SynQor
Advancing The Power Curve

InQor Railway

Application Note 10/27/08 Rev. 2

Summary

SynQor has developed the InQor product line for the industrial and transportation industries. These ruggedized converters are specifically designed for the harsh environments associated with such applications. This application note will address the European standards **EN50155** and **RIA12** and how to meet these standards using the InQor dc-dc converters.

Introduction

EN50155 (IEC571) as well as **RIA12** specify the design requirements of electrical equipment for railway rolling stock equipment applications. Included in these specifications:

- Input Voltage Range
- Surge Protection
- Power Interruption and Backup
- Operational Temperature
- Shock and Vibration

Operating Input Voltage Range

(Input power for rolling stock equipment may be in several voltage ranges with additional transient levels)

EN50155 (IEC571) requirements

"Electronic equipment supplied by accumulator batteries without a stabilizing device shall operate satisfactorily for all of the values of the supply voltage within the range defined below (measured at the input terminals of the equipment)"

- Static Input Range Definitions
  - Minimum Voltage = 0.7 V_{in}
  - Nominal Voltage = V_{in}
  - Rated Voltage = 1.15 V_{in}
  - Maximum Voltage = 1.25 V_{in}

  Voltage fluctuations between 0.6 V_{in} and 1.4 V_{in} not exceeding 0.1 second shall not cause deviation of function.

  Voltage fluctuations between 1.25 V_{in} and 1.4 V_{in} not exceeding 1 second shall not cause damage; equipment may not be fully functional during these fluctuations.

Nominal	Input Range	Transients		InQor		
Input (V_{in})	0.7 V_{in} - 1.25 V_{in}	Low (0.1 s) 0.6 V_{in}	High (1 s) 1.4 V_{in}	Input Ranges		
12 V	8.4-15 V	7.2 V	16.8 V	9-22 V		9-75 V
12/24 V	12.6-22.5 V	10.8 V	25.2 V		9-36 V	
24 V	16.8-30 V	14.4 V	33.6 V	18-36 V*		
36 V	25.2-45 V	21.6 V	50.4 V		18-75 V	18-135 V
48 V	33.6-60 V	28.8 V	67.2 V	18-75 V**	34-135 V	
72 V	50.4-90 V	43.2 V	100.8 V	42-110 V		
110 V	77-138 V	66 V	154 V	66-160 V	42-160 V	34-160 V

Table 1: Input Specifications for EN50155

*Contact SynQor Applications Engineering
**InQor (IQ36) will meet the requirements of 48 V nominal input

The InQor standard product exceeds all of the voltage and transient requirements stated in **EN50155**, except for the low transient and 0.7 V_{in} requirement on 24 V nominal input voltage.

Surge Protection

RIA12 specifies that equipment must withstand a surge voltage of 3.5 times the nominal input voltage for 20 ms.

V_{in} Nominal	3.5 V_{in}
24 V	84 V
36 V	126 V
48 V	168 V
72 V	252 V
110 V	385 V

Table 2: Surge Voltages

If a Transient Voltage Suppressor (TVS) is used as transient suppressor, the approximate energy in the TVS is given by the following equation:

$$E = \left(\frac{3.5\,V_{in} - V_{tvs}}{R_S} \right) \times V_{tvs} \times t$$

$$E = \left(\frac{385\ V - 160\ V}{0.2} \right) \times 160\ V \times .02 = \textbf{3600 joules}$$

A typical SMB package 160 V TVS can only dissipate on the order of 10 joules, making a TVS imprac-

tical. A surge isolation circuit is required and component values will be determined by the amplitude, duration and converter input power level.

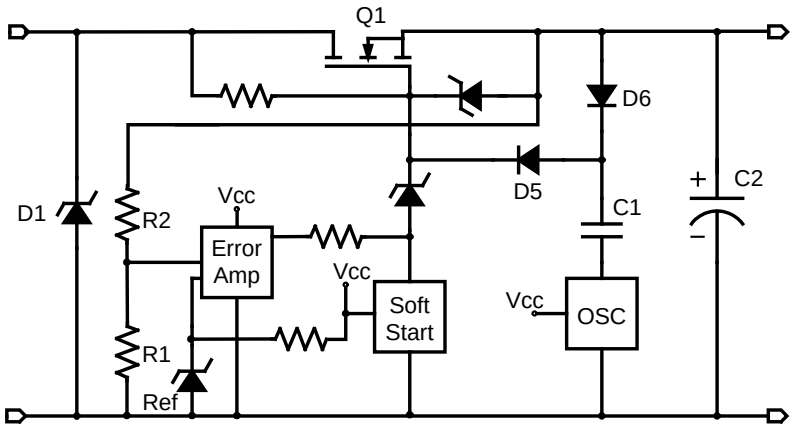

Figure 1: Surge isolation block diagram

Circuit Description

The diagram above is designed to protect the converter from large transients. Each input voltage and transient specification will require different values of critical components. A control power source (Vcc) is required to power this active circuit.

D1	TVS will equal maximum transient voltage
Q1	MOSFET switch blocking high voltage during transients, protecting the converter. It must have a safe operating area capability compatible with the converter input power level, transient magnitude and duration.
R1/R2	A voltage divider circuit to sense the voltage at the input of the converter
Ref	Control voltage reference supplied from Vcc
Error Amp	Circuit to control the voltage at the input of the converter as set by R1/R2 and compared to a reference voltage
Soft Start	Turns Q1 on gradually at startup to lower surge current
Osc	Provides gate drive to Q1 with C1, D5, D6 acting as a charge pump
C2	Decoupling and damping for input to the converter

Circuit Operation

Essentially, this circuit is a linear regulator that is set for a voltage above any normal operating level, but lower than the maximum input voltage rating of the converter. During normal operation, the series FET is saturated and dissipates very little power. When a transient occurs, the FET blocks the excess voltage and dissipates the transient energy while providing continuous power to the converter at a controlled voltage.

The circuit can also function as a surge limiter on start-up, by holding the gate of Q1 low during the initial power-up time and then gradually allowing the circuit to drive it normally.

Fast Transient Specification

Equipment must also be able to withstand a direct transient of 1800V lasting 50us. The impedance of the transient source is specified as 100Ω, with transient energy of approximately 0.1J.

To protect the converter from such a transient, the energy must be diverted from the converter's input and the peak voltage held at or below the transient input voltage specification on the converter's datasheet. A TVS device is a good choice for this purpose. It should be connected across the converter's input terminals to take best advantage of filtering impedances between the transient source and the converter. Any additional filtering inductance will help reduce the current in the TVS and limit its clamping voltage. See diagram:

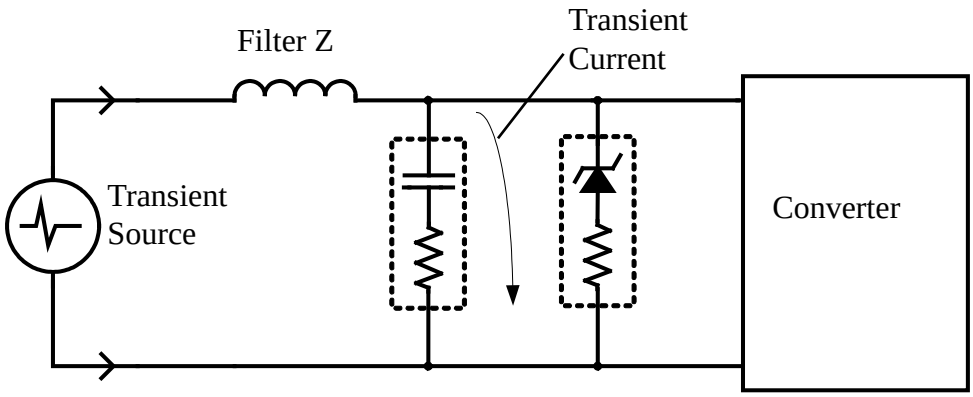

Figure 2. Fast transient block diagram

Power Interruption and Backup Interruption

EN50155 (IEC571) requirements

Interruptions of up to 10 ms may occur on input voltage
Class S2: 10 ms interruptions shall not cause any equipment failure.

Supply Change Over

From EN50155

Equipment supplied with power alternatively from an accumulator battery and a stabilized source shall operate satisfactorily as follows:

- Class C1: at 0.6 V_{in} during 100 ms (without interruptions)
- Class C2: during a supply break of 30 ms

Class C1 is met within the operating input voltage range of the InQor series with the exception of the IQ24 series as described above in the Operating Input Voltage Range section.

To meet the requirements of Class C2, the capacitance at the output of the transient circuit would have to be increased so the converter has at least minimum voltage at the end of the line break transient to maintain its output. For higher power levels, this may be prohibitive. Contact SynQor applications engineering.

Operational Temperature

EN50155 (IEC571) requirements

Electronic equipment shall be designed and manufactured to meet the full performance specification requirement for the selected temperature categories as stated in table 3.

Operating Temperature Classes	External Ambient Temperature	Internal Cubicle Temperature	Internal Cubicle Over-temperature	Air Temperature Around PCB
T1	-25 to +40°C	-25 to +55°C	+15°C	-25 to +70°C
T2	-40 to +35°C	-40 to +55°C	+15°C	-40 to +70°C
T3	-25 to +45°C	-25 to +70°C	+15°C	-25 to +85°C
TX	-40 to +50°C	-40 to +70°C	+15°C	-40 to +85°C

Table 3: Ambient Temperature

The specified operating temperature of the InQor products is -40 to +100ºC case temperature. In addition, these products can be directly mounted to a chassis for improved cooling.

Shock and Vibration

Per **EN501545** the equipment shall be able to withstand, without deterioration or malfunction, vibrations and shocks that occur in service.

- Frequency Range: 5 to 150 Hz
- Cross-over Frequency: 8.2 Hz
- Displacement Amplitude: 7.5 mm
- Acceleration Amplitude: 20 m/s^2
- Semi-sinusoidal Shock: 50 m/s^2 for 50 ms

The InQor products are filled with a permanently-elastic, thermally-conductive encapsulant that enables the device to survive rigorous shock and vibration conditions by mechanically bonding all components to the case through the encapsulant.