APPLICATION NOTE

Meeting EN 50155 Standard with IMX DC-DC Converters

Introduction

All electronic equipment integrated into trains/rolling stock must comply with the international standard EN50155, this standard covers specification requirements ranging from operating temperature, vibration, shock, humidity, I/P voltage ranges and EMC, that electronic equipment must meet.

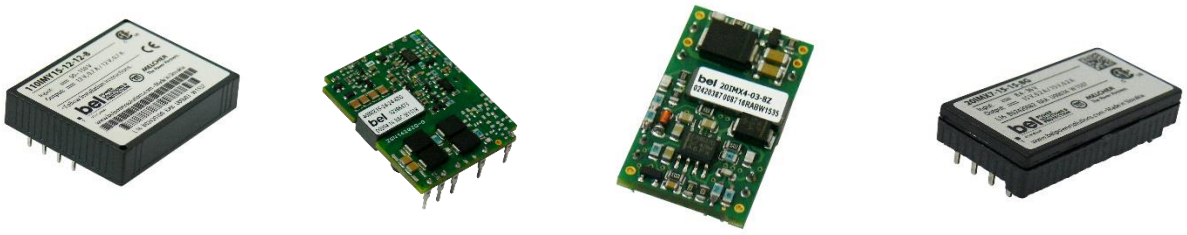
NOTE – there are other railway standards applicable to geographic regions with different parameters, this application note will only discuss EN50155.

As trains become more technically advanced and passenger friendly with additional infotainment systems and safety critical operational equipment, it is clear that a clean isolated, uninterrupted power source is required. These type of electrical systems and functions such as monitoring sensors around the train, air conditioning, lighting, door opening, communication and entertainment systems will inherently include CPUs, DSPs, analogue circuitry and highly sensitive sensors which all have to be powered from the on board battery system within the train.

The battery is typically located within the drive train locomotive at the front or rear and therefore the voltage has to travel long distances by cable to the application, so is highly prone to RF disturbances, voltage drops and transients. The batteries are also charged from the generator typically 15% above V*nom*, and also used to drive starter motors, relays, switch gear and other high power loads, the result of which is an almost unusable, highly fluctuating, noisy voltage source available to power other auxiliary equipment.

This is where the established and proven reliability of Bel Power Solutions' IMX range of DC-DC converters developed by Melcher/Bel Power Solutions have been the industry standard choice for isolated DC-DC voltage converters for over two decades.
Please see more detail of specifications within individual data sheets at belpowersolutions.com

Within the scope of EN50155 it calls out a substandard EN50121 which covers the EMC aspects that equipment should comply to, including Conducted & Radiated Emissions, Fast Transient Bursts, Surge, and Conducted RF.



IMX range of DC-DC converters

I/P VOLTAGE RANGE REQUIREMENTS OF EN50155

Power from the locomotives onboard battery system is available for use to power electrical systems on board, the battery voltages are commonly 24 V, 48 V, 72V, 96 V, 110 V.
Due to the high demand on these batteries there are inevitably dips and surges with a wide variation that electrical equipment must work from, the variations associated with these battery voltages are specified in EN50155 as
0.7 - 1.25 of V*nom*, and a transient spec of 0.6 – 1.4 for 100 ms that electrical equipment must reliably be powered from. This is where the IMX range of converters lend themselves neatly within this demanding environment.

Battery Voltage	24 V	48 V	72 V	110 V
I/P V Range Continuous	16.8 – 33.0 V	33.6 – 60.0 V	50.4 – 90.0 V	77.0 – 137.5 V
I/P V Range – 100 msec	14.4 - 33.6 V	28.8 – 67.2 V	43.2 – 100.8 V	66.0 – 154.0 V

IMX DC/DC Model	20IMX	40IMX	70IMX	110IMX
I/P V Range	8.4 – 36.0 V	16.8 – 75.0 V	40.0 – 121.0 V	60.0 – 150.0 V

Note – Each converter has a repetitive surge voltage rating eg 110IMX can withstand surges of 168v for 3 sec. Also the converters can typically operate down to 80% of Vin Min with reduced o/p power (see individual data sheets).

Table 1 - I/P Voltage Ranges as per EN50155

Table 1 above shows the required operating voltage ranges according to EN50155, and the input voltage range of Bel Power Solutions IMX DC-DC Converters.

IMX RANGE OF DC-DC CONVERTERS

The IMX range of DC-DC Converters from Bel Power Solutions are designed for harsh transportation applications, in particular rolling stock.
With power ranges of 4 W, 7 W, 15 W, 35 W and 70 W package variants.
The isolated output voltages of the converter can be seriesed or paralleled giving a multitude of options. The converters have wide operating input voltages and extreme operating temperatures of -40°C to +85°C.
They are also designed for use in an operating ambient temperature range of -40°C - +70°C with no additional cooling or heatsinking.

Flexible features include:

- Up to four isolated o/p voltages offering flexible voltages of 5 V to 60 V DC O/P.
- Trimmable outputs.
- Shutdown/Inhibit.
- Frequency Synchronization.
- Programmable input undervoltage lockout.
- Thermal Protection.
- +5 V Ref O/P.
- Open Frame or cased versions available. Conformally coated.

The converters are tested and approved to harsh environmental conditions as defined by EN50155, EN60068 & Mil Std 810 and have high MTBF figures to Mil HDBK-217f under benign, fixed and mobile conditions.

EN50121 EMC REQUIREMENTS

RADIATED EMISSIONS – Using EN55011 as the standard for measuring references the applicable limits are :
30 MHz – 230 MHz = 40 dBµV/m , 230 MHz – 1 GHz = 47 dBµV/m
CONDUCTED EMISSIONS – Using EN55011 as the standard for measuring references the applicable limits are :
150 kHz – 500 kHz = 99 dBµV , 500 kHz – 30 MHz = 93 dBµV
FAST TRANSIENT BURST – defined by standard EN61000-4-4, as ± 2 kV line to line.
SURGE – defined by standard EN61000-4-5, as +/- 2 kV line to ground, ±1kV line to line.
CONDUCTED RF – defined by standard EN61000-4-6, as 150 kHz – 80 MHz, 10 V (rms).
ESD
RF

EMI FILTER

In order to comply with the above requirements for EN50121 an Input EMI filter should be considered and also there are some advisory notes that should be taken into account.

The schematic shown in *Figure 1* is designed to meet the conducted emission specification and also provide immunity protection to the above requirements.

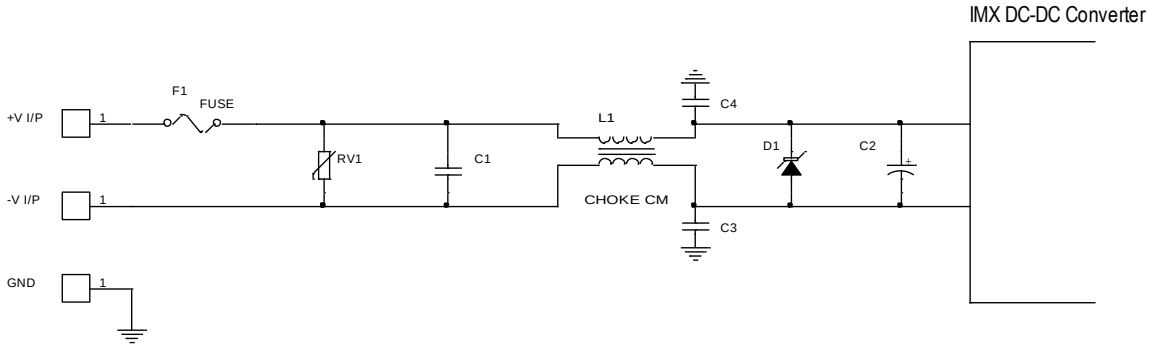


Figure 1

CIRCUIT DESCRIPTION

An input fuse is recommended to prevent excess current flow under fault conditions (see web data sheet for preferred values).
The common mode choke L1 consists of two identical windings on a single high permeability core, configured so that differential (+V to –V) cancel each other, the full inductance of each winding is available to attenuate common mode currents with respect to earth, but only the leakage inductance will attenuate differential mode interference.
If differential mode noise is present, then the addition of a differential choke in each line after the common mode choke is required.
Capacitors C3 & C4 (Y caps) attenuate common mode interference, the effectiveness of these capacitors depends very much on the common mode source impedance of the application. This is normally a function of stray capacitance coupling to earth, which depends on layout of the input filter on the PCB.
It is recommended to include a ground plane (earth) within the PCB around the area of the filter to provide a low impedance path to earth. The I/P filter should be situated as close as possible to the I/P of the converter for maximum benefit. There is also the possibility of earthing the case IMX35/IMX70 to reduce radiated emissions also.
C1 provides attenuation of differential mode noise, whilst C2 provides i/p source impedance stability for the DC-DC converter, whilst fig 2 shows only the input side of the filter it is also good practice to provide some o/p capacitance on the DC-DC converter (C6 typical value 10 µf – 100 µf, C5 = 100 n ceramic), this serves several purposes, to attenuate ripple and noise on the o/p, to provide energy storage for transient loading and can attenuate transients and surge on the o/p side that can flow through the converter. See fig 3.
Transients are generated when current through inductance is interrupted, typical examples of these are switched inductive loads, motors, relay coils, transformers and even long cables. There is also the possibility of voltage surges on the line due to generator function or lightning. So from an immunity point of view a metal oxide varistor (MOV) and a tranzorb are advised to be placed within the filter as shown, when an incoming transient exceeds the breakdown voltage value of these devices they turn from a high impedance to low impedance and absorb the excess energy, this energy is transferred as heat in the device and therefore consideration must be adhered to the power rating of the devices.

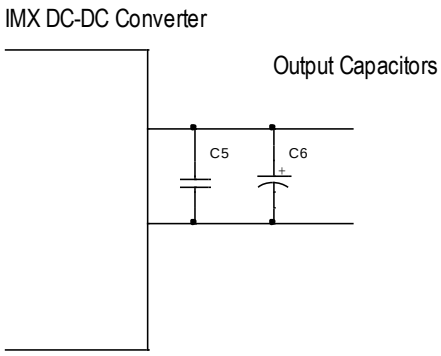


Figure 2 - Capacitance on the output of converter

TABLE OF COMPONENT VALUES

Notes on Component values:

RV1 = Metal Oxide Varistor type Epcos B72210S range of 12 mm disc.
C1 = 470 nf 250 VDC polyester cap.
L1 = Common mode choke/inductor.
C3/4 = Ceramic Y caps 2n2.
D1 = 1500 W Unidirectional Tranzorb, ST Micro electronics or equiv.
C2 = Electrolytic capacitors 125°C rated.

IMX4 & 7

	RV1	C1	L1	C3/4	D1	C2
20IMX4/7	38vDC	470nf poly	3.3mH 1.5A	2n2 Ceramic Y cap	1.5KE39A	68uf 100v
40IMX4/7	85vDC	470nf poly	3.3mH 1.5A	2n2 Ceramic Y cap	1.5KE82A	68uf 100v
70IMX4/7	125vDC	470nf poly	3.3mH 1.5A	2n2 Ceramic Y cap	1.5KE150A	100uf 200v
110IMX7	150vDC	470nf poly	3.3mH 1.5A	2n2 Ceramic Y cap	1.5KE180A	100uf 200v

IMX15

	RV1	C1	L1	C3/4	D1	C2
20IMX15	38vDC	470nf poly	1.2mH 3A	2n2 Ceramic Y cap	1.5KE39A	330uf 63v
40IMX15	85vDC	470nf poly	1.2mH 3A	2n2 Ceramic Y cap	1.5KE82A	2x 100uf 100v
110IMX15	150vDC	470nf poly	1.2mH 3A	2n2 Ceramic Y cap	1.5KE180A	2x 100uf 200v

IMX35

	RV1	C1	L1	C3/4	D1	C2
20IMX15	38vDC	470nf poly	700uH 4A	2n2 Ceramic Y cap	1.5KE39A	330uf 63v
40IMX15	85vDC	470nf poly	700uH 4A	2n2 Ceramic Y cap	1.5KE82A	2x 100uf 100v
70IMX15	125vDC	470nf poly	700uH 4A	2n2 Ceramic Y cap	1.5KE150A	2x 100uf 200v
110IMX15	150vDC	470nf poly	700uH 4A	2n2 Ceramic Y cap	1.5KE180A	2x 100uf 200v

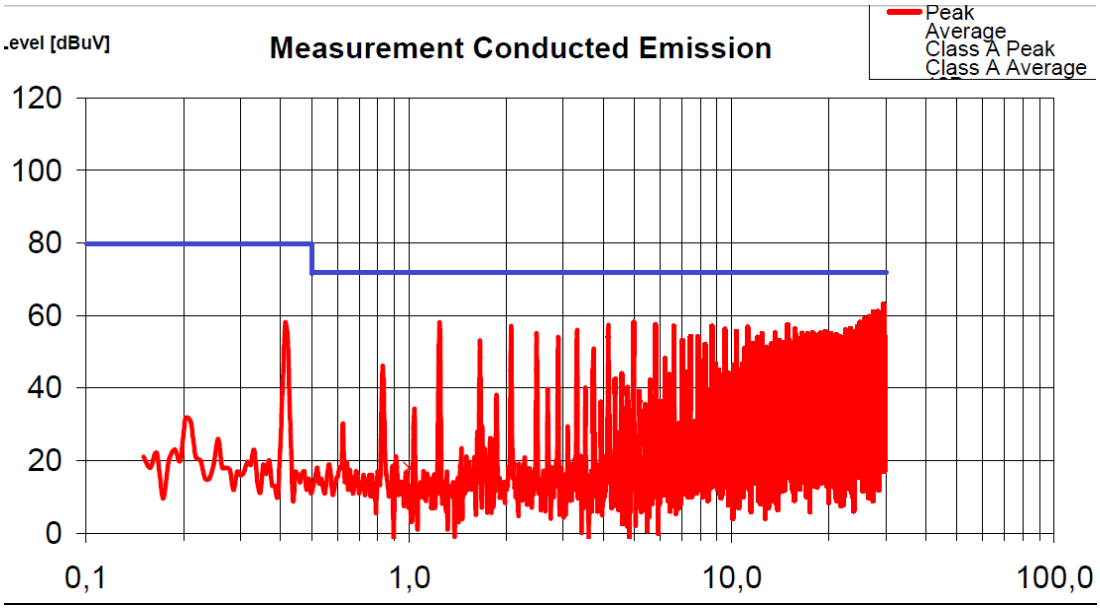


Figure 3 - Example of IMX35 conducted Emissions with EN55011 class A limit QP (case not earthed)

