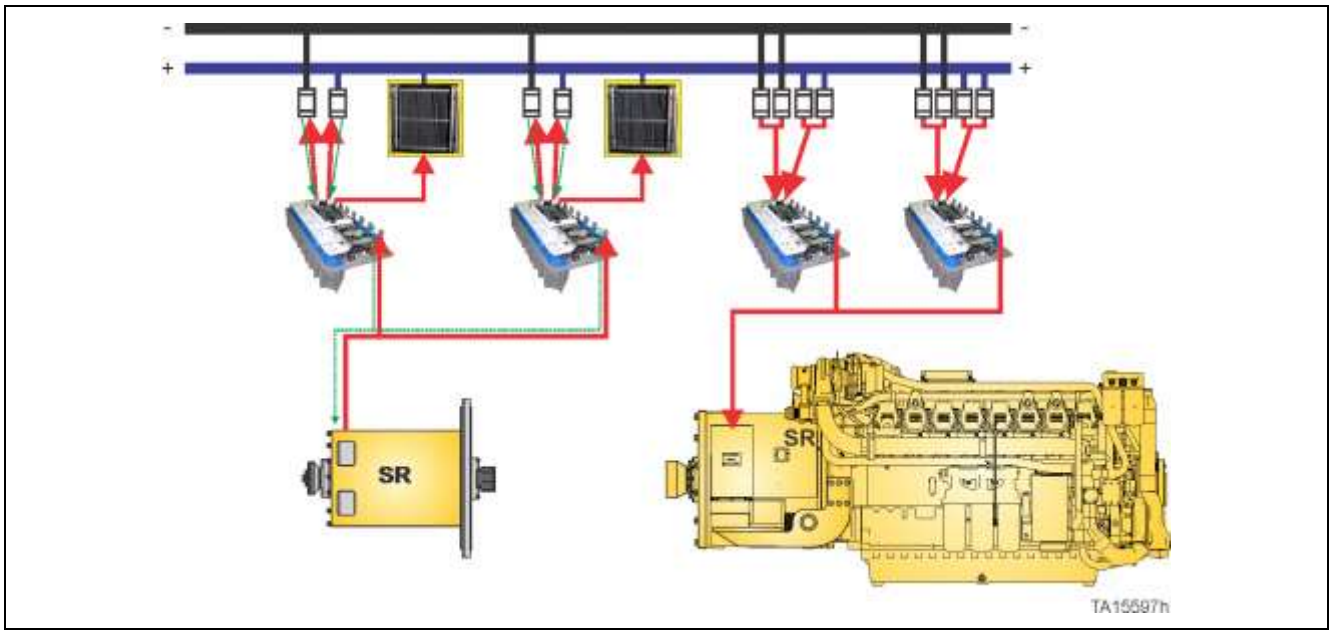


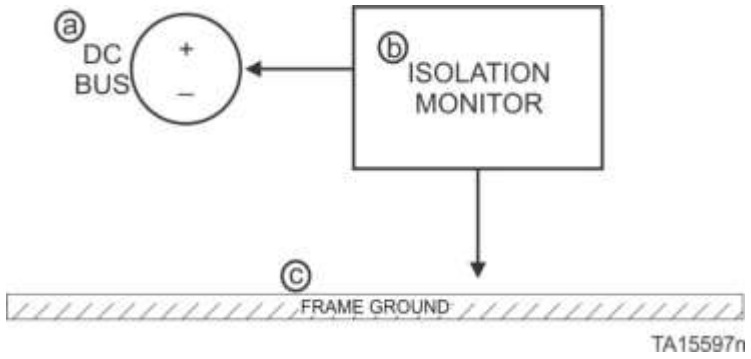
Figure 15. Extended braking

As the 4 motors can create more energy in braking than the engine and parasitic’s can consume, surplus energy is dissipated across the braking grids.

Isolation Monitoring Circuit

The Hi-Voltage bus on the Generation2, P&H wheel loader has high impedance to the machine frame ground (a floating system with no connection to the machine frame). The Isolation Monitor Circuit monitors insulation resistance between the Hi-Voltage bus and frame ground. This is accomplished by monitoring the true resistive path to ground by measuring an induced signal generated by the Isolation Monitor Circuit.

It is an active system, and can detect potential bus isolation issues with only pre-charge bus voltage applied (LINCS II booted). With this system, contact between either side of the Hi-Voltage bus and machine frame will not result in large arcs or blown fuses.



a. DC bus

b. Isolation monitor

c. Frame ground

Figure 16. Isolation monitor circuit

There are two warnings associated with Isolation Monitoring:

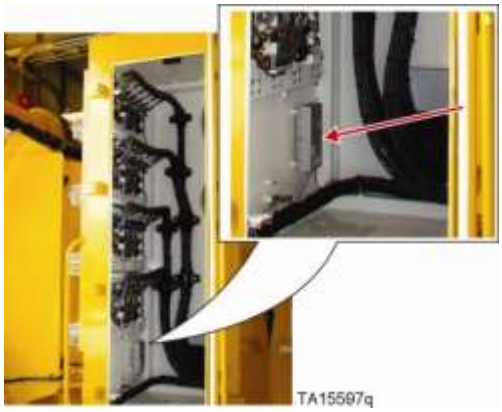
1. “Isolation fault”

- If sensor determines bus isolation below an acceptable value.

2. “Sensor/cable fail open”

- If system determines sensor is not correctly monitoring the HV bus.

The Isolation Monitor Circuit contains a single sensor located at the bottom of the Electrical Converter Cabinet.



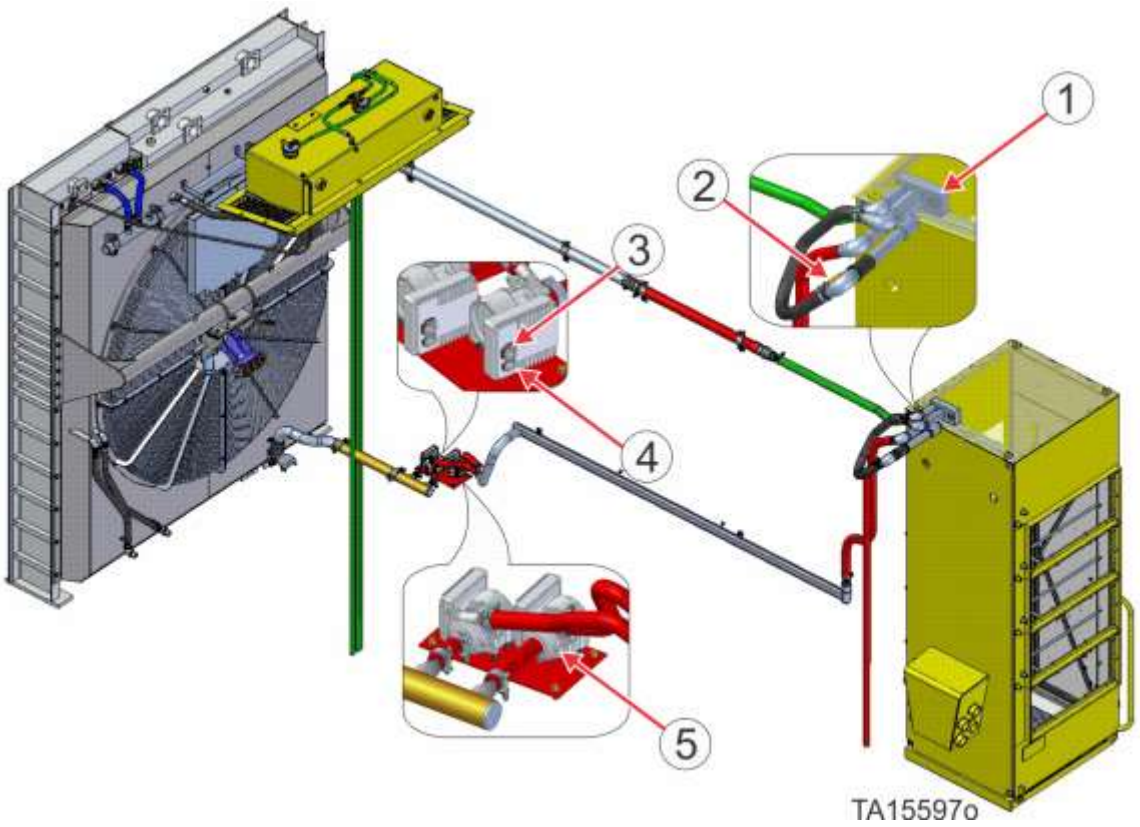
Location inside electrical converter cabinet can vary by machine model

Figure 17. Isolation monitor circuit

The sensor has a single 6-pin connector that interfaces with the LINCS II System which provides source voltage, source ground, output, and output ground.

Figure 18. Isolation monitor

IGBT Cooling System



1) Pressure check valve, **2)** Max pressure check valve, **3)** 24V Connector, **4)** CAN bus connector, **5)** Pumps

Figure 19. IGBT cooling system (typical)

The converter assemblies are cooled by a dedicated closed loop liquid cooling system which consists of a reservoir, circulation pumps, cooler core, and plumbing. The CAN controlled pumps supply liquid flow based on the greatest converter assembly temperature. The pumps will run at full speed if the CAN data link is missing.

24V is supplied to the pumps through a separate connection. This 24V powers the digital part of the pump as well as being used to rotate the impellers.

Pressure is limited by a bypass check valve. A safety check valve (vented to atmosphere) is installed as an extra safety feature.

The system is monitored for low level in the reservoir, and communication to the pump itself.

This Page Intentionally Left Blank