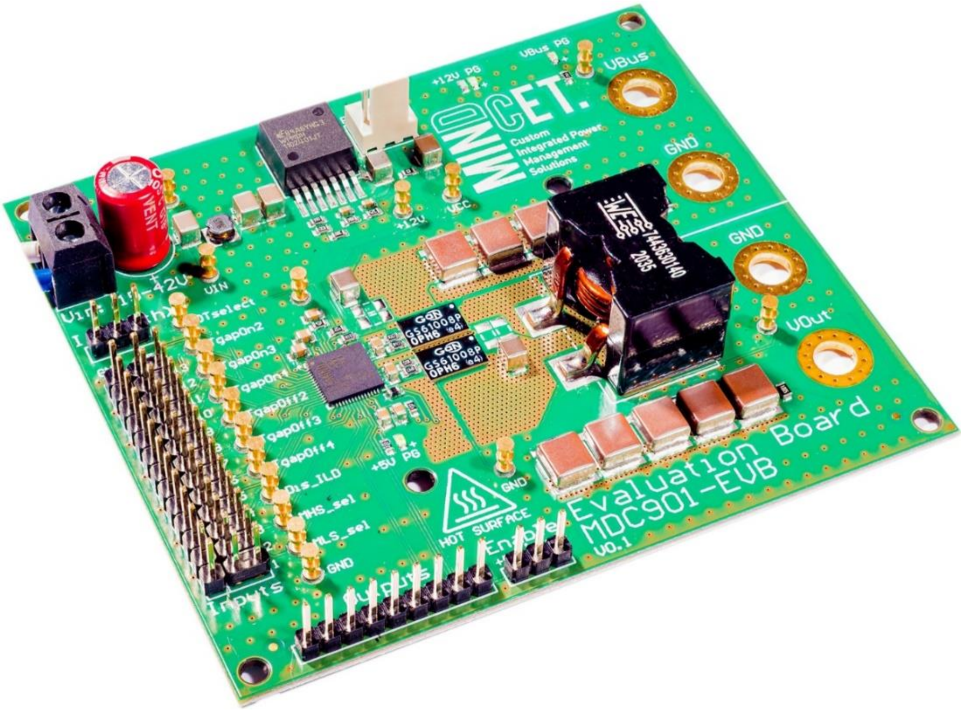
MDC901-EVKHB

Technical Manual

MDC901 200V GaN Gate Driver Half-Bridge Evaluation Kit

Integrated High-Side and Low-Side GaN Gate Driver



For the current version of this Technical Manual and accompanying product documentation, visit mindcet.com or scan the QR code.

**For safe and proper use,
follow these instructions.
Keep them for future reference.**

WARNING: ONLY qualified personnel* should handle this board!

WARNING: Electrical Shock Hazard - Hazardous high voltage may be present on the board during the test and even brief contact during operation may result in severe injury or death. Follow all locally approved safety procedures when working around high voltage.

Never leave the board operating unattended. After board is de-energized, only first touch the board once all capacitors are discharged.

CAUTION: PCB Surfaces may become hot during operation! Do not touch board during operation or for 10 minutes following proper power down of the board.

CAUTION: This product contains parts that are ESD sensitive. Follow proper ESD handling procedures when handling the evaluation board and do not apply excessive voltages to the power supplies, the bus voltages, signal inputs or outputs.

*Qualified personnel (skilled persons) is defined as an individual with relevant technical education, training, or experience to enable perceiving risks and avoiding hazards occurring during use of this product (Source: IEEE 82079-1 3.36)

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Introduction

The MDC901-EVKHB evaluation kit is designed to allow the user to simply and flexibly evaluate the MDC901 200V GaN gate driver in a half bridge configuration. The evaluation board (EVB) utilizes GaN System®'s 100V enhancement mode HEMTs together with passive and active components from Würth Elektronik. The kit provides complete out-of-the-box testing capabilities for quick implementation. At a PCB size of 80x90mm², the evaluation board is compact and is accompanied with all required components to quickly begin testing.

This Technical Manual serves the primary purpose as the EVB handling & usage guide with accompanying information such as the EVB schematics and EVB measurement conditions and techniques.

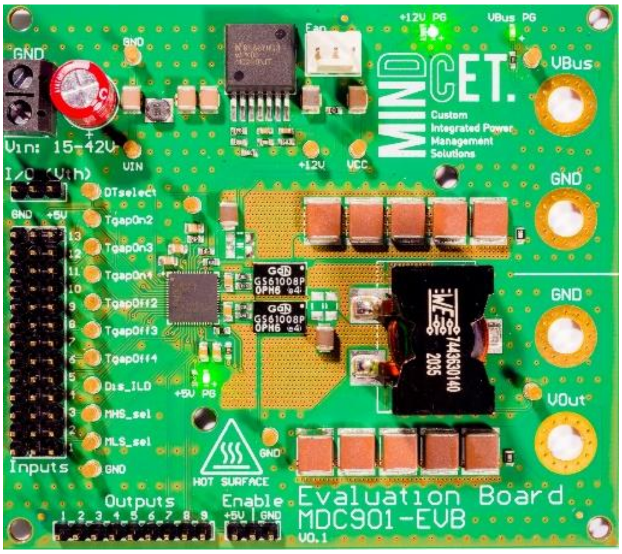


Figure 1: MDC901-EVBHB 100V Half-bridge GaN evaluation board, top view

Within the Technical Manual, the individual evaluation board (as shown in Figure 1), is referred to as the EVB where the full evaluation kit (displayed in Figure 2) is referred to as the EVK.

Evaluation Kit Contents

The MDC901-EVKHB evaluation kit contains the necessary hardware for out-of-the-box testing capability:

Quantity	Component Description
1	MDC901-EVBHB Half-bridge evaluation board
1	Heatsink & fan assembly w/ thermal interface material (Alpha Heatsink type FSR30-15M32-0T2S1ZL)
1	Plexiglass protection cover (MDC-EVK-9PC8)
4	Electric power cable w/ crimped ring connector
4	Connector set (screws, washers, and nuts)
1	Coaxial BNC cable to PWM (BNC Plug to 0.64mm Square Pin Sockets Hirschmann 933844001)
4	M3 Spacer stud set (4mm and 2mm)
1	EVB Terms of Use manual
1	Reusable storage box

Figure 2: MDC901-EVKHB evaluation kit displayed in the reuable box

External Equipment

Further equipment is needed for evaluating the EVB, specifically:

- Non-conductive, clean working surface
- High power, high voltage DC supply
- Low power, low voltage DC power supply
- PWM function generator (e.g. arbitrary waveform generator (AWG))
- Oscilloscope or DMM
- Resistive load

Overview

The evaluation board (EVB) is designed in a half bridge configuration to form a buck converter for step-down conversion. One MinDCet MDC901 GaN gate driver is present driving two GaN Systems GS61008P 100V enhancement mode high mobility transistors (e-HEMT).

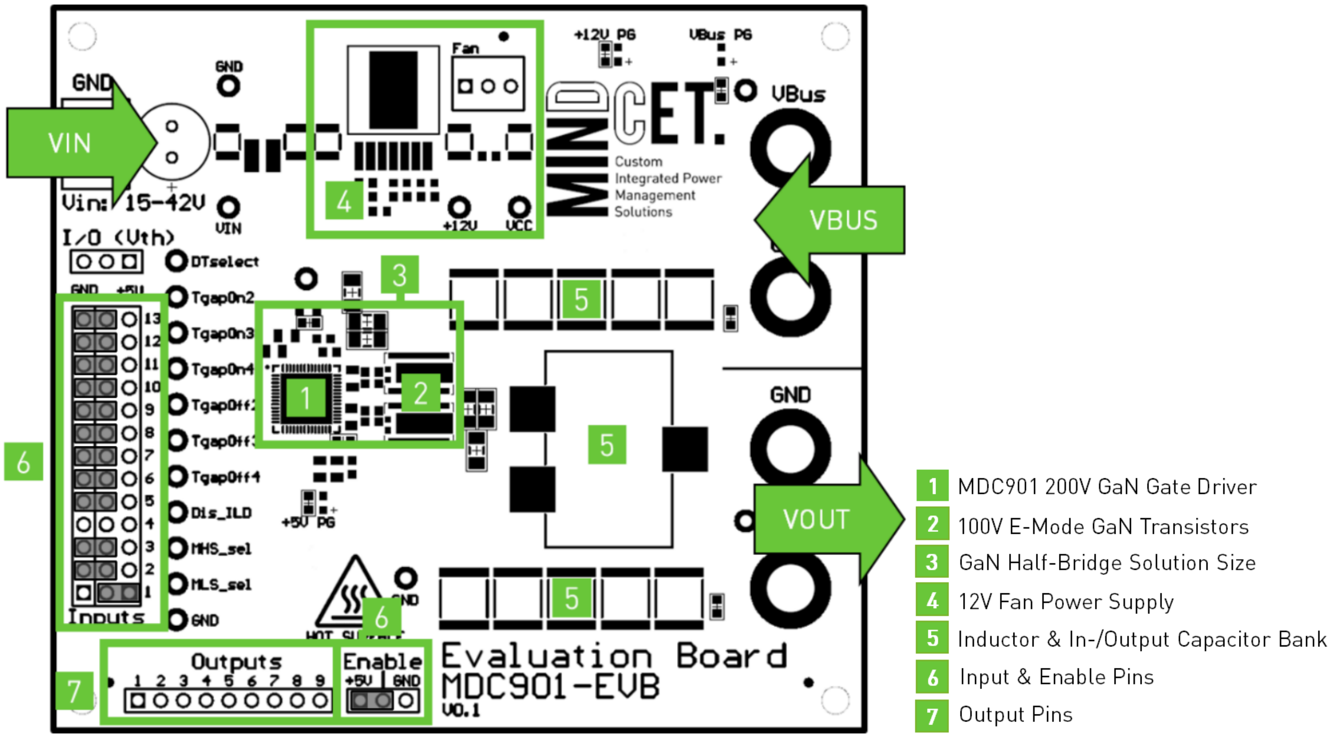


Figure 3: EVB layout description based, labeled by key aspects (gray boxes are the default jumper positions)

The EVB is separated into blocks for description purposes, as displayed in Figure 3.

1 MDC901 200V GaN Gate Driver

The MDC901 gate driver IC is a QFN56 7x7mm² package for precise driving of the GaN transistors.

For specifications and more information, refer to the most recent datasheet at https://www.mindcet.com/asic-products

2 100V E-Mode GaN Transistors

Two GaN Systems GS61008P enhancement mode GaN HEMTs, with a V_{DS} rating of 100V, are present on board as high and low side power switches in the half-bridge. The GS61008P has a size of 7.5 x 4.6 x 0.51mm³ and $R_{DS(ON)}$ of 8 mΩ. The GaN HEMTs leverage GaN's properties for high power densities with high voltage breakdown and high switching frequency.

For specifications and more information, refer to the most recent datasheet at https://www.gansystems.com/gan-transistors/gs61008p

3 GaN Half-Bridge Solution Size

The entire GaN half-bridge, including the (2) GaN HEMTs, (1) MDC901 gate driver, and required surrounding passives, has a highly compact footprint of 20x21mm².

4 12V Fan Power Supply

The VDRM MAGI³C Power Module from Würth Elektronik provides a regulated 12V output, suppling the fan as well as the MDC901 itself.

For specifications and more information, refer to the most recent datasheet at https://www.we-online.de/powermodules

5 Inductor & Input/output Capacitor Bank

For direct EVB evaluation purposes, a 1.4µH Würth Elektronik inductor and the fitting input/output capacitors were selected for a buck converter topology, designed for high current applications up to 30A output current.

6 Input Pins

The Inputs table describes the jumper position for the default IC state, which is for automatic dead time control.

Table 1: Input Pin Descriptions, function and default state

Pin #	Pin Name	Default State	Function
-	ENABLE	+5V	General enable for gate driver functionality
1	MLS_sel	+5V	Operating mode selection state according to *Table 2*. EVB designed only for synchronous buck mode **Maintain default state (+5V)**
2	MHS_sel	GND	Operating mode selection state according to *Table 2*. EVB designed only for synchronous buck mode **Maintain default state (GND)**
3	Dis_ILD	GND	Digital PWM input controlling HS and LS driver functions. Maintain default state (GND)
4	VinHS	PWM (0/5V)	Digital PWM input controlling HS and LS drivers.
5	VinLS	GND	Digital PWM input controlling HS and LS drivers. Function reflected in Table 1
6	TgapOff_4	GND	Digital dead-time generation tuning input for feed forward turn-off delay. See *Manual Dead time* Selection
7	TgapOff_3	GND	Digital dead-time generation tuning input for feed forward turn-off delay. See *Manual Dead time* Selection
8	TgapOff_2	GND	Digital dead-time generation tuning input for feed forward turn-off delay. See *Manual Dead time* Selection
9	ZVS_IN	GND	Digital input for feedforward dead-time generation. Active high.
10	TgapOn_4	GND	Digital dead-time generation tuning input for feed forward turn-on delay. See *Manual Dead time* Selection
11	TgapOn_3	GND	Digital dead-time generation tuning input for feed forward turn-on delay. See *Manual Dead time* Selection
12	TgapOn_2	GND	Digital dead-time generation tuning input for feed forward turn-on delay. See *Manual Dead time* Selection
13	DTselect	GND	Digital input for selection of closed loop or feedforward dead-time generation (automatic and manual dead time, respectively). Active high. See *Manual Dead time* Selection CAUTION: Dead time mode must be monitored with an oscilloscope

The default jumper positions are demonstrated in the EVK lid diagram with gray boxes and in Figure 3. For more information on the pin functions, refer to the MDC901 datasheet.

7 Output Pins

Pin #	Pin Name	Function
1	TEMPOUT	IC chip temperature (MDC901 internal sensor). Measure voltage and calculate temperature according to Section *Temperature Measurement*
2	NTC_In	Board temperature. Measure resistance between NTC_In and NTC_Out to calculate temperature according to Section "Temperature Measurement"
3	NTC_Out	Board temperature at NTC, placed just below MDC901. See NTC_In.
4	UVLS	Digital output, undervoltage on the LS supplies (both regulated as preregulated supply levels). Will give a low output in case of undervoltage condition.
5	UVHS	Digital output, undervoltage on the HS supplies (both regulated as preregulated supply levels). Will give a low output in case of undervoltage condition.
6	PP_Alarm	Open-drain output, for detecting push-pull errors in the gate sensing. Active low.
7	TMGateHS	Digital signal, gate feedback of high-side driver
8	TMGateLS	Digital signal, gate feedback of low-side driver
9	VDD_LOGIC	Digital 5V linear regulator. Can drive limited external resistive loads, but should not be loaded capacitively.

For more information on the pin functions, refer to the MDC901 datasheet.

Vxxx Vin, Vbus and Vout

Vin is connected to the low voltage power supply and has an allowable input range of 15-42V. Vbus is connected to the high power, high voltage power supply and with an intended input range of 0-48V. Vout is the stepped down, outgoing power, connected to the (electronic) load with a voltage range of 0 to Vbus.

Additional EVB Features

Test pin probe points are installed for Vbus, Vout, and GND for waveform and efficiency measurements. For higher power loss situations, there is a 30x30mm² heat sink and fan assembly with thermal interface material applied, which can be fastened to the back of the PCB using the integrated spring pin system. Further information on operating conditions for safe handling of the EVB can be found in *EVB Operation Conditions*. Power Good indicators, which are individually labelled LEDs, signal the presence of power for the 5V supply (to the MDC901), the 12V fan supply and Vbus (labeled +5 PG, +12 PG and Vbus PG, respectively). When the LED illuminates, voltage is present on the corresponding supply.

Board Block Diagram

The EVB layout has been simplified to a block diagram in Figure 4 to demonstrate the primary electrical connections on the board, centered around the functionality of the MDC901 GaN gate driver.

For the full MDC901-EVBHB schematics, please refer to the EVB Schematic section within the *Appendix*.

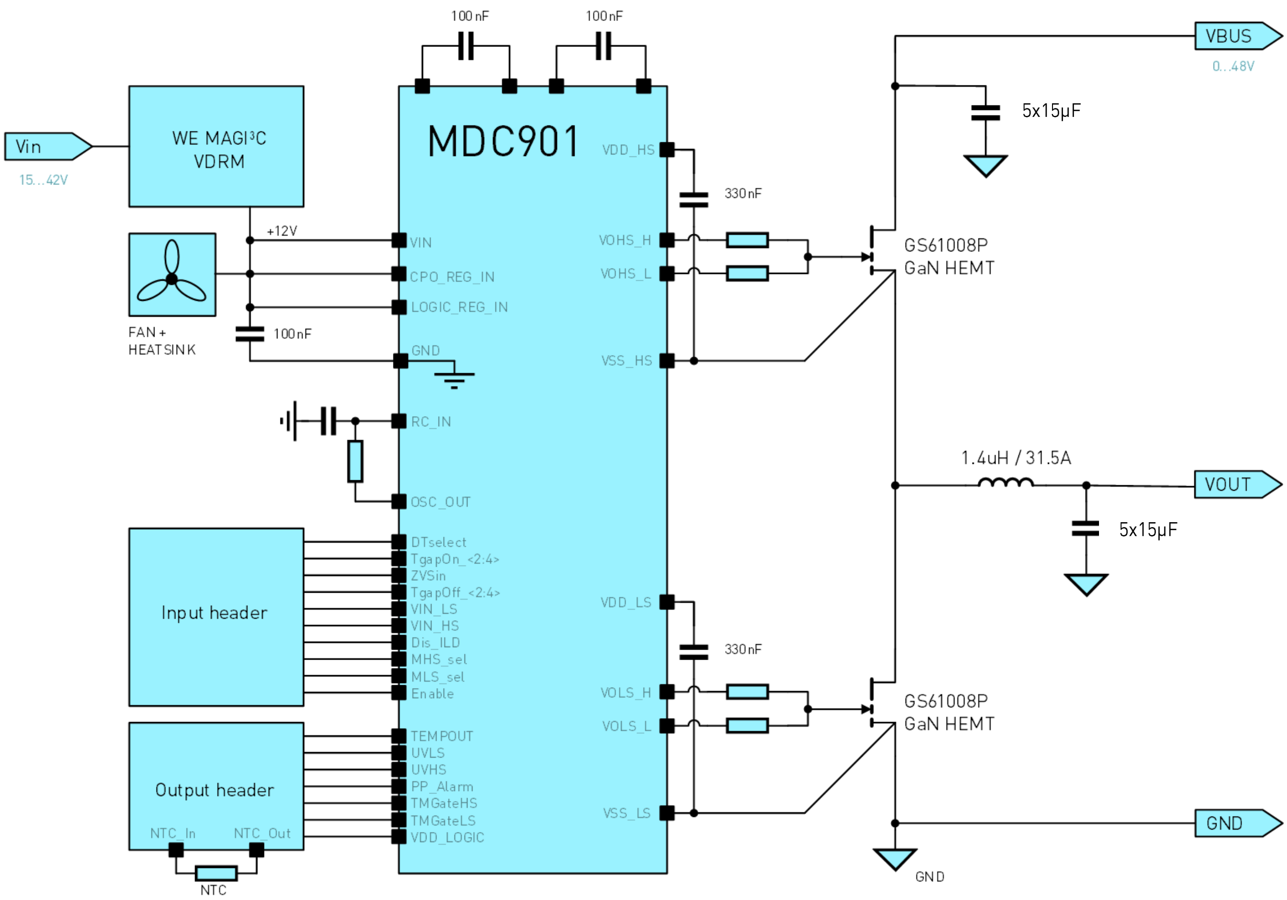


Figure 5: Block diagram of the MDC901

Board Handling Instructions & Quick Start

Before board operation, refer to the *EVB Operation Conditions* Section to determine whether the fan/heat sink assembly (hereby referred to as fan assembly) is required.

In the instance that tests are to be conducted under conditions without the fan assembly, it is highly recommended to first conduct all non-fan assembly tests followed by higher power test with the fan assembly installed, as the thermal interface material is difficult to remove.

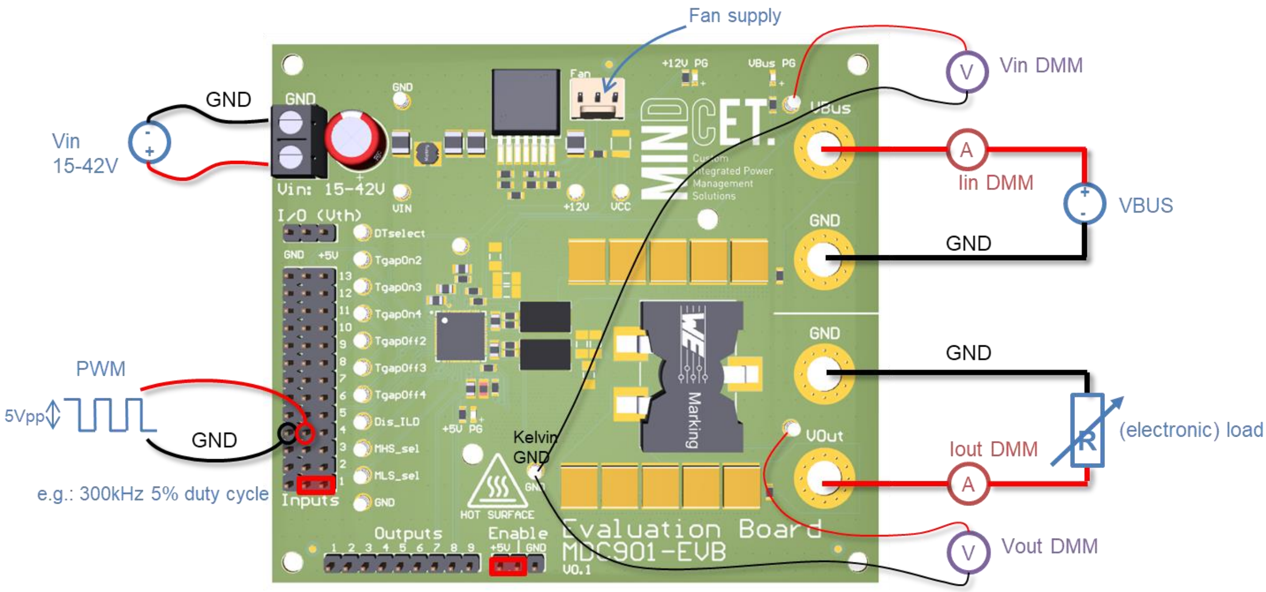


Figure 6: Standard EVB setup with external supply connections in automatic dead time mode

First Time EVB Preparation

1. Solder test points or equivalent on VBus, Vout, and GND for efficiency measurement (required data for monitoring the total power loss, Ploss)
2. Prepare the bare end of the power cables with the fitting connector type for the power supply connector (as necessary)
3. Install the heat sink on the back of the PCB
    a. Remove the protective film from the TIM layer
    b. Align heat sink brass push pins with the mounting holes, where the heatsink will be covering the square, bare copper area)
    c. Apply even and firm pressure to top of push pin while supporting the PCB front side near the mounting hole with counter pressure (avoid touching the PCB components)
    d. Repeat with the second push pin When pins are properly through the PCB mounting hole, the pin head should be split open
4. Plug fan connector into the fan socket on PCB front side (Figure 3, block 4) to power the fan.

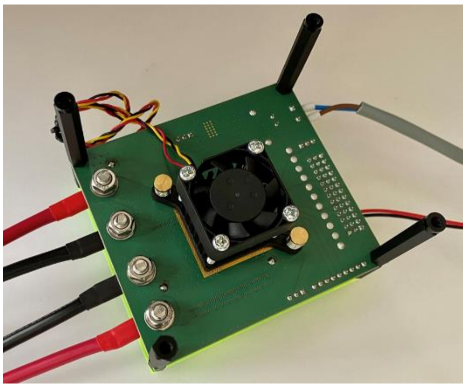


Figure 7: Heat sink unit installed on the EVB backside

***Note**: Removal of heat sink after installation not recommended*

Preparations: Electrical and Mechanical Setup

1. Setup a clean laboratory environment. EVB to be placed on a non-conductive surface to minimize the risk of an electric shock or fire.
2. Setup the external equipment
    a. Power supply **Vbus at 0V**
    b. Power supply Vin at a voltage between 15V and 42V (24V recommended)
    c. (electronic) load initialized to 0A
    d. PWM generator (e.g. arbitrary waveform generator (AWG)) square wave with peak-to-peak Vpp= 5V (0V to 5V, high impedance)

3. Install the plastic spacer studs in each corner of the EVB (see Figure 9.(right))
    a. 4 cm studs on the PCB bottom side
    b. 2 cm studs on the top side
4. Connect the power cables:
    a. Ring terminals to the PCB using the included bolt + washer + nut (according to Figure 8)
    b. Free end to the power supply/load (with appropriate Vbus to high voltage power supply, Vout to (electronic) load

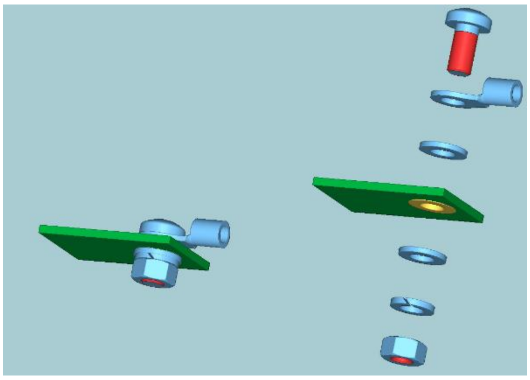
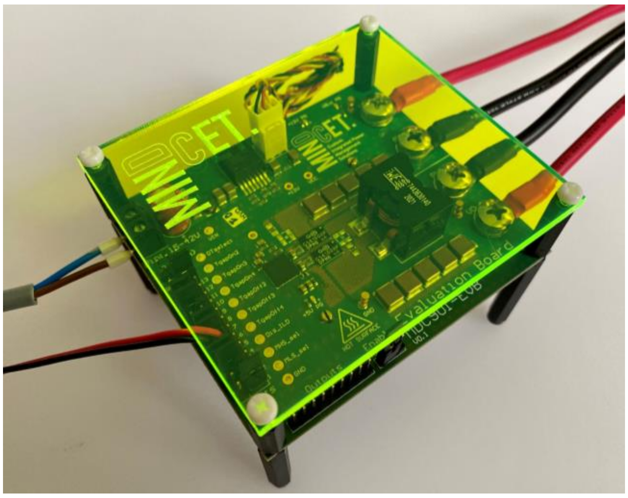


Figure 8: Power cables connector assembly

5. Connect the Vin supply cable
    a. Ferule to the PCB terminal block Vin
    b. Banana connector to the power supply
6. Connect the coaxial cable
    a. BNC connector to AWG
    b. Female header to VinHS for BUCK mode (Input Pin 4)
7. Connect fan supply cable to "Fan supply" header, labeled accordingly in Figure 6
8. Install the plexiglass cover on the spacer studs with the nylon M3 screws, as displayed in Figure 9



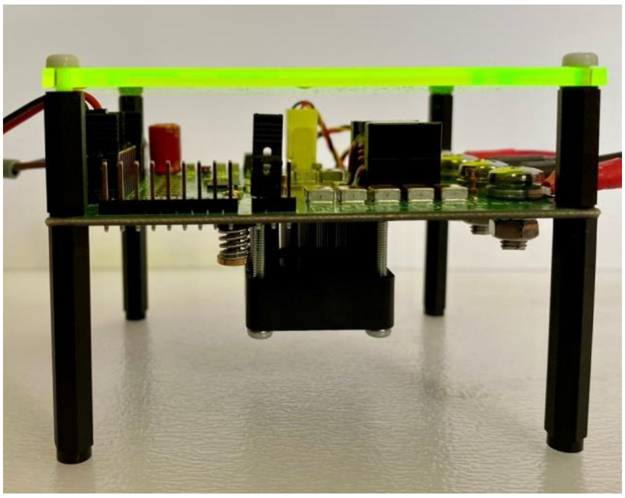


Figure 9: (left) Fully assembled EVB, ready for testing with a side view demonstrating the heat sink and plexiglass assembly (pictured right)

> ***Caution****: Do not touch the power cables and maintain distance to the EVB during operation to maintain the proper tabletop position of the board, as demonstrated in Figure 9.*

9. Setup the external equipment
    a. Power supply **Vbus at 0V**
    b. Power supply Vin at a voltage between 15V and 42V (24V recommended)
    c. (electronic) load initialized to 0A
    d. PWM generator (e.g. arbitrary waveform generator (AWG)) square wave with peak-to-peak Vpp= 5V (0V to 5V, high impedance)

Essential Rules for Operation

- Prepare your measurements by checking the graphs and calculating the expected values (see sections *EVB Operation Conditions* and *Electrical &Thermal Results (General)*)
- Never leave the setup unattended

- Never disable the external PWM while Vbus is high (can lead to shorting evet of the half bridge)
- **Immediately switch off Vbus when safety limits are exceeded**
- Measuring the temperature of the chip and board is a highly recommended safety feature
- Altering duty cycle during operation NOT RECOMMENDED due to PWM function generator spikes or delays (e.g. when software controlled) that can lead to a short circuit event of the HS/LS HEMTs
- The Vbus input voltage should never exceed 100V including ringing! (Max Vbus=75V)

Powering Up: General-Sequence

1. Check if the desired setpoint is within the limits of temperature, current and voltage, most importantly for the expected power loss. See *EVB Operation Conditions* and cross reference *Electrical &Thermal Results (General)*
   a. Heatsink installed+FAN ON (forced cooling) → ***Ploss*= 20W max**
   b. Heatsink installed +FAN OFF (natural convection) → ***Ploss*= 4.5W max**
2. Ensure all preparations (previous section) were properly completed.
3. Verify the LED status
   a. PG 5V: ON
   b. PG 12V: ON
   c. PG Vbus: **OFF**
4. Setup the desired jumper combinations (refer to *Dead Time Control Conditions*)
   a. Dead-time: automatic or manual
   b. Switching mode: buck
   c. Enable pin to 5V
5. Set the PWM signal to the desired frequency and duty cycle. (if not regulated in closed loop)
6. Increase Vbus while monitoring Vout. (only continue when the output is as expected)
7. Increase the output load current while monitoring Vout.
8. Lower Vbus and Iout back to zero when finished

Power Down & Disconnect Procedure

1. Slowly power down Vbus voltage back to zero and turn off
2. Shut down the PWM function generator
3. Wait at least 5 minutes (with fan on) or 10 minutes (without fan assembly installed) after operation for EVB to fully de-energize and cool down
4. Shut down low voltage power supply
5. Disconnect coaxial cable
6. Disconnect the power cables from high voltage supply (with supply off)
7. Disconnect the input supply (Vin) from low voltage power supply (supply is off)
8. Disconnect cables from EVB as desired (EVB can fit into storage container with cables still attached)

Measurement Example: Buck Mode with Auto Dead time

1. Ensure all preparations (previous section) were properly completed.
2. Fan is connected and running
3. Verify the LED status
   a. PG 5V: ON
   b. PG 12V: ON
   c. PG Vbus: **OFF**
4. Setup jumpers in the default position, as described in Table 1Figure 3: EVB layout description based, labeled by key aspects (gray boxes are the default jumper positions) and shown in Figure 3
   a. Auto dead time: DT-select=GND (pull down makes this unnecessary)

    b. Buck mode: MLS_SEL=5V (MHS_SEL=GND - pull down makes this unnecessary)
5. Set the PWM frequency to 300kHz and duty cycle to 25%
6. Increase the voltage of Vbus to 48V
7. Verify whether the output voltage is 12V (Note, the expected voltage will be <12V due to losses)
8. Increase the load current up to 5A and measure Vbus, Ibus, Vout and Iout
    a. An efficiency of approximately 93% (calculated based on Equation 5-Equation 8) is to be expected
9. Power down Vbus to 0V and the load current Iout to 0A

Measurement Example: Buck Mode with Manual Dead time (11.8ns (theoretical))

1. Setup jumpers like in Figure 10
    a. Manual dead time: DT-select=5V (Pin 1)
    b. Buck mode: MLS_SEL=5V (Pin 13)
    c. TgapOff2 & TgapOn2 (Pins 8 & 12) = 5V
2. Fan connected
3. Set the PWM frequency to 300kHz and duty cycle to 25%
4. Increase the voltage of Vbus to 48V
5. Verify whether the output voltage is 12V (Note, the expected voltage will be <12V due to losses)
6. Increase the load current up to 5A and measure Vbus, Ibus, Vout and Iout
    a. An efficiency of ca. 94% (calculated based “Efficiency Calculation”) is to be expected
7. Power down Vbus to 0V and the load current Iout to 0A

Helpful Information

- The converter exemplifies the best performance in the 100kHz to 1MHz switching frequency range
- A 0% or 100% duty cycle are non-switching situations of conversion
- Perform tests first without the heat sink/fan assembly heat sink as removal of the heat sink after installation may damage the thermal adhesive
- Automatic dead-time is conservative and results in a higher power loss compared to a well-tuned manual dead time
- Manual dead time requires user verification by oscilloscope measurements
- Powering down Vbus with an active load current may de-energize quicker as the capacitors are drained

Dead Time Control Conditions

The MDC901 has different built-in dead time control options for optimizing device performance for high efficiency.

Automatic Dead time

The default jumper positions described in the Default State column of the *Input Pins* table provides the configuration for automatic dead time. This mode will monitor the gate voltages of HS and LS switches, to guarantee a break-between operation of HS and LS GaN transistor. In this condition, the dead time is ensured, but cannot be controlled and is longer than what can be achieved in manual dead time mode.

Automatic deadtime mode is consequently dynamic and ensures the dead time, even in changing loads and duty cycle conditions. However, the inherently longer dead time (compared to a manually selected dead time) leads to higher switching losses and resultantly lower efficiency.

Manual Dead time Selection

CAUTION: Dead time must be monitored by an oscilloscope in manual dead time mode to avoid high side/low side FET switch overlap

The MDC901-EVBHB is specifically designed for the synchronous buck mode, defined by MHS_sel=GND and MLS_sel=+5V (Input Pins 1 and 2) The MDC901 IC offers four operating modes are available for MDC901 operation, described in Table 2.

Only use the EVB in the synchronous buck mode state.

Table 2: Truth table for mode selection

mode select	synch/async buck/boost	sync buck PWM=VinHS	sync boost PWM=VinLS	transparent VinLS & VinHS
MHS_sel	0	0	1	1
MLS_sel	0	1	0	1

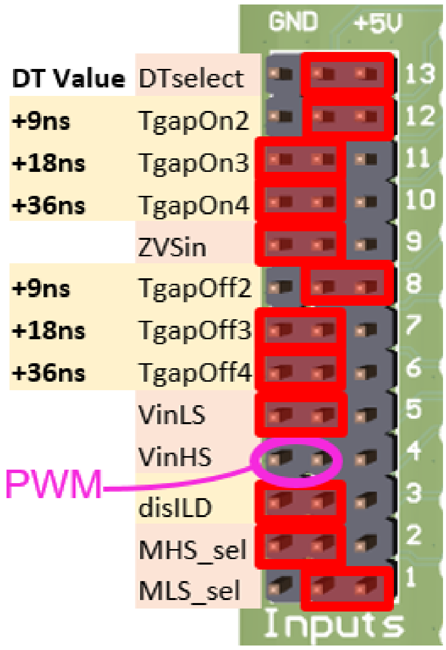
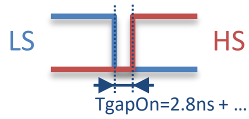


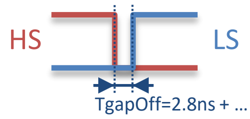
Figure 10: Jumper positions for synchronous buck mode with manual dead time of (theoretical) 11.8ns (red boxes are jumpers positions)

To operate the EVB in manual dead time mode, the input pin states jumpers must be placed for MHS_sel (GND) and MLS_sel (+5V) for synchronous buck mode, as well as the jumpers on disILD (GND) and DTselect (+5V) to enable manual dead time selection.

TgapOn is the dead time between the LS falling and HS rising as shown to the right:



TgapOff is the reverse situation to TgapOn from HS off to LS switching on.



The input pins jumper positions for TgapOn<2:4> and TgapOff<2:4> determine the respective total dead time according to the following equations:

Equation 1 $$TgapOn = 2.8ns + TgapOn2 + TgapOn3 + TgapOn4$$

Equation 2 $$TgapOff = 2.8ns + TgapOff2 + TgapOff3 + TgapOff4$$

Where Table 3 defines the amount of dead time for each pin input.

Figure 10 displays an example of the EVB configured for manual dead time in synchronous buck mode (

Table 3: Dead time adjustment variable values

Pin State	TgapOn2 /TgapOff2	TgapOn3/TgapOff3	TgapOn4/TgaOff4
+5 / open	9ns	18ns	36ns
GND	0ns	0ns	0ns

The listed TgapOn/Off dead time adjustment values are theoretical and can differ to experimental results.

For the example in Figure 10, the placed jumpers result in a dead time of TgapOn=2.8ns + 9ns=11.8ns and TgapOff=11.8ns.

Temperature Measurements

In addition to the on-board temperature sensor of the MDC901 IC, the evaluation board offers a second temperature measurement point in the proximity of the MDC901 IC and GaN HEMTs. The board temperature sensor is a NTC thermistor placed just below the MDC901, serving as a confirmation point of the IC temperature and provides insight into the GaN half-bridge temperature.

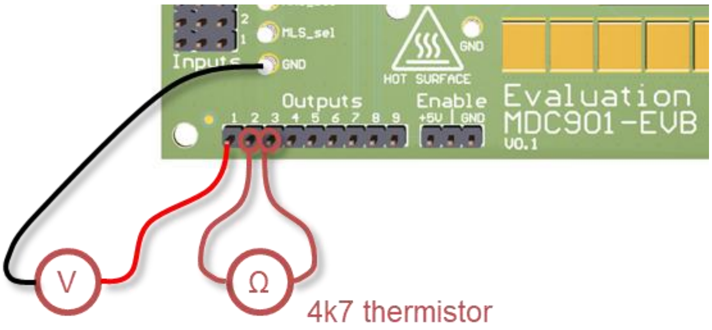


Figure 11: Board and internal IC temperature sensing measurement

For the board temperature, measure the resistance (R) of the 4.7kΩ thermistor with a high impedance (>100MΩ) digital multimeter between output pins 2 and 3.

The following equation converts the measured resistance value R to temperature:

Equation 3

$$Tboard = \frac{T_0\,\beta_{25/85}}{T_0\,ln\left(\frac{R}{R_0}\right)+\beta_{25/85}}\,[°C]$$

$$R_0 = 298.15\text{K}$$
$$T_0 = 4700\Omega$$
$$\beta_{25/85} = 3830$$

The gate driver IC temperature is calculated based on the measured voltage between output pin 1 and GND, according to:

Equation 4

$$Tchip = \frac{V-0.48}{0.0016} + 25\ [°\text{C}]$$

EVB Operation Conditions

Operating conditions are conditions under which operation of the EVB is intended to be in a safe range and functional. Adherence to the maximum values and the close monitoring of the conditions (e.g. Vbus, Ibus, Vout and Iout) is critical to prevent harm to the board or user.

Monitoring of the Tboard temperature, as described in *Temperature Measurements* and the total power loss Ploss (through monitoring Vbus, Ibus, Vout and Iout) is required for ensuring safe board operation. Ploss is calculated according to the following equations:

Equation 5 $$Pin = Vbus\ \times Ibus\ [W]$$

Equation 6 $$Pout = Vout\ \times Iout\ [W]$$

Equation 7 $$Ploss = Pin - Pout\ [W]$$

Equation 8 $$Efficiency = \frac{Pout}{Pin} \times 100\%\ [\%]$$

The operation safety limit is a temperature rise of 25°C of Tboard over the ambient temperature Tambient. Tambient should be measured in a 30 cm vicinity at EVB level, away from air currents for a representative measurement.

Safe usage: the total power loss (Ploss) defines the safe operating conditions to prevent overheating and damage to EVB

- **Ploss= 20W max WITH heatsink+fan**
- **Ploss= 4.5W max WITHOUT fan on (heatsink installed)**

These Ploss values are to be strictly adhered to, taking priority over the temperature rise measurement.

CAUTION: First confirm Ploss levels at lower operating conditions, then continue to higher power levels / switching frequencies

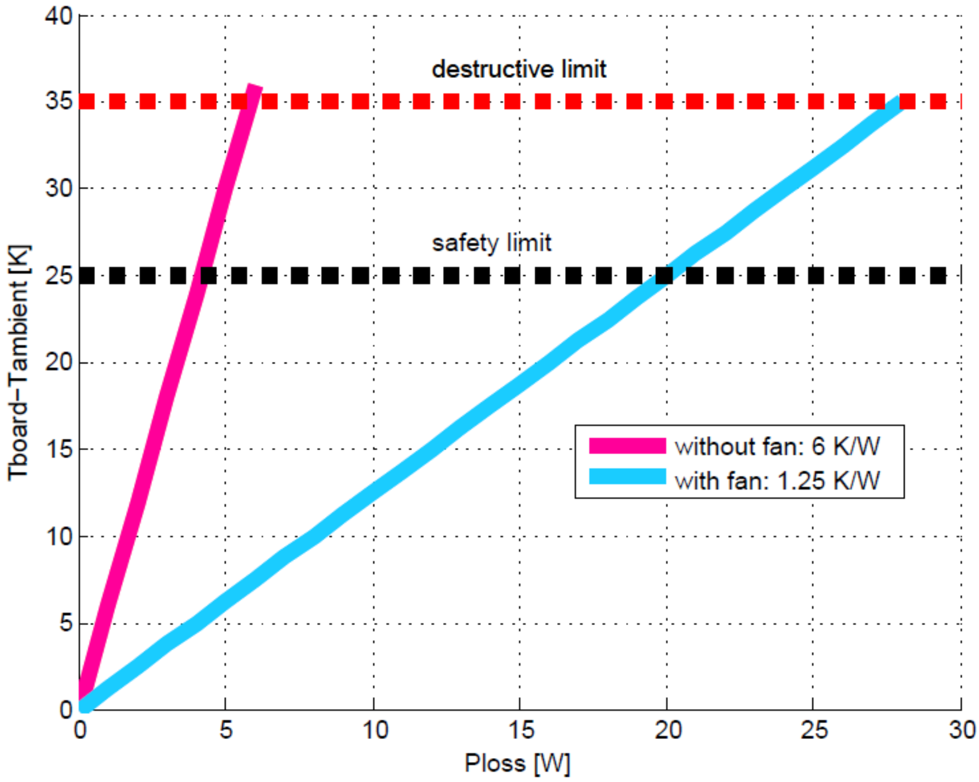


Figure 12:Safe EVB operating conditions defined by total power loss (Ploss)

Table 4: EVB minimum and maximum operating parameters

Parameter	Min.	Recommended	Max.	Unit	Notes
Vin	15		42*	V	
Vbus	0	-	75	V	Absolute max of 100V including overshoot & ringing
Fsw (PWM)	0	300 to 700	1000	kHz	
Iout	0	-	30	A	
Board temperature	-	-	90	°C	Do not exceed 90°C on any component under operating conditions

All voltage values are referenced respective to GND.

Inductor losses

The power inductor used in the MDC901-EVBHB board is a Würth Elektronik type 7443630140, with a saturation current of 31.5A.

Depending on the operating conditions used on the EVB, the inductor will exhibit AC power losses, depending on DC and AC current conditions, which will also contribute to the overall dissipation on the board.

This inductor was characterized using the MADMIX system. Figure 13 depicts the losses depending on the frequency and ripple current.

The ripple current will depend on the following equation (δ is the duty cycle).

Equation 9

$$I_{rip} = \frac{V_{bus}\delta(1-\delta)}{f_{sw}L}$$

Based on the ripple current and the graph in Figure 13, the AC losses can be determined. The DC losses are Joule losses, defined by

Equation 10

$$P_{dc} = R_{dc}.I_{dc}{}^2$$

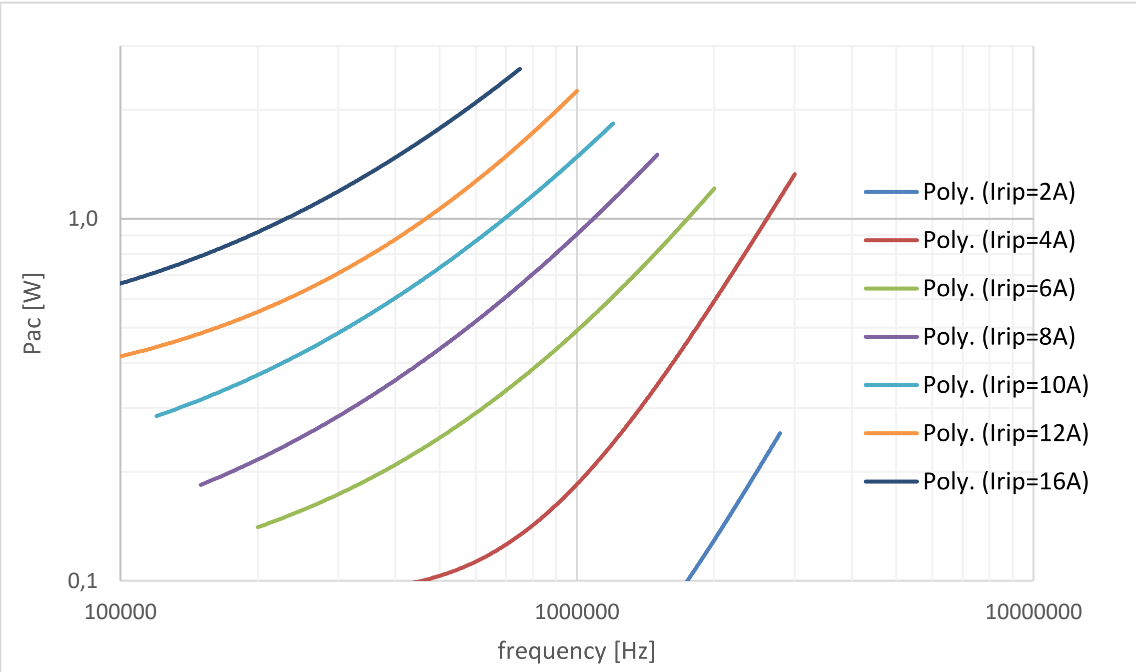


Figure 13: AC losses of the 1.4 µH (WE 7443630140) power inductor on the EVB

Figure 14 depicts the inductor losses in a few typical applications, Vbus =48V +- 25% to Vout = 3.3V & 12V

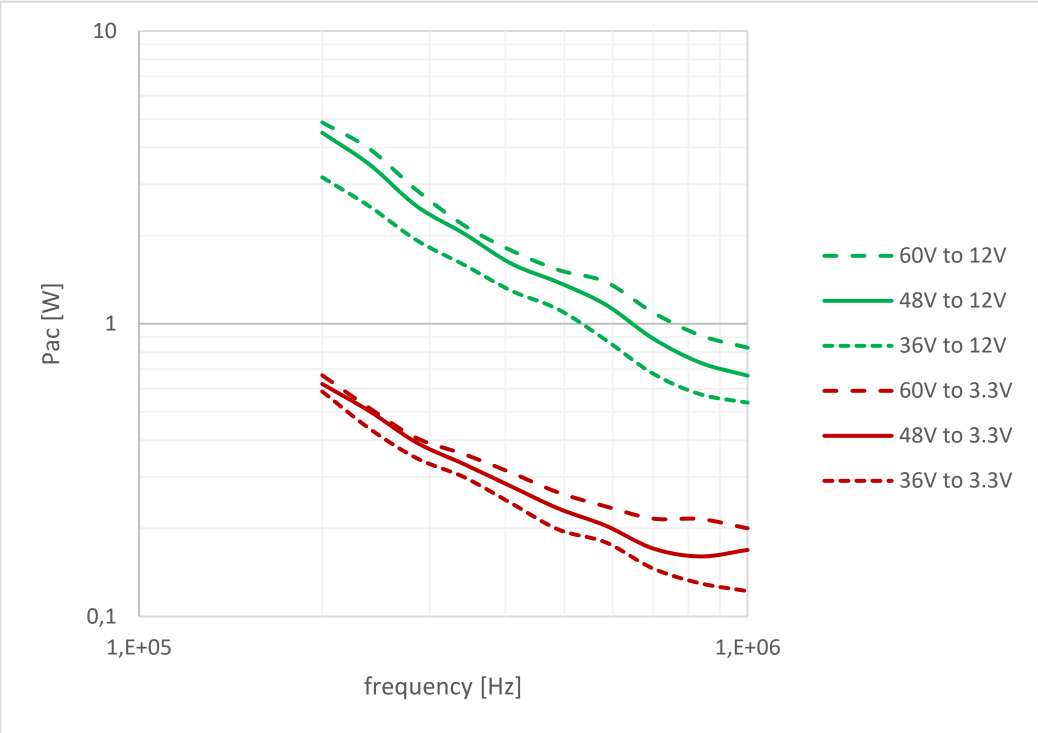
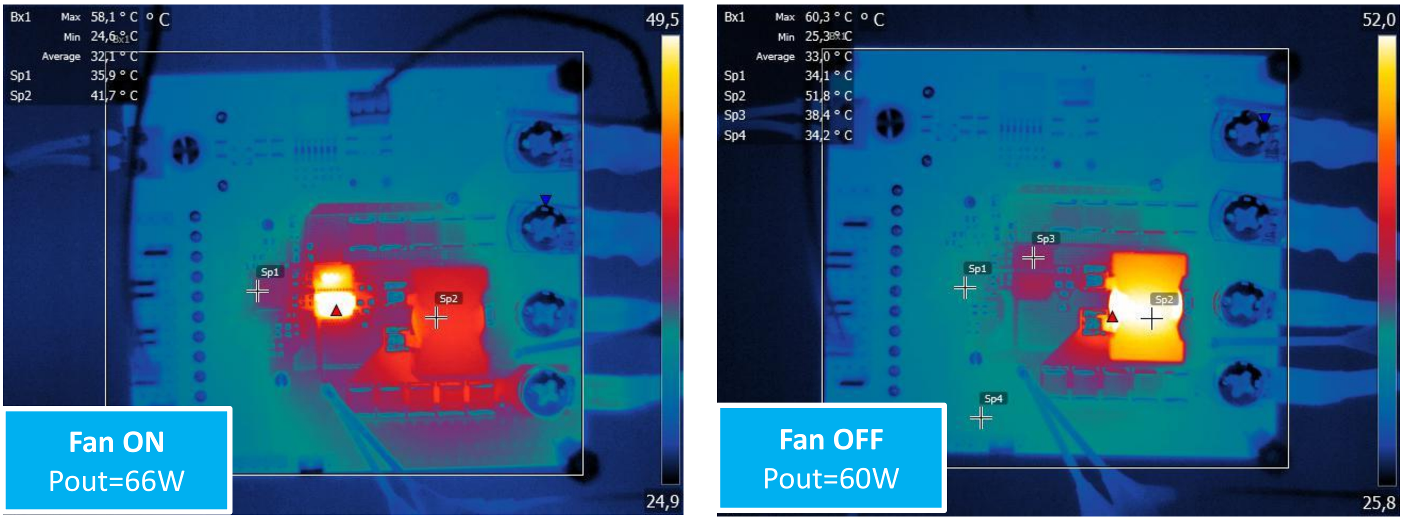


Figure 14: AC losses of the power inductor on the EVB in a few typical conversion ratio applications

Performance Evaluation

Benchmarked Conditons

Manual dead time of (theoretical) 11.8ns



Vin=48V, Vout=3.3V, Iout= 20A, fsw=300kHz

Efficiency = 88.6% Ploss = 8.5W

Max Temp (LS HEMT) = 58.1°C

Vin=48V, Vout=12V, Iout= 5A, fsw=300kHz

Efficiency = 94.2% Ploss = 3.8W

Max Temp (Inductor Core) = 60.3°C

Figure 15: Thermal images of the EVB at 48V to 3.3V (fan on, 20A load) and 48V to 12V (fan off, 5A load)

Ambient temperature = 23°C

Electrical &Thermal Results (General)

EVB performance was evaluated in a step-down conversion of 48 to 12 V and 3.3V applications (respectively), sweeping over a switching frequency range from 300 to 700 kHz and an output current (Iout) from 0.5 A to 20 A, with the heatsink attached and fan turned on.

Efficiency

Peak efficiency is obtained at 500kHz, at 96.5%, keeping the output voltage constant at 12V (by varying the duty cycle) in manual dead time mode with a theoretical dead time of 11.8s.

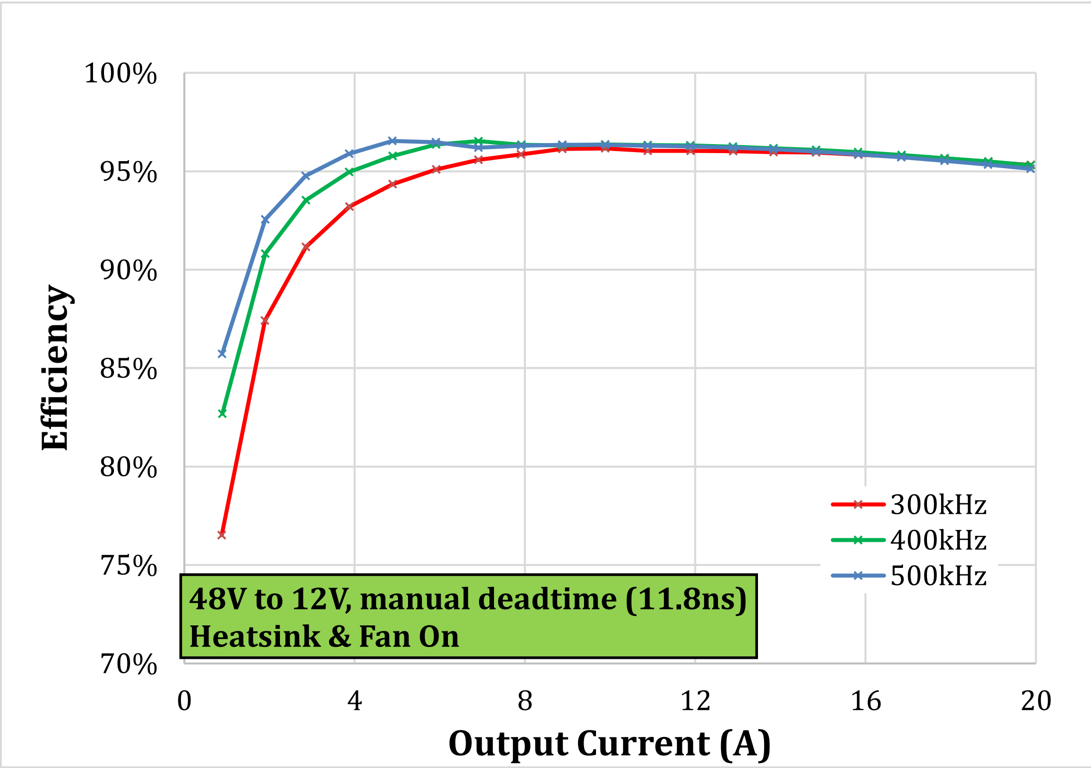


Figure 16: EVB efficiency plots of 48V to 12V conversion at varying switching frequencies up to 20A output current

For 48V to Peak efficiency is obtained at 500kHz, at 96.5%, keeping the output voltage constant at 12V (by varying the duty cycle) in manual dead time mode with a theoretical dead time of 11.8s.

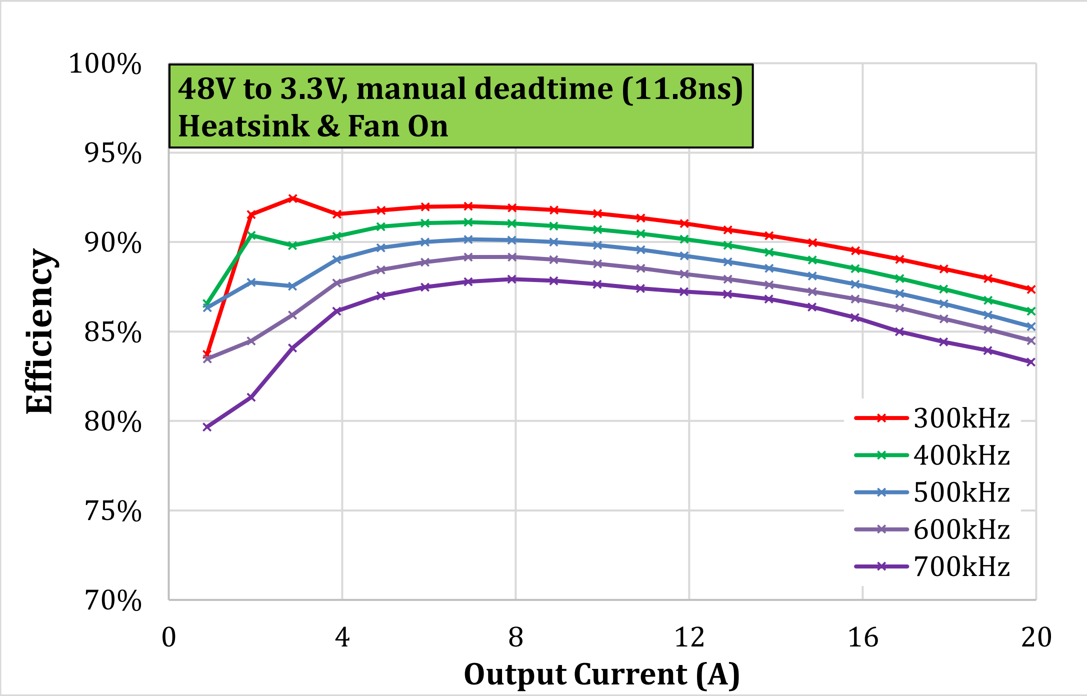


Figure 17: EVB efficiency plots of 48V to 3.3V conversion at varying switching frequencies up to 20A output current

Power Losses
The efficiency can be represented by the power loss value, which is key in defining the board operating range and the necessity of installing the heatsink and fan assembly.

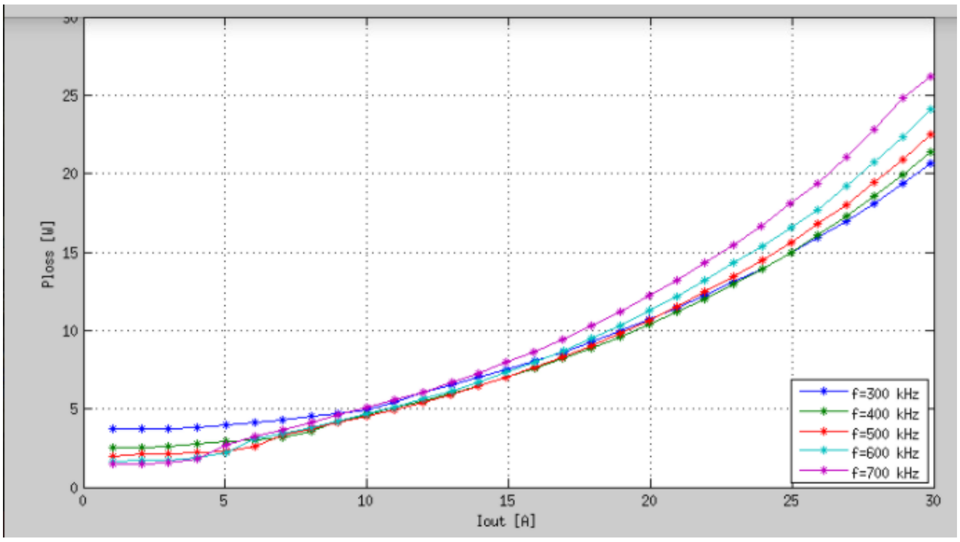


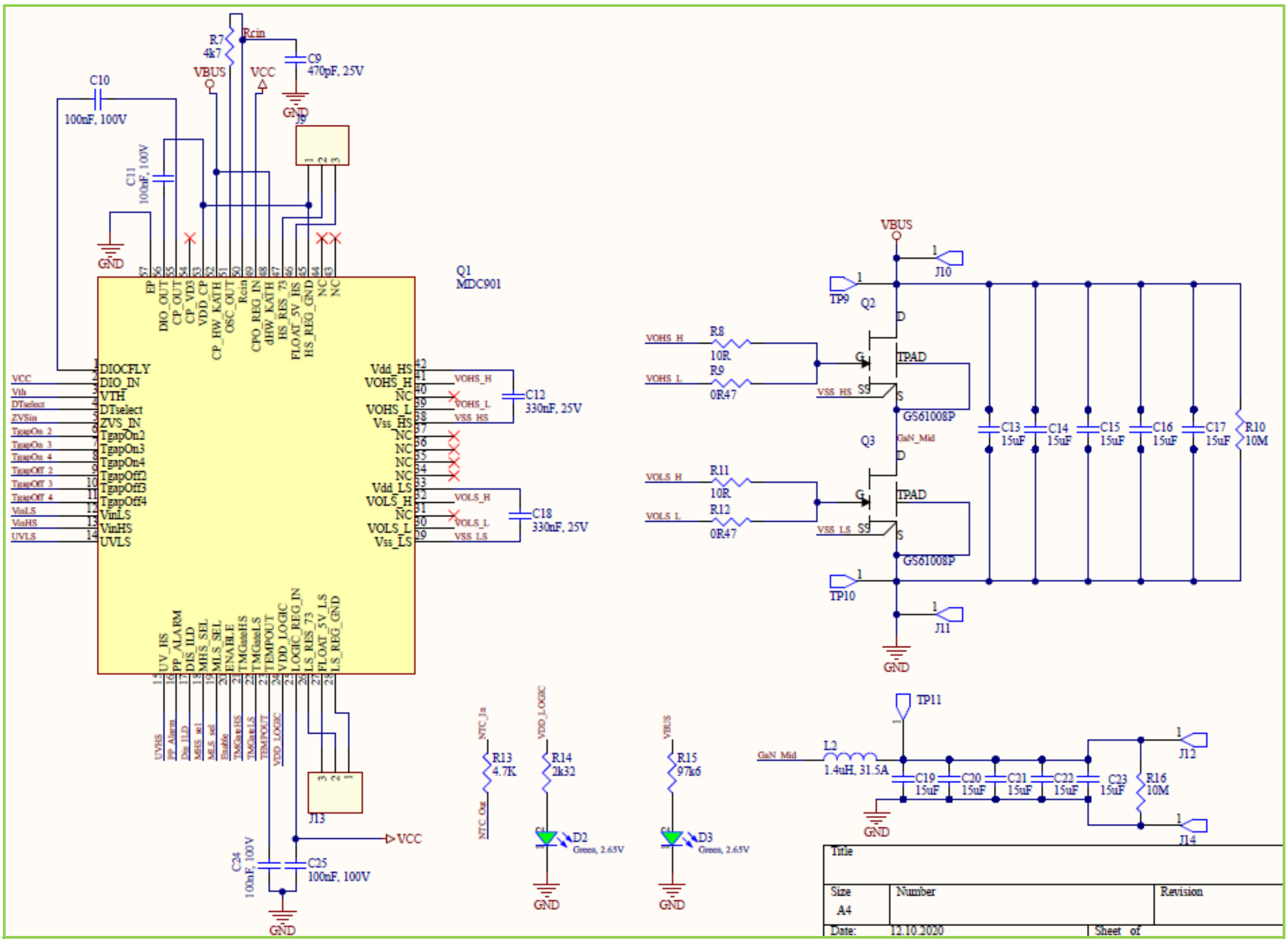
Figure 18: Power loss values based on output current at varying switching frequencies

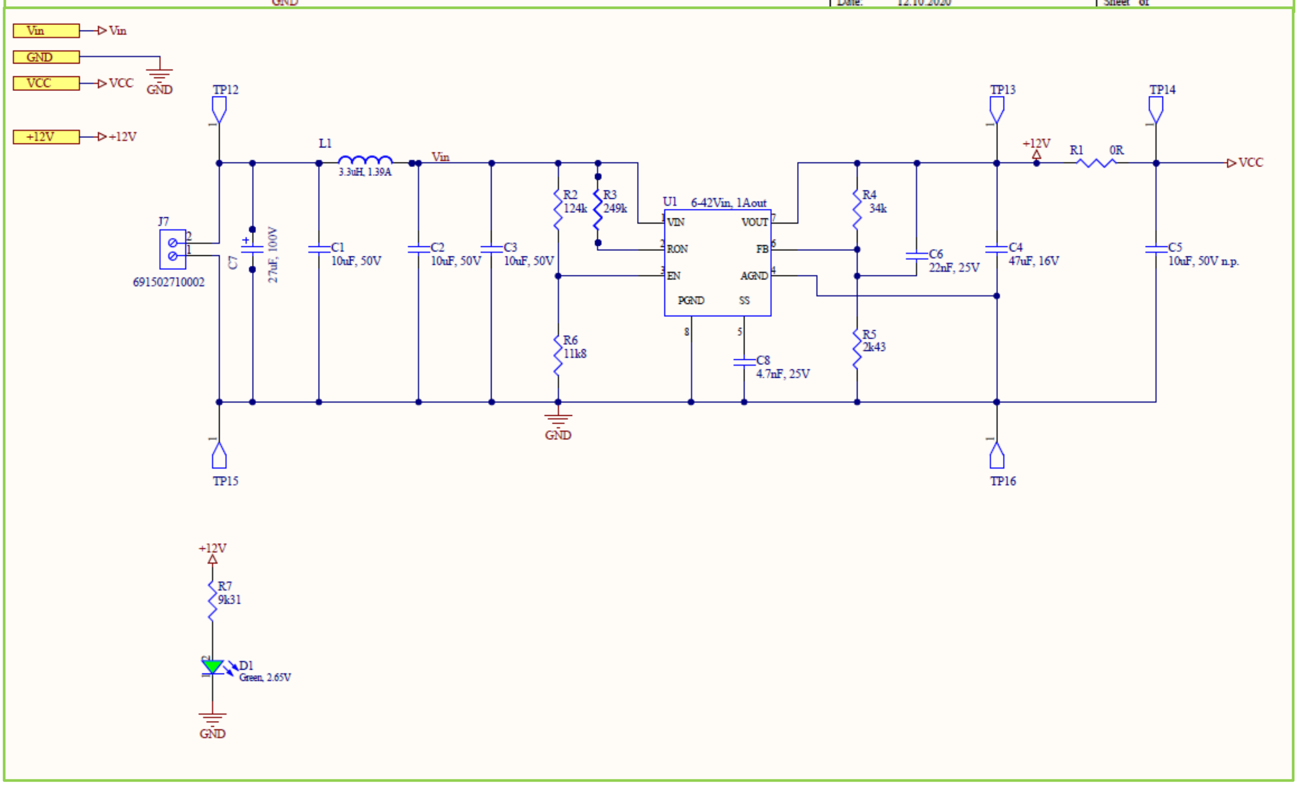
Storage Conditions

The EVB is best stored in the original packaging under room temperature with dry conditions. After testing and proper de-energizing/cool-down time, the EVB can be placed in the large compartment of the foam insert (the EVB spacer studs align with the holes in the foam to better secure the EVB during storage and transportation). Normal ESD handling precautions, including for storage, apply.

Appendix

EVB Schematic





Bill of Materials

Available upon request, please contact support@mindcet.com

PCB Design / Gerber Files

For assistance in accelerating the design-in phase, the EVB layout files are available upon request. For the most recent version, please contact support@mindcet.com

Cautions and Warnings

The following conditions apply to all goods within the product series of MinDCet NV

General:
All recommendations according to the general technical usage and specifications of this guide have to be complied with.

The usage and operation of the product within ambient conditions which probably alloy or harm the component surface has to be avoided.

The responsibility for the applicability of customer specific products and use in a particular customer design is always within the authority of the customer. All technical specifications for standard products do also apply for customer specific products.

Residual washing varnish agent that is used during the production to clean the application might change the characteristics of the body, pins or termination. The washing varnish agent could have a negative effect on the long-term function of the product.
Direct mechanical impact to the product shall be prevented as the material of the body, pins or termination could flake or in the worst case it could break. As these devices are sensitive to electrostatic discharge customer shall follow proper IC Handling Procedures.

Customer acknowledges and agrees that it is solely responsible for compliance with all legal, regulatory and safety-related requirements concerning its products, and any use of MinDCet NV components in its applications, notwithstanding any applications-related information or support that may be provided by MinDCet NV. Customer represents and agrees that it has all the necessary expertise to create and implement safeguards which anticipate dangerous consequences of failures, monitor failures and their consequences lessen the likelihood of failures that might cause harm and take appropriate remedial actions. Customer will fully indemnify MinDCet NV and its representatives against any damages arising out of the use of any MinDCet NV components in safety-critical applications.

Product specific:
Follow all instructions mentioned in the MDC901 datasheet and this technical manual, especially:

- All products are supposed to be used before the end of the period of 12 months based on the product date-code.
- Violation of the technical product specifications such as exceeding the absolute maximum ratings will void the warranty. It is also recommended to return the body to the original packaging (ESD bag) and reseal the package.
- ESD prevention methods need to be followed for manual handling and processing by machinery.

Important Notice

The Technical Manual is based on our knowledge and experience of typical requirements concerning these areas. It serves as general guidance and should not be construed as a commitment for the suitability for customer applications by MinDCet NV (hereafter referred to as MDC). The information in the Application Note is subject to change without notice. This document and parts thereof must not be reproduced or copied without written permission, and contents thereof must not be imparted to a third party nor be used for any unauthorized purpose. MinDCet NV and are not liable for application assistance of any kind. Customers may use MDC's assistance and product recommendations for their applications and design. The responsibility for the applicability and use of MDC Products in a particular customer design is always solely within the authority of the customer. Due to this fact it is up to the customer to evaluate and investigate, where appropriate, and decide whether the device with the specific product characteristics described in the product specification is valid and suitable for the respective customer application or not. The technical specifications are stated in the current datasheet of the products. Therefore the customers shall use the datasheets and are cautioned to verify that datasheets are current. The current data sheets can be downloaded at www.mindcet.com. Customers shall strictly observe any product-specific notes, cautions and warnings. MDC reserves the right to make corrections, modifications, enhancements, improvements, and other changes to its products and services. MDC DOES NOT WARRANT OR REPRESENT THAT ANY LICENSE, EITHER EXPRESS OR IMPLIED, IS GRANTED UNDER ANY PATENT RIGHT, COPYRIGHT, MASK WORK RIGHT, OR OTHER INTELLECTUAL PROPERTY RIGHT RELATING TO ANY COMBINATION, MACHINE, OR PROCESS IN WHICH MDC PRODUCTS OR SERVICES ARE USED. INFORMATION PUBLISHED BY MDC REGARDING THIRD-PARTY PRODUCTS OR SERVICES DOES NOT CONSTITUTE A LICENSE FROM MDC TO USE SUCH PRODUCTS OR SERVICES OR A WARRANTY OR ENDORSEMENT THEREOF. MDC products are not authorized for use in safety-critical applications, or where a failure of the product is reasonably expected to cause severe personal injury or death. Moreover, MDC products are neither designed nor intended for use in areas such as military, aerospace, aviation, nuclear control, submarine, transportation (automotive control, train control, ship control), transportation signal, disaster prevention, medical, public information network etc. Customers shall inform MDC about the intent of such usage before design-in stage. In certain customer applications requiring a very high level of safety and in which the malfunction or failure of an electronic component could endanger human life or health, customers must ensure that they have all necessary expertise in the safety and regulatory ramifications of their applications. Customers acknowledge and agree that they are solely responsible for all legal, regulatory and safety-related requirements concerning their products and any use of MDC products in such safety-critical applications, notwithstanding any applications-related information or support that may be provided by MDC. CUSTOMERS SHALL INDEMNIFY MDC AGAINST ANY DAMAGES ARISING OUT OF THE USE OF MDC PRODUCTS IN SUCH SAFETY-CRITICAL APPLICATIONS.

The following conditions apply to all goods within the product range of MinDCet NV:

1. General Customer Responsibility

Some goods within the product range of MinDCet NV contain statements regarding general suitability for certain application areas. These statements about suitability are based on our knowledge and experience of typical requirements concerning the areas, serve as general guidance and cannot be estimated as binding statements about the suitability for a customer application. The responsibility for the applicability and use in a particular customer design is always solely within the authority of the customer. Due to this fact it is up to the customer to evaluate, where appropriate to investigate and decide whether the device with the specific product characteristics described in the product specification is valid and suitable for the respective customer application or not. Accordingly, the customer is cautioned to verify that the datasheet is current before placing orders.

2. Customer Responsibility related to Specific, in particular Safety-Relevant Applications

It has to be clearly pointed out that the possibility of a malfunction of electronic components or failure before the end of the usual lifetime cannot be completely eliminated in the current state of the art, even if the products are operated within the range of the specifications. In certain customer applications requiring a very high level of safety and especially in customer applications in which the malfunction or failure of an electronic component could endanger human life or health it must be ensured by most advanced technological aid of suitable design of the customer application that no injury or damage is caused to third parties in the event of malfunction or failure of an electronic component.

3. Best Care and Attention
Any product-specific notes, warnings and cautions must be strictly observed.

4. Customer Support for Product Specifications
Some products within the product range may contain substances which are subject to restrictions in certain jurisdictions in order to serve specific technical requirements. Necessary information is available on request. In this case the field sales engineer or the internal sales person in charge should be contacted who will be happy to support in this matter.

5. Product R&D
Due to constant product improvement product specifications may change from time to time. As a standard reporting procedure of the Product Change Notification (PCN) according to the JEDEC-Standard we inform about minor and major changes. In case of further queries regarding the PCN, the field sales engineer or the internal sales person in charge should be contacted. The basic responsibility of the customer as per Section 1 and 2 remains unaffected.

6. Product Life Cycle
Due to technical progress and economical evaluation we also reserve the right to discontinue production and delivery of products. As a standard reporting procedure of the Product Termination Notification (PTN) according to the JEDEC-Standard we will inform at an early stage about inevitable product discontinuance. According to this we cannot guarantee that all products within our product range will always be available. Therefore it needs to be verified with the field sales engineer or the internal sales person in charge about the current product availability expectancy before or when the product for application design-in disposal is considered. The approach named above does not apply in the case of individual agreements deviating from the foregoing for customer-specific products.

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8. General Terms and Conditions
Unless otherwise agreed in individual contracts, all orders are subject to the current version of the "General Terms and Conditions of MinDCet NV", last version available at www.mindcet.com.

Contact Information

For product questions and technical assistance, please contact support@mindcet.com

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