Intended Audience

This application note concerns application engineers and system engineers with technical background and contains useful information to help integrating THN 15UIR and THN 20UIR converters into the final application.

Introduction

The following features are described in this application note.

Enhanced Hold-Up function (see chapter «Enhanced Hold-Up function»)
The mentioned series contain an additional power hold-up function. The BUS pin is an additional feature providing a fixed voltage for charging capacitors. In general, to meet the conditions described in EN 50155, a sufficient number of aluminum electrolytic capacitors is needed to provide enough energy to extend Hold-up time. Different from the common way of hold-up functions, wether in a 24 V system or a 110 V system, the BUS pin always provides 21.4 V, which can be used with 25 V rated capacitors instead of high-priced 200 V rated capacitors

Inrush Current Limitation (see chapter «Inrush Current Limitation»)
The use of a Hold-Up capacitor helps reducing high inrush currents. No extra components will be needed. Inrush current limitation works self-sufficient as soon as Enhanced Hold-Up function is in use.

Background

When it comes to electronic equipment for rolling stock, EN 50155 is the most widely followed standard and is the gateway for power products to enter railway applications. It describes the conditions of input voltage, ambient temperature, isolation, interruption...etc. Compared with the general industrial application, the conditions are stricter in order to ensure the safety of public transportation and passengers. With the development of various industrial technologies and the requirements of miniaturization, it is a challenge for power modules and other electronic devices to meet high reliability and also meet requirements of regulations in harsh environment.

The following input voltage criteria are defined in the EN 50155 standard:

Voltage Range	Duration	Criteria
0.7 to 1.25 V_{nom}	continuous	A
1.25 to 1.4 V_{nom}	≤ 1000 ms	B
0.6 to 1.4 V_{nom}	≤ 100 ms	A

Table 1: input voltage criteria

The following interruption and change-over criteria are defined in the EN 50155 standard:

Due to a short circuit in the DC transmission line, the input voltage will drop to zero in a short time.		
Interruption	**Duration**	**Criteria**
S1		No performance criterion is requested but the equipment shall continue to operate as specified after the voltage interruption
S2	≤ 10 ms	A
S3	≤ 20 ms	A

Table 2: interruption criteria

The supply break is an open circuit and not a short circuit (“high impedance” condition). Due to switching from one source to another input voltage will drop.		
Change over	**Duration**	**Criteria**
C1	≤ 100 ms (0.6 x Unom)	A
C2	≤ 30 ms	B

Table 3: change-over criteria

Enhanced Hold-Up function

Recommended Input circuit

It is recommended to apply the circuit as follows. A series diode should be added to the input circuit to prevent stored Hold-up energy from flowing back to the DC Source in the event of a short circuit in the source path.

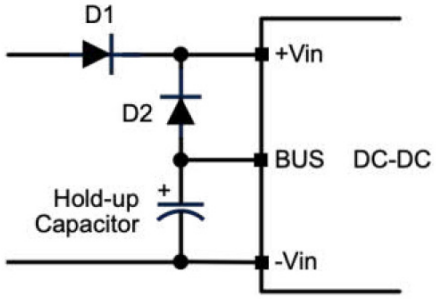

Figure 1: recommended input circuit

When an supply voltage interruption occurs, the input voltage will drop to the BUS voltage, and then the capacitors start discharging and provide energy to the power module. For best hold-up results UVLO should not be used. It has to be noted that the interval time of repeating interruptions is 10 seconds.
It has to be noted that the voltage of 21.4 V at the BUS pin is provided only if input voltage is 24 VDC or higher. If the input voltage is lower, enhanced hold-up function can not be guaranteed.

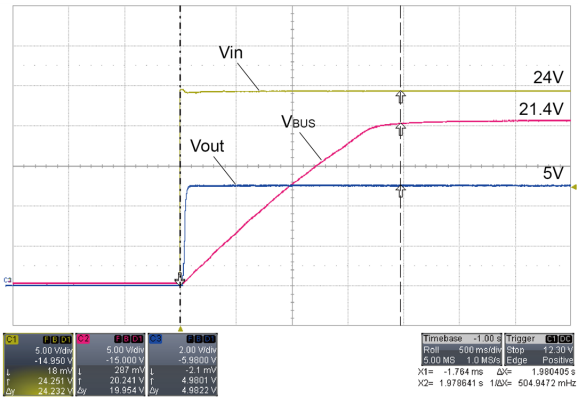

Figure 2: Start-up characteristic
V_{in} = 24 V / Full load / $C_{hold-up}$ = 11‘000 µF

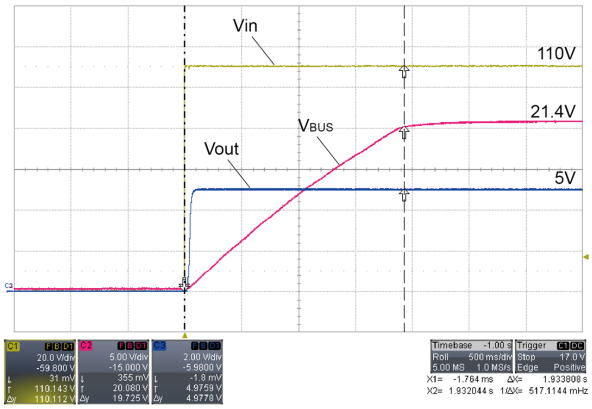

Figure 3: Start-up characteristic
V_{in} = 110 V / Full load / $C_{hold-up}$ = 11‘000 µF

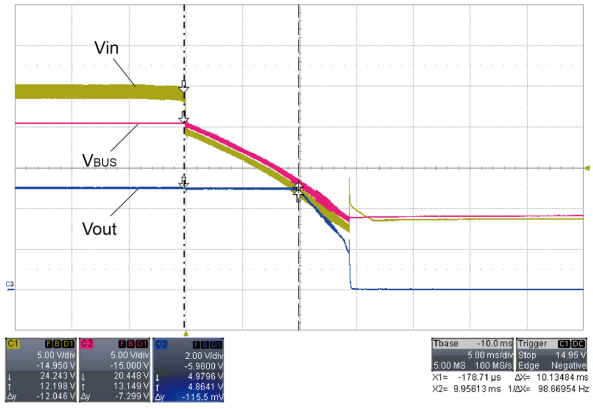

Figure 4: Hold-up characteristic after supply interruption
V_{in} = 24 V; Full load; $C_{hold-up}$ = 11‘000 µF

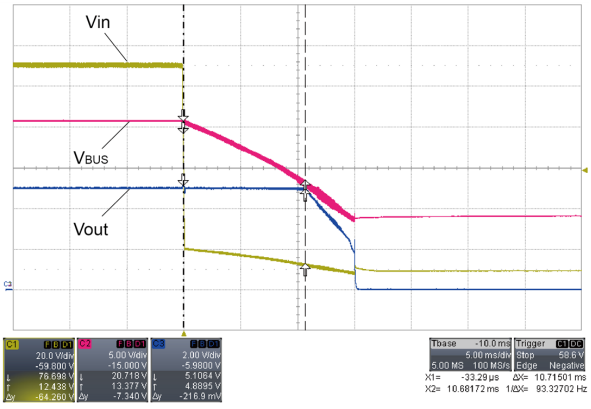

Figure 5: Hold-up characteristic after supply interruption
V_{in} = 110 V; Full load; $C_{hold-up}$ = 11‘000 µF

Calculation

The required capacitance of the hold-up capacitor can be calculated by using the following formulas:

For 36 Vin model (THN xx-36xxUIR)**:**

$$C_{Hold\text{-}up} = 0.0077 \times (P_{out} / \eta) \times t$$

For 72 Vin models (THN xx-72xxUIR)**:**

$$C_{Hold\text{-}up} = 0.0096 \times (P_{out} / \eta) \times t$$

$C_{Hold\text{-}up}$	Total capacitance of the hold-up capacitor [F]
P_{out}	max. Output power [W]
η	Efficiency [%]
t	max. Hold-up time [s]

Recommended capacitance for $C_{HOLD\text{-}UP}$

Interruption Change-over	Model	Nominal Input Voltage 36 V	Model	Nominal Input Voltage 110 V
Capacitor voltage rating		25 V		25 V
S2 (10 ms)	THN 15-3611UIR	1'328 µF	THN 15-7211UIR	1'655 µF
	THN 15-3612UIR	1'313 µF	THN 15-7212UIR	1'636 µF
	THN 15-3613UIR		THN 15-7213UIR	1'655 µF
	THN 15-3615UIR		THN 15-7215UIR	
	THN 15-3622UIR	1'328 µF	THN 15-7222UIR	
	THN 15-3623UIR	1'313 µF	THN 15-7223UIR	
S3 (20 ms)	THN 15-3611UIR	2'655 µF	THN 15-7211UIR	3'310 µF
	THN 15-3612UIR	2'625 µF	THN 15-7212UIR	3'273 µF
	THN 15-3613UIR		THN 15-7213UIR	3'310 µF
	THN 15-3615UIR		THN 15-7215UIR	
	THN 15-3622UIR	2'655 µF	THN 15-7222UIR	
	THN 15-3623UIR	2'625 µF	THN 15-7223UIR	
C1 0.6 x Unom 100 ms	THN 15-36xxUIR	$C_{HOLD\text{-}UP}$ not required	THN 15-72xxUIR	$C_{HOLD\text{-}UP}$ not required
C2 (30 ms)	THN 15-3611UIR	3'983 µF	THN 15-7211UIR	4'966 µF
	THN 15-3612UIR	3'938 µF	THN 15-7212UIR	4'909 µF
	THN 15-3613UIR		THN 15-7213UIR	4'966 µF
	THN 15-3615UIR		THN 15-7215UIR	
	THN 15-3622UIR	3'983 µF	THN 15-7222UIR	
	THN 15-3623UIR	3'938 µF	THN 15-7223UIR	

Table 4: Recommended capacitance for $C_{HOLD\text{-}UP}$ at full load, depending on THN 15UIR model and nominal input voltage

Note: Max. hold-up capacitance must not exceed 7'000 µF. If a higher hold-up capacitance is needed anyway please contact TRACO POWER.

It is furthermore possible to use a lower capacitance for $C_{HOLD\text{-}UP}$ when actual output load is not full load. The required capacitance can be calculated by building the ratio between actual delivering output power and full load output power.

$$C_{HOLD\text{-}UP\_lower} = (\text{Actual Output Power} / \text{Full Load Output Power}) \times \text{Recommended } C_{HOLD\text{-}UP}$$

Interruption Change-over	Model	Nominal Input Voltage 36 V	Model	Nominal Input Voltage 110 V
Capacitor voltage rating		25 V		25 V
S2 (10 ms)	THN 20-3611UIR	1'770 µF	THN 20-7211UIR	2'207 µF
	THN 20-3612UIR	1'750 µF	THN 20-7212UIR	2'182 µF
	THN 20-3613UIR		THN 20-7213UIR	
	THN 20-3615UIR		THN 20-7215UIR	
	THN 20-3622UIR		THN 20-7222UIR	
	THN 20-3623UIR		THN 20-7223UIR	
S3 (20 ms)	THN 20-3611UIR	3'540 µF	THN 20-7211UIR	4'414 µF
	THN 20-3612UIR	3'500 µF	THN 20-7212UIR	4'364 µF
	THN 20-3613UIR		THN 20-7213UIR	
	THN 20-3615UIR		THN 20-7215UIR	
	THN 20-3622UIR		THN 20-7222UIR	
	THN 20-3623UIR		THN 20-7223UIR	
C1 0.6 x Unom 100 ms	THN 20-36xxUIR	$C_{HOLD-UP}$ not required	THN 20-72xxUIR	$C_{HOLD-UP}$ not required
C2 (30 ms)	THN 20-3611UIR	5'310 µF	THN 20-7211UIR	6'621 µF
	THN 20-3612UIR	5'250 µF	THN 20-7212UIR	6'545 µF
	THN 20-3613UIR		THN 20-7213UIR	
	THN 20-3615UIR		THN 20-7215UIR	
	THN 20-3622UIR		THN 20-7222UIR	
	THN 20-3623UIR		THN 20-7223UIR	

Table 5: Recommended capacitance for $C_{HOLD-UP}$ at full load, depending on THN 20UIR model and nominal input voltage

Note: Max. hold-up capacitance must not exceed 7'000 µF. If a higher hold-up capacitance is needed anyway please contact TRACO POWER.

It is furthermore possible to use a lower capacitance for $C_{HOLD-UP}$ when actual output load is not full load. The required capacitance can be calculated by building the ratio between actual delivering output power and full load output power.

$$C_{HOLD-UP\_lower} = (\text{Actual Output Power} / \text{Full Load Output Power}) \times \text{Recommended } C_{HOLD-UP}$$

Inrush Current Limitation

Inrush current is one important characteristic that engineers must consider. When the input voltage begins to supply, the hold-up capacitors at the input terminal will cause a high inrush current, which often blows a fuse or causes error operation to other devices.
By connecting capacitors to the BUS pin, the inrush current is limited effectively via the internal charging path that reduces the need of extra external components.

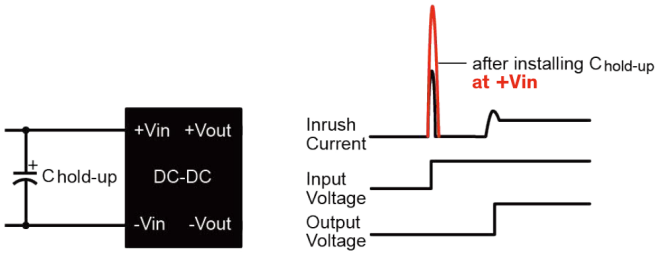

Figure 6: Capacitor at the input terminal between + Vin and - Vin

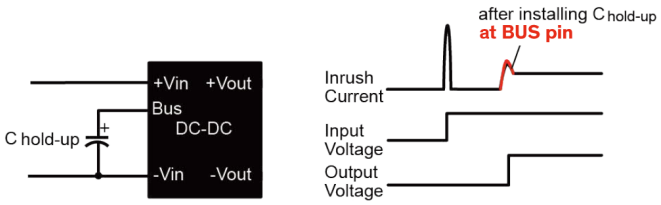

Figure 7: Capacitor between BUS and - Vin

Conclusion

With the possibility to connect capacitors at the BUS pin instead of connecting them at the input line it is possible to:
- To use cost-optimized and better available low voltage capacitors. For for high input voltage applications as well.
- To prevent very high inrush currents due to the hold-up capacitance.