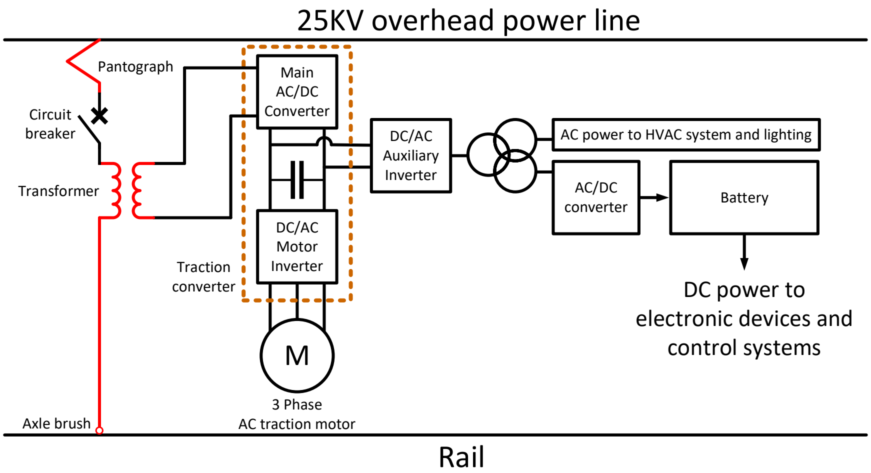
Aimtec Railway Power Supplies

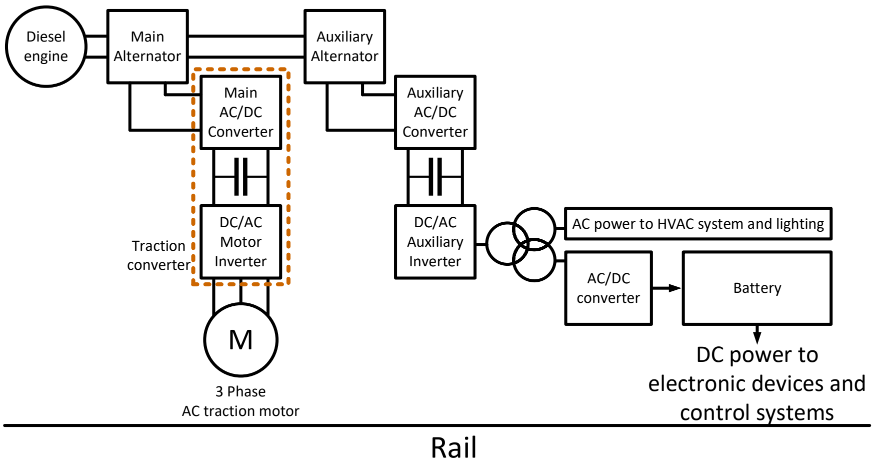
Trains are subject to operate in harsh environments that subject it to high temperatures, high humidity, vibrations and high salinity. Modern trains are equipped with various electronic devices, which need to be powered in a reliable way in order to prevent certain systems from failure.

Below are two diagrams showing the typical power solutions of an electric-powered train and a diesel-powered train.

The electrically powered train is powered from the overhead power line through the pantograph. The transformer steps down the high voltage and feeds the power into the main AC/DC converter. Two DC/AC inverters located after the main converter convert the DC power back to AC and one supplies the traction motor while the other supplies the auxiliary power. AC power provided by the DC/AC auxiliary inverter is converted into three-phase and powers the HVAC and lighting directly. Finally, an AC/DC converter converts the three-phase AC into DC then powers the important electronic devices and control systems. A battery is connected to ensure the continuous operation of the critical control devices.



A diesel-powered train gets its power from the diesel engine and two alternators. Unlike the electric-powered train, the diesel-powered train does not share the main AC/DC converter. Instead, the diesel-powered train has two independent power systems, one for traction and the other for auxiliary power. Besides the aforementioned difference, the rest of the power layout remains identical to the electrically powered train.



Depending on the manufacturers, the train auxiliary power voltage level can be either 24V, 36V, 48V, 72V, 96V or 110V. 110V and 72V are the most common voltage levels as higher voltages lower the current and reduce the wiring space and weight. However, most of the electronic devices require 3.3V, 5V or 12V. This is where the Aimtec railway power supplies can step in and help to convert the higher auxiliary voltage into one that can power the electronic devices.

Railway products are expected to have a long life cycle and low failure rates. To qualify as railway power supplies, the EN50155 (Railway Applications - Electronic equipment used on rolling stock) standard needs to be met. It specifies the minimum requirements for railway electronics based on input voltage, mechanical performance, thermal performance, isolation, and electromagnetic compatibility.

Input voltage range:

The auxiliary power drives multiple plug doors, motors and relay coils. Since there are a number of heavy loads connected to the auxiliary power, the voltage is expected to fluctuate. The below table shows the EN50155 requirement on the input voltage. Railway electronics need to be able to accept wide-input ranges of 0.7 to 1.25 times the nominal voltage, brownout of 0.6 times the nominal voltage and transient of 1.4 times the nominal voltage.

Nominal Input	Continuous input (0.7 – 1.25 Nominal)	Brownout 100ms (0.6 Nominal)	Transient 1s (1.4 Nominal)
24V	16.8 - 30	14.4	33.6
36V	25.2 - 45	16.8	39.2
48V	33.6 - 60	28.8	67.2
72V	50.4 - 90	43.2	100.8
96V	67.2 - 120	57.6	134.4
110V	77 – 137.5	66	154

Electromagnetic Compatibility (EMC):

The auxiliary power battery is usually placed at the front or rear of a train. This results in the power line having to travel long distances before reaching the target devices. In this case, the line acts like an antenna and will pick up noise from the traction motor, main transformer and pantograph. The personal electronic devices carried by the passengers also have a negative impact. To avoid railway electronic devices from been affected by electromagnetic interference, EN50155 refers to the EN50121-3-2 and regulates the minimum EMC requirements.

EMC		
EMI	Conducted Emissions	Frequency / level: 0.15~0.5MHz / 99 dBuV Frequency / level: 0.5~30MHz / 93 dBuV
	Radiated Emissions	Frequency / level: 30~230MHz / 40 dB(uV/m) Frequency / level: 230~1000MHz / 47 dB(uV/m)
EMS	ESD Immunity	Air Discharge: ±8KVDC Contact Discharge: ±6KVDC
	Radio- Frequency, Electromagnetic Field Immunity	Frequency / Field: 80~1000MHz/20V/m Frequency / Field: 1400~2100MHz/10V/m Frequency / Field: 2100~2500MHz/5V/m
	Electrical Fast Transient/ Burst Immunity	±2KVDC
	Surge Immunity	Line to ground: ±2KVDC Line to line: ±1KVDC
	Radio- Frequency, Conducted Disturbances Immunity	Frequency / Field: 0.15 to 80MHz/10Vrms

Mechanical Requirements:

As trains are subject to extreme vibration, EN50155 also specifies the minimum mechanical requirements that railway electronics must meet. There are 4 different levels of mechanical requirements based on where the devices are installed. Category 1 class A is for components installed directly onto the car body. Category 1 class B is for components installed on the underframe which is attached to the car body. Category 2 is for bogie mounted components and category 3 is for axle mounted components. Generally, category 1 class B requirement applies unless otherwise specified.

1B Body Mounted Class B	
Functional Random Vibration Test	Frequency Range: 5Hz~150Hz for mass ≤ 500kg RMS Value: X-Axis 0.071G (0.7m/s²) Y-Axis 0.046G (0.45m/s²) Z-Axis 0.103G (1.01m/s²) Time: 10min each axis
Increased Random Vibration Test	Frequency Range: 5Hz~150Hz for mass ≤ 500kg RMS Value: X-Axis 0.404G (3.96m/s²) Y-Axis 0.260G (2.55m/s²) Z-Axis 0.583G (5.72m/s²) Time: 5 hours each axis
Shock Test	Wave Form: Half Sine Wave RMS Value: X-Axis 5.098G (50m/s²) Y-Axis 3.059G (30m/s²) Z-Axis 3.059G (30m/s²) Time: 30mS each axis Shock/Bump Times: 3 times for each direction, total 6 directions

Thermal (temperature, humidity) Requirements:

Based on the location and type of components, there are six temperature classes. OT stands for "Operating temperature class". OT5 and OT6 apply to semiconductor, while OT1 and OT2 apply to components installed in the passenger cabin. OT3 and OT4 are for components installed in technical cabinets. Generally, OT3 requirement applies unless otherwise specified.

Class	Required Temperature Range
OT1	-25°C - +55°C
OT2	-40°C - +55°C
OT3	-25°C - +70°C
OT4	-40°C - +70°C
OT5	-25°C - +85°C
OT6	-40°C - +85°C

Isolation Requirements:

EN50155 specifies the minimum isolation and insulation requirements. The minimum insulation value is 20MΩ under the 500VDC test. The isolation requirements are shown in the table below. The test voltage should be maintained for 1 minute for a typical test and 10s for a routine test.

Battery voltage	Required Isolation
< 72VDC	500VAC or 750VDC
72 – 125VDC	1000VAC or 1500VDC
125 – 315VDC	1500VAC or 2200VDC

Application Examples:

1] Plug door: Pneumatic plug doors have always been the most popular type of door in the public transit industry. However, they are slowly being replaced with electrical drive plug doors. These doors feature accurate obstacle detection, easy installation and require less maintenance as checking for leaks in the pipes is not required.

The below example shows a simplified block diagram of an electrical drive plug door system where the voltage is 110VDC. The power goes through an EMC filter first to filter out unwanted noise. Two AM10EW-11005SH22-NZ the convert the 110VDC to 5V to power the controller and the motor. Having 2 separate converters for the controller and the motor helps isolate the interference coming from the motor.

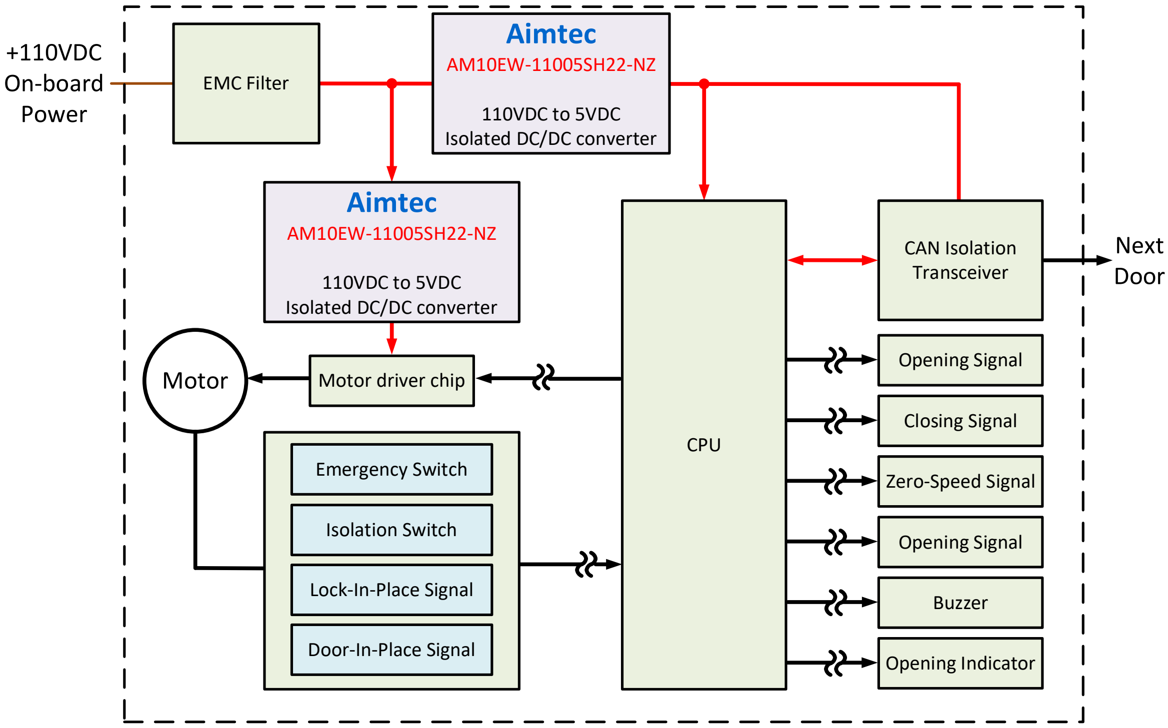


Figure 1. Plug door

2] Screen doors: Screen doors have been widely installed in major stations around the world. It prevents the passengers from falling onto the tracks and helps the HVAC system run more efficiently.

The below system uses a pneumatic solution to control the door opening and closing. The system voltage is 110VDC and features an UPS power supply in case of an emergency. The input power goes through the first filter which feeds directly into the motor. The second filter filters out the noise coming from the motor and sends 110 VDC to the motor driver. The AM20EW-11015SH22-NZ converts the 110VDC to 15VDC and serves as the main power supply of the control circuit. The AMSR1-7805-NZ, a high-efficiency switching regulator, steps down the 15VDC to 5VDC and powers the MCU. The isolated CAN transceivers are powered by the AM10CW-2405-NZ to ensure the signal quality. Finally, an AM1LS-1515SH30-NZ converter serves as additional protection and powers the hall circuit which can be used to detect obstacles at the gate.

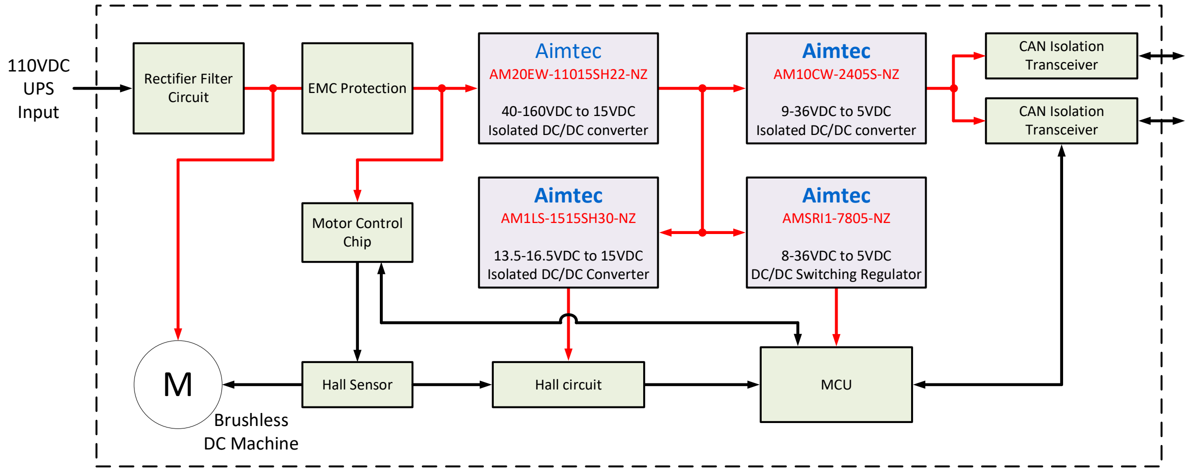


Figure 2. Screen door

3] Train information displays: The information displays tell the passengers their current location and the upcoming station. The display receives the data from the train information system and displays it accordingly. As the signal line has to go through several cabins, it tends to pick up a lot of noise. The display unit must be designed so that it is immune to the noise and interference generated in the railway environment.

To ensure the information is displayed correctly, the below example uses an AMFW110-0.9NZ EMC filter to filter out the noise picked up by the power line. The AM75QB-11024SA30JZ-K serves as the main power supply for the entire display unit. It converts the 110VDC to 24VDC and powers the LED matrix directly. An AMSRI1-7805-NZ switching regulator converts the 24VDC to 5VDC and powers the MCU, display driver, and 485 communication module. Finally, an AM1DR-0505S-NZ isolated converter is used to provide the power to the 485 signal line. The isolated communication module helps further reduce the chances of the display unit being interfered with.

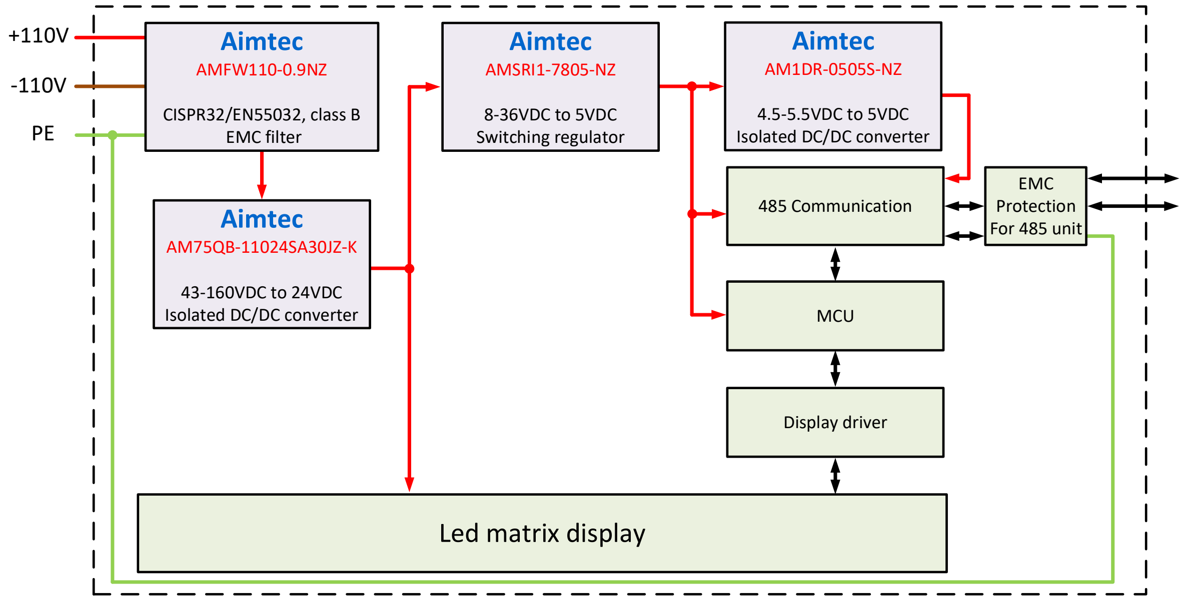


Figure 3. Train information display

4] Bogie monitoring system: The bogie monitoring systems monitors the bogie status including the steering angle, vibration and temperature. The system can identify if there are any abnormal or possible failures on the bogie based on the data pattern and sends out warnings or maintenance notices. As the traction motor is located within the bogie, the sensors are subject to extreme electromagnetic interference.

Similar to the display unit, the monitoring system also uses an AMFW110-0.9NZ to ensure its electromagnetic immunity. An AM50QB-11015SA30JZ following the EMC filter converts the 110VDC system voltage down to 15VDC and powers the bogie sensors. To add an extra layer of reliability, a second isolated converter, the AM15C-1205S-NZ, is used to power the MCU, HMI, and communication module.

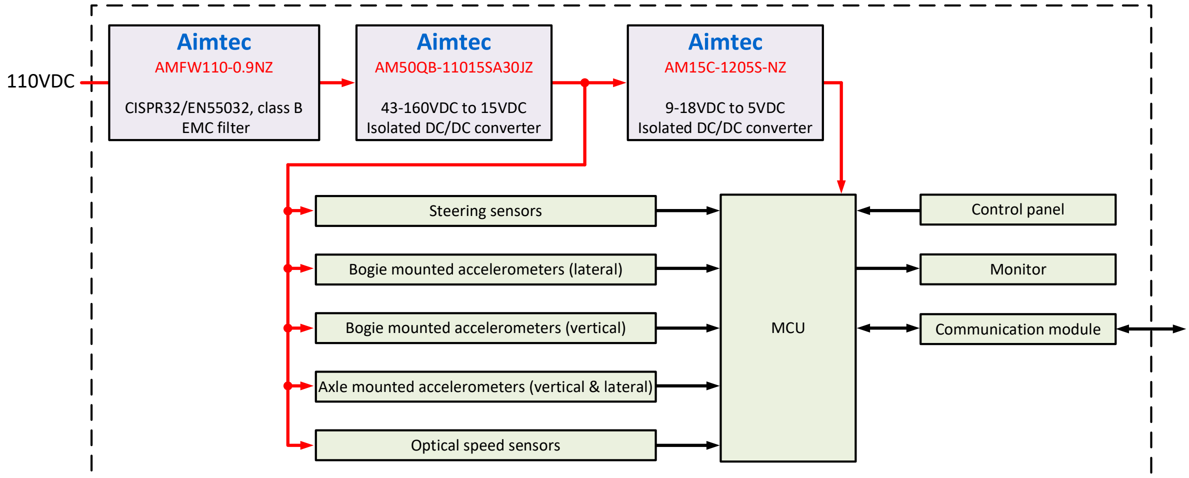


Figure 4. Bogie monitoring system

5] Train VIP seats: VIP seats are seats found in the high-end cabins. Each seat requires an independent control system to control its position.

The below seat control diagram uses a similar power solution as the bogie monitoring system. An AMFW110-0.9NZ is placed at the input of the system to provide the necessary EMC protection. An AM100QB-11024SA30JZ is used as the main converter to convert the 110VDC input voltage to 24VDC and powers the seat motors directly. Unlike the bogie monitoring system, the seat motor control wires do not span long distances and are not exposed to the traction motor electromagnetic interference. Hence, the power of the control circuit is provided by the AMSRI1-7805VDC switching regulator which converts the 24VDC to 5VDC.

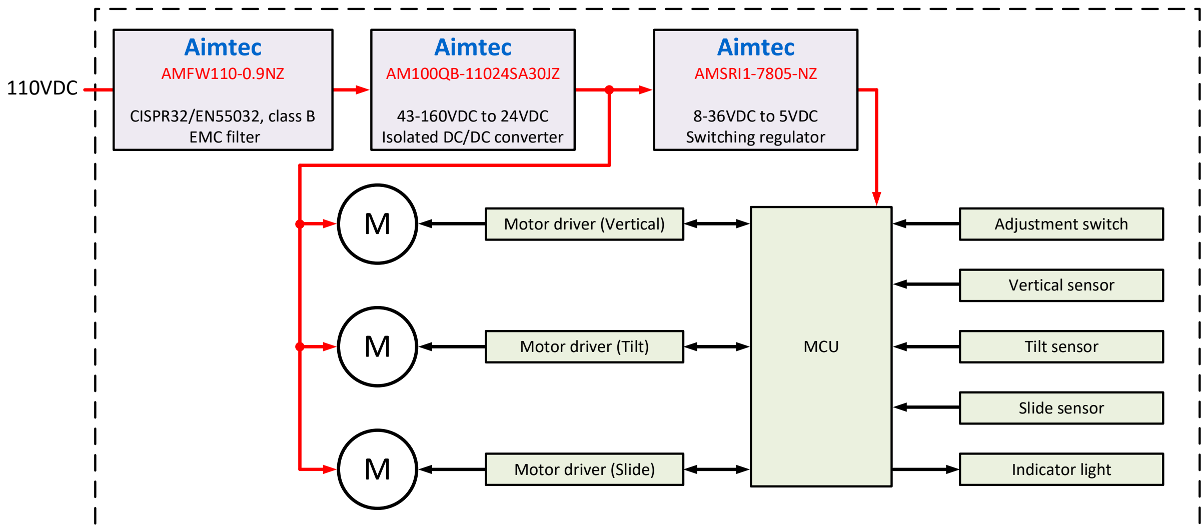


Figure 5. Train VIP seat

6] Train operation monitor system: The train operating system is the heart of the train. The below example shows a simplified block diagram of the system.

The system implements an EMC protection device with an input overvoltage protection feature at the input. As the monitoring system needs to communicate with multiple devices on the train or the trackside, multiple isolated converters are used to avoid cross-interference between each I/O module.

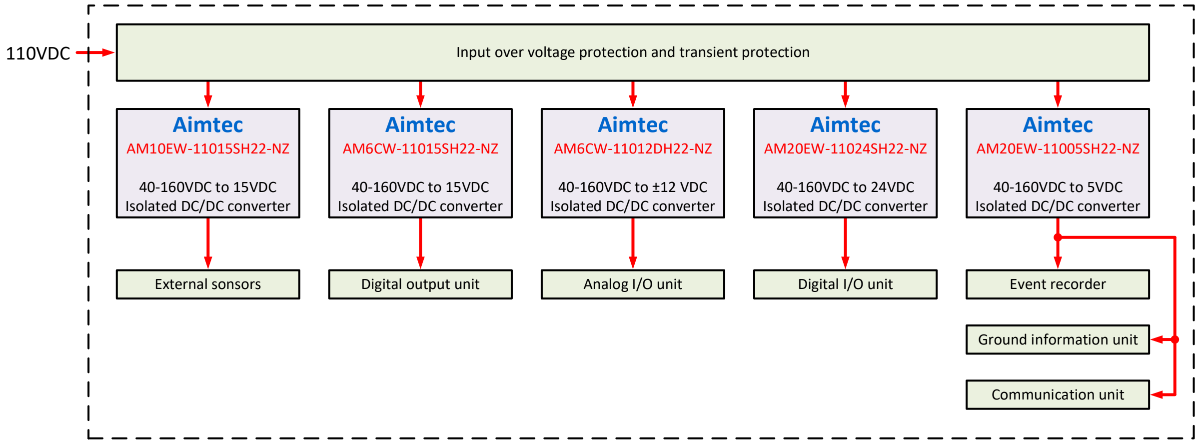


Figure 6. Train operation monitor system

Aimtec railway converter offerings

Aimtec Series	Power (W)	Input (VDC)	Single Output (VDC)	Dual Output (VDC)	Operating Temperature (°C)	Isolation I/O (VDC)
AM6CW-110xxSH22-NZ	6	40-160	5, 12, 15, 24	-	-40 to +85	2.25k
AM6TW-NZ	6	9-36/18-72	3.3, 5, 12, 15, 24	±5, ±9, ±12, ±15, ±24	-40 to +85	1.5k
AM8TW-xH30Z	8	13-70/42-176	3.3, 5, 12, 15	±5, ±12, ±15	-40 to +85	3k
AM10EW-110xxSH22-NZ	10	40-160	3.3, 5, 12, 15, 24	-	-40 to +85	2.25k
AM10TW-NZ	10	9-36/18-72	3.3, 5, 12, 15, 24	±5, ±12, ±15	-40 to +85	1.5k
AM15EW-110xxSH22-NZ	15	40-160	3.3, 5, 12, 15, 24	-	-40 to +85	2.25k
AM20EW-110xxxH22-NZ	20	40-160	5, 12, 15, 24	-	-40 to +85	2.25k(single), 3k(dual)
AM20CWR-ZK	20	13-70/42-176	3.3, 5,12,15	±5, ±12, ±15	-40 to +100	3k
AM25EUW-ZK	25	16-160	5, 12, 15, 24	-	-40 to +100	3k
AM40EW-NZ	40	40-160	3.3, 5, 12, 15, 24, 48	-	-40 to +85	3k
AM50QB-NZ	50	66-160	5, 12, 15, 24	-	-40 to +100	3k
AM50QB-JZ	50	43-160	3.3, 5, 12, 15, 24, 48	-	-40 to +105	3kVAC
AM75QB-110xxS-NZ	75	66-160	5, 12, 15, 24	-	-40 to +100	3k
AM75QB-JZ	75	43-160	3.3, 5, 12, 15, 24, 48	-	-40 to +105	3kVAC
AM100QB-NZ	100	66-160	12, 15, 24	-	-40 to +85	3k
AM100QB-JZ	100	43-160	3.3, 5, 12, 15, 24, 48	-	-40 to +105	3kVAC
AM150QB-NZ	150	18-75	5, 12, 15, 24, 48	-	-40 to +85	2.25k
AM150HB-NZ	150	66-160	12, 15, 24	-	-40 to +100	3k
AM150HB-JZ	150	43-160	5, 12, 15, 24, 48	-	-40 to +105	3kVAC
AM200QB-NZ	200	18-75	5, 12, 15, 24, 48	-	-40 to +85	2.25k
AM200HB-JZ	200	43-160	5, 12, 15, 24, 48, 54	-	-40 to +105	3kVAC
AM250ST-NZ	250	43-160	5, 12, 15, 24, 48, 54	-	-40 to +100	3kVAC

About Aimtec:

Founded in 2002, Aimtec is a global designer and manufacturer of modular AC/DC and DC/DC switching power supplies. The company's standard products include DC/DC converters up to 200 W, AC/DC converters and LED drivers reaching 250 W.

Aimtec converters assist customers worldwide in reducing engineering design time and expenses while facilitating miniaturization and performance enhancements of their end products.

For more information, please visit Aimtec at www.Aimtec.com