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# CASE STUDY

### SPECIALISTS IN ELECTRONIC & ELECTROMECHANICAL ROOT CAUSE FAULT FINDING AND RESOLUTION

### **Problem - Exploding Bus Bar Capacitors**

- Violent rupture of case of main reservoir DC link capacitors supplying the traction inverters (1000V).
- The released material caused significant collateral damage to the main bus bar and to the associated traction inverter.
- Similar failures had previously been investigated by the OEM, but the customer wanted an independent opinion; to understand the cause and whether any preventative measures could be taken.

### Investigation

Component technology and characteristics identified.

Typical failure modes examined against visual evidence of the failed capacitor. Several hypotheses were proposed and examined.





### Result

- Most likely reason for failure was identified along with possible aggravating factors.
- Recommendations given for further investigation, inspection and monitoring methods.

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### SPECIALISTS IN ELECTRONIC & ELECTROMECHANICAL ROOT CAUSE FAULT FINDING AND RESOLUTION

### **Problem - Motor Monitoring Panel Reliability**

Failure rate of traction motor monitoring panel was increasing, causing service disruption

### Investigation

- Fault was traced to cracking of internal PCB in a voltage monitoring device (VMD) fitted to the monitoring panel main PCB.
- SET conducted vibration testing of the panel to verify hypothesis that resonance of the panel was capable of causing the observed cracking. Tests indicated that the VMD was seeing vibration levels far in excess of those specified for the device when tested at levels specified in EN61673.
- Tests indicated that a previous modification made by the OEM had reduced low frequency flexing of the main PCB but had not addressed the higher frequency resonance and had introduced new resonance modes





### Result

Report with recommendations on design changes (verified during tests) to bring vibration levels at the VMD within its specified range

Actions taken prevented reoccurrence of the symptoms on overhauled units

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### CASE STUDY

### SPECIALISTS IN ELECTRONIC & ELECTROMECHANICAL ROOT CAUSE FAULT FINDING AND RESOLUTION

### Problem - Traction inverters IGBT failures

Routine analysis by SET of its repair database indicated an emerging problem with increasing rates of both new and repeat repair operations on traction inverters.

### Investigation

Further analysis of data implicated the gate drive card.

Extensive investigation of units with intermittent faults revealed micro-cracking of joints around a Zener diode only visible under magnification.

Cracking was caused by thermal cycling of the device (heats each time vehicle accelerates) resulting in cyclic stresses in the solder joints and ultimately fatigue fracturing

- causing intermittent electrical connection.



### Solution

The solution adopted by SET was to add thermal bridges around the device to reduce the depth of the thermal cycles - verified via laboratory tests.



### Result

Traction inverters failure rate reduced by 38% in 2015 compared to 2014, primarily as a result of the gate drive modifications.



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### SPECIALISTS IN ELECTRONIC & ELECTROMECHANICAL ROOT CAUSE FAULT FINDING AND RESOLUTION

### Problem - Interface Panels Overhaul

Failing relays on brake blender and other interface panels resulting in service interruptions

### Challenges for SET

- Rapid turn around required to fit with vehicle access periods.
- Ensuring quality of overhaul on boards that had previously been heavily reworked
- Sourcing of custom parts



### Solution

In order to meet customer's combined requirements of speed and quality SET adopted the following strategy:

- SET engineer stationed at customer's service depot to enable overhaul to be carried out on-site to eliminate transport delays
- Custom test equipment created to ensure fully functional units were returned to customer, including functional areas not affected by the component replacements



#### Result

Process ran smoothly and efficiently

No failures have been reported to SET since the overhaul was completed in August 2016



# CASE STUDY

SPECIALISTS IN ELECTRONIC & ELECTROMECHANICAL ROOT CAUSE FAULT FINDING AND RESOLUTION

### **Problem - Catering Oven Supply Interruptions**

A batch of new catering ovens was unable to be deployed because they needed a modification that was no longer available. This was hampering improvements in service levels.

The problem addressed by the modification was that cooking cycles of microwave catering ovens were being interrupted by power supply drop outs causing the programmer to be reset. This had resulted in catering delays and wasted food.

### Challenges for SET

No documentation available regarding the modification



#### Solution

Sample microwave reverse engineered to produce schematics and to understand the interface and interaction with the programmer

- PCBs and assemblies created
- Comprehensive modification procedure defined to ensure that electrical and microwave safety were not compromised by the modification, as well as ensuring that the desired interrupt rejection was achieved

One unit was modified and the process was verified



### Result

All units have been successfully upgraded to achieve the performance specified by the customer





## CASE STUDY

### SPECIALISTS IN ELECTRONIC & ELECTROMECHANICAL ROOT CAUSE FAULT FINDING AND RESOLUTION

### Problem - Inverter handling Health & Safety issue

A high risk handling activity had been identified at the customer's depot where engineers have to invert traction packs before fitting.



#### **Solution**

SET designed and manufactured a turning rig.

SET specified and had produced a set of customised packing cases that ensured that equipment arrived at the depot the correct way up for their processes.



#### Result

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The risk due to turning the equipment on-site was removed.