AN2011-01
MA400E12/17 and MA401E12/17 – Module Adapter Board for IHM IGBT Modules
Attention please!

THE INFORMATION GIVEN IN THIS APPLICATION NOTE IS GIVEN AS A HINT FOR THE IMPLEMENTATION OF THE INFINEON TECHNOLOGIES COMPONENT ONLY AND SHALL NOT BE REGARDED AS ANY DESCRIPTION OR WARRANTY OF A CERTAIN FUNCTIONALITY, CONDITION OR QUALITY OF THE INFINEON TECHNOLOGIES COMPONENT. THE RECIPIENT OF THIS APPLICATION NOTE MUST VERIFY ANY FUNCTION DESCRIBED HEREIN IN THE REAL APPLICATION. INFINEON TECHNOLOGIES HEREBY DISCLAIMS ANY AND ALL WARRANTIES AND LIABILITIES OF ANY KIND (INCLUDING WITHOUT LIMITATION WARRANTIES OF NON-INFRINGEMENT OF INTELLECTUAL PROPERTY RIGHTS OF ANY THIRD PARTY) WITH RESPECT TO ANY AND ALL INFORMATION GIVEN IN THIS APPLICATION NOTE.

Information

For further information on technology, delivery terms and conditions and prices please contact your nearest Infineon Technologies Office (www.infineon.com).

Warnings

Due to technical requirements components may contain dangerous substances. For information on the types in question please contact your nearest Infineon Technologies Office. Infineon Technologies Components may only be used in life-support devices or systems with the express written approval of Infineon Technologies, if a failure of such components can reasonably be expected to cause the failure of that life-support device or system, or to affect the safety or effectiveness of that device or system. Life support devices or systems are intended to be implanted in the human body, or to support and/or maintain and sustain and/or protect human life. If they fail, it is reasonable to assume that the health of the user or other persons may be endangered.

AN2011-01

Revision History: 2011-01, V1.1
Previous Version: V1.0
major changes since last revision:
- Email address updated
- SP number updated

Author: Alain Siani (IFAG IMM INP M AE)

We Listen to Your Comments

Any information within this document that you feel is wrong, unclear or missing at all? Your feedback will help us to continuously improve the quality of this document. Please send your proposal (including a reference to this document) to: [WAR-IGBT-Application@infineon.com]
Table of contents

1 INTRODUCTION .................................................................................................................. 4
2 DESIGN FEATURES ............................................................................................................ 5
  2.1 Main features ...................................................................................................................... 5
  2.2 Key data ............................................................................................................................ 5
  2.3 Mechanical dimensions and mounting procedure ............................................................. 6
  2.4 Pin assignment .................................................................................................................... 7
3 ELECTRICAL FEATURES ..................................................................................................... 8
  3.1 Functionality on board ....................................................................................................... 8
  3.2 Gate resistors .................................................................................................................... 8
  3.3 Gate signal amplifier ........................................................................................................ 8
  3.4 $V_{CE}$ monitoring for short circuit detection ................................................................. 9
  3.5 Active clamping – boosted version .................................................................................. 10
  3.6 Maximum switching frequency ....................................................................................... 10
  3.8 Parallel operation ............................................................................................................ 12
4 SCHEMATIC AND LAYOUT ................................................................................................. 13
  4.1 Schematic ........................................................................................................................ 13
  4.2 Assembly drawing ........................................................................................................... 14
  4.3 Layout .............................................................................................................................. 14
  4.4 Bill of Material – MA400E12_EVAL / MA401E12_EVAL ............................................. 15
  4.5 Bill of Material – MA400E17_EVAL / MA401E17_EVAL ............................................. 16
5 HOW TO ORDER EVALUATION DRIVER BOARDS ........................................................... 17

Part number explanation:

- MA: Module Adapter board
- 40: Output current (40 A)
- X: Suitable for 2400 V IHMA and IHMB
- Exx: Suitable for 1700 V IHMA and IHMB

For example:
- MA400E12_EVAL: Suitable for 2400 V IHMA and IHMB
- MA400E17_EVAL: Suitable for 1700 V IHMA and IHMB

E12: Suitable for 1200 V IHMA and IHMB
E17: Suitable for 1700 V IHMA and IHMB

0 for 140mmx130mm single switch IHMA and IHMB
1 for 140mmx190mm single switch IHMA and IHMB

40 A output driver current
1 Introduction

The MA40xE12 and MA40xE17 evaluation adapter boards are developed for the driving of 1200V and 1700V single switch IHM modules with an integrated active booster and additionally short circuit protection feature to assure an easy and optimum functionality of the IGBT. Used in conjunction with the 2ED300E17-SFO evaluation adapter board and the 2ED300C17-S or -ST EiceDRIVER™ turns the adapter evaluation board into the Flexible driver Starter Kit displayed in Figure 1b. The Flexible Evaluation adapter board is dedicated to single module operation. In cases of IHM parallel switching, one 2ED300E17-SFO adapter board and one 2ED300C17-S driver is required for up to three modules paralleled, each equipped with one MA40xExx board.

The MA40xExx module adapter boards are available from Infineon in small quantities. Functions and properties of these parts are described in the datasheet chapter of this document whereas the remaining paragraphs provide information intended to enable the customer to copy, modify and qualify the design for their own specific application.

Environmental conditions were considered in the design of the MA40xExx. The requirements for lead-free reflow soldering have been considered when components were selected. However the design was only tested as described in this document but not qualified regarding manufacturing and operation over the whole operating ambient temperature range or lifetime.

The boards provided by Infineon are subjected to functional testing only. Due to their purpose evaluation boards are not subjected to the same procedures regarding Returned Material Analysis (RMA), Process Change Notification (PCN) and Product Withdraw (PWD) as regular products. See Legal Disclaimer and Warnings for further restrictions on Infineon warranty and liability.

![Module Adapter board, MA400E12](image1.png) ![Driver Starter Kit for IHM module](image2.png)

Figure 1  a) Module Adapter board, MA400E12,  b) Driver Starter Kit for IHM module
Module Adapter Board
for IHM IGBT Modules

2 Design features

Electrical features of the evaluation board and mechanical dimensions including necessary interface connections are presented in following sections.

2.1 Main features

The MA40xExx module adapter board offers the following features:
- Electrically and mechanically suitable for IHM modules family
- Design target for operating temperature: -55°C to 85°C
- Different gate resistor values for turning-on and -off are possible
- The IGBT is protected against temporary overvoltages during turn-off by Active Clamping
- Diodes for IGBT desaturation monitoring to handle short circuit conditions are implemented
- All components, except connectors, are surface mount devices (SMD) with lead free 260°C soldering profile
- PCB is designed to fulfill the requirements of IEC61800-5-1, pollution degree 2, overvoltage category III (creepage – 11mm)

If the MA40xExx is not used with the 2ED300E17-SFO adapter board and a 2ED300C17-S EiceDRIVER™ these additional features might be useful:
- Booster-Stage input resistance is 90Ω
- Can be used with max. ±20V isolated power supply. Due to IGBT short circuit performance a maximum value of $V_{GE} \sim 15V$ is recommended
- Asymmetric power supply is also allowed e.g. -8V and +15V
- Input PWM voltage level should be selected according to the power supply voltage level. If an asymmetrical supply voltage of -8V/+15V is applied, the PWM signal should not exceed +15V and should not be lower than -8V

2.2 Key data

All values given in the table below are typical values, measured at an ambient temperature of $T_A = 25$ °C.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
<th>Value</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>$V_{DC}$</td>
<td>maximum DC voltage supply</td>
<td>±20</td>
<td>V</td>
</tr>
<tr>
<td>$I_G$</td>
<td>peak output current</td>
<td>±40</td>
<td>A</td>
</tr>
<tr>
<td>$R_{Gmin}$</td>
<td>minimum gate resistor value when $V_{DC}=\pm15V$ (internal module resistor $R_{INT}$ + external $R_{EXT}$)</td>
<td>0.1</td>
<td>Ω</td>
</tr>
<tr>
<td>$P_{DC/DC}$</td>
<td>max DC/DC output power per one channel$^1$</td>
<td>4</td>
<td>W</td>
</tr>
<tr>
<td>$f_S$</td>
<td>maximum PWM signal frequency</td>
<td>60</td>
<td>kHz</td>
</tr>
<tr>
<td>$T_{op}$</td>
<td>operating temperature (design target)$^2$</td>
<td>-55...+85</td>
<td>°C</td>
</tr>
<tr>
<td>$T_{sto}$</td>
<td>storage temperature (design target)</td>
<td>-55...+85</td>
<td>°C</td>
</tr>
</tbody>
</table>

$^1$ Only when MA400Exx is used together with 2ED300E17-SFO adapter board and 2ED300C17-S EiceDRIVER™

$^2$ Maximum ambient temperature strictly depends on MA40xExx load conditions.
2.3 Mechanical dimensions and mounting procedure

The MA40xExx should be screwed to the IHM auxiliary terminals according to AN2004-05. In that way necessary connections between module adapter and module itself are done correctly as shown in Figure 2.

![Figure 2](image)

**Figure 2** The MA400E12 correctly mounted on an IHM module

PCB outline and relevant dimensions needed for better system integration are shown in Figure 3.

![Figure 3](image)

**Figure 3** Dimensions of the MA400E12/17 module adapter board

The mechanical difference between MA400Exx and MA401Exx is the shifted position of the gate and emitter screw terminals according to the related IHM housing.

---

3 The AN2004-05: "Mounting process IHM modules" is available on the Infineon website.
2.4 Pin assignment

After the module adapter has been correctly mounted to the IHM module, all external electrical control signals are to be applied to connector X2 as shown on Figure 4 and listed in Table 2. If the MA40xExx is used in combination with the 2ED300E17-SFO, control signals required for module driving should be connected to the input interface of the 2ED300E17-SFO as described within the AN2007-05. In that way no additional connections between module and IGBT driver are needed.

![Diagram of connections between MA40xExx and 2ED300E17-SFO](image)

**Figure 4** Connections between 2ED300E17-SFO and MA400Exx or MA401Exx

<table>
<thead>
<tr>
<th>Pin</th>
<th>Label</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>X2.1</td>
<td>VCESAT</td>
<td>Desaturation voltage monitoring output</td>
</tr>
<tr>
<td>X2.2</td>
<td>VGE</td>
<td>Gate-emitter signal source</td>
</tr>
<tr>
<td>X2.3</td>
<td>VDC-</td>
<td>Isolated DC/DC negative voltage supply</td>
</tr>
<tr>
<td>X2.4</td>
<td>COM</td>
<td>Auxiliary emitter and power supply ground</td>
</tr>
<tr>
<td>X2.5</td>
<td>VDC+</td>
<td>Isolated DC/DC positive voltage supply</td>
</tr>
</tbody>
</table>

**Table 2** The external electrical signals description of MA400Exx and MA401Exx
3 Electrical features

The following section describes details of the adapter boards related to their electrical features.

3.1 Functionality on board

The MA400Exx or MA401Exx provide the following functions:
- Possibility to implement different gate resistors for turn-on and turn-off
- Bipolar booster stage with an output current of 40A
- \( V_{CE} \) monitoring for short circuit detection
- Active clamping

Figure 5 below depicts the MA40xExx with the functions described above and shows their physical location.

3.2 Gate resistors

Any MA40xExx is assembled and delivered without gate resistors as shown on Figure 5. The correct gate resistors have to be soldered by the customer according to the IGBT module used.

In case the values of \( R_{Gon} \) and \( R_{Goff} \) need to be different, the Diode D25 needs to be assembled to separately adjust the values of \( R_{Gon} \) and \( R_{Goff} \).

3.3 Gate signal amplifier

While the IGBT switches on or off, high peaks of the gate current have to be delivered from the driver. Usually there is no technical problem when driving a single module. If one IGBT driver is used for modules connected in parallel, the driver’s amplifier has to provide the cumulated gate currents. This switching condition leads to the gate power loss being concentrated in one relatively small physical area and may result in thermal problems. The high peak currents also require a high current gain driver.

Overcoming gain limitation becomes possible when the module adapter includes a dedicated gate signal amplifier. The schematic in Figure 6 shows, that the MA40xExx has an emitter follower or booster stage already implemented. Thanks to six complementary bipolar transistors connected in parallel the minimum gain \( @I_G=40A \) is not smaller than 100 based on ZXTN2010Z and ZXTP2012Z bipolar transistors datasheets.

---


---
Having a booster stage comes with the benefit to get excellent control on the gate-emitter voltage of any IHM-type module and enables a simplified design in paralleling IGBT-modules.

3.4 V_{CE} monitoring for short circuit detection

If the IGBT conducts a current a few times higher than the nominal value, the transistor desaturates and the voltage across the device increases. This behavior can be used for short circuit detection and turn-off of the IGBT. The short circuit needs to be detected and the IGBT has to be turned off without exceeding its maximum blocking voltage, within 10\mu s.

When the MA40xExx is connected to a 2ED300E17-SFO the R_{SSD} resistors that define the Soft Shut Down function must be chosen correctly in order to ensure proper short circuit protection. The detailed procedure is described in AN2007-05 chapter 3.5. Figure 7a shows the short circuit behavior of FZ1600R17HP4_B2 IHMB modules where short circuit protection on the 2ED300E17-SFO was disabled. To protect the device from destruction in this test, the gate-pulse applied to turn on had a duration of 10\mu s. High \(dl_{\text{C}}/dt\) during turn-off creates a large overvoltage spike which is limited by active clamping. Figure 7b depicts how soft shut-down with a properly selected R_{SSD} limits the short circuit time to less than 10\mu s and additionally decreases the collector current slew rate during turn-off.
3.5 Active clamping – boosted version

Active clamping is a technique which keeps transient overvoltages below the critical limits when the IGBT switches off. The standard approach to active clamping is to use a chain of avalanche diodes connected between the auxiliary collector and the gate of an IGBT module. When the Collector-Emitter voltage exceeds the diodes breakdown voltage the diodes current sums up with the current from the driver output. Due to the now increased gate-emitter voltage the transistor is held in an active mode and the turn off process is prolonged. The \( \frac{di}{dt} \) slows down which results in a limited voltage overshoot. Avalanche diodes conduct high peak currents during this time period in which the clamping is actively limiting the overvoltage.

Overvoltage protection within the MA40xExx is based on an improved variant of the active clamping as described above. The clamping diodes are connected directly to the IGBT’s gate but also to the input of the amplifier located on the MA40xExx. Therefore the major amount of current for recharging the gate is derived from the gate driver power supply instead of being drained through the clamping diodes. This provides more consistent clamping voltage due to operating the clamping diodes at a lower current level and furthermore enables the clamping circuit to be designed independently from the selected external gate resistor.

Figure 8 below displays the switching behavior of a FZ1600R17HP4 IGBT module at 900V DC voltage. During the turn off sequence, the gate current \( I_G \) from the booster, the current \( I_{CLAMP} \) through the active clamping diodes, the gate voltage \( V_{GE} \), the IGBT collector emitter voltage \( V_{CE} \) and the IGBT current \( I_C \) have been monitored. At the nominal current in figure 8a, the magnitude of the IGBT collector emitter voltage does not exceed the breakdown voltage of the avalanche diodes. The current through the diodes remains close to zero. At increased current levels, switching leads to an overshoot exceeding the avalanche diode breakdown voltage. The diodes now conduct high peak currents as marked in region A. This current leads to recharging of the gate by activating the booster stage and turning on the gate-voltage again. The IGBT is held in linear operation with decreasing collector current. As a consequence, the voltage across the device is reduced. As soon as the overvoltage gets down to the desired level, the clamping diodes return to blocking state turning off the gate as marked in region B. The turn-off procedure of the IGBT continues as desired.

![Figure 8](image)

**Figure 8**  Switching behavior of the FZ1600R17HP4_B2 IHM module with boosted active clamping where: a) \( V_{DC}=900V, I_C=1600A \), b) \( V_{DC}=900V, I_C=3200A \), \( R_{Goff}=0.47\Omega \) and \( T_j=25^\circ C \)

3.6 Maximum switching frequency

The switching frequency of an IGBT is limited either by the maximum power of the driver or by the maximum temperature of the PCB due to the power losses in the external gate resistors. These power losses in the gate resistors depend on the IGBT gate charge, gate voltage level and on the switching frequency of the IGBT. Due to the power losses in the external gate resistors heat will be generated, which leads to an increase of the PCB temperature in the neighborhood of these resistors. This temperature must not be higher than the operating temperature allowed for the PCB in use, i.e. 105°C for a standard FR4 material.
The calculation of the power losses in the gate resistors can be done by utilizing equation 1:

\[ P_{\text{dis}} = P(R_{\text{EXT}}) + P(R_{\text{INT}}) = \Delta V_{\text{out}} \cdot f_s \cdot Q_G \]  

(1)

The parameters used describe:
- \( P_{\text{dis}} \) the power dissipated [W],
- \( \Delta V_{\text{out}} \) the voltage step at the driver output [V],
- \( f_s \) the switching frequency [Hz],
- \( Q_G \) the IGBT gate charge for the given gate voltage range as given in the datasheet.

The complete gate resistor consists of the internal gate resistor \( R_{\text{INT}} \) and an external gate resistor \( R_{\text{EXT}} \) mounted on the MA40xE12/E17. Due to that, a part of the according losses will be dissipated directly through the DCB into the base plate, whereas the other part of the power losses will be dissipated externally to the ambient air and into the PCB. The ratio of the losses dissipated internally \( P(R_{\text{INT}}) \) and externally \( P(R_{\text{EXT}}) \) corresponds directly to the ratio of the mentioned resistors \( R_{\text{INT}} \) and \( R_{\text{EXT}} \). Figure 9 presents a measurement result showing the external gate resistor temperature as function of the losses generated in that resistor. It can be read from the graph, that for the ambient temperature of 25°C and the base plate temperature of 125°C the maximum temperature of the PCB reaches 105°C with power losses in \( R_{\text{EXT}} \) equal to 1.1W. In that case the limiting factor for the switching frequency is not the DC/DC converter with its available power of 4W per channel. Operation is limited due to the maximum temperature of the PCB. Higher switching frequency can only be obtained by utilizing a PCB with higher melting temperature or resistors with improved thermal transfer to ambient.

**Figure 9** MA400E12/17 PCB temperature vs. gate resistor power losses

In order to calculate the allowed power losses \( P(R_{\text{EXT}}) \) when the base plate and the ambient temperatures differ from the example shown above, formula (2) can be used.

\[ \frac{P(R_{\text{EXT}})}{W} = \left( \frac{105^\circ C - T_C}{71} \right) + \left( \frac{105^\circ C - T_A}{58} \right) \]  

(2)
Finally, the suggested IGBT maximum switching frequency for a given $T_C$ and a $T_A$ for the MA400Exx used in combination with the 2ED300E17-SFO is given by formula (3)

$$\frac{f_s}{Hz} = \frac{P(R_{EXT})}{W} \cdot \left( \frac{R_{INT}}{\Omega} + \frac{R_{EXT}}{\Omega} \right)$$

$$30 \cdot k \cdot \frac{R_{EXT}}{\Omega} \cdot \frac{Q_s}{\mu C}$$

(3)

The factor $k=1.2$ represents a set of tolerances and is based on measurements and experiences.

### 3.8 Parallel operation

The Flexible Starter Kit consisting of one 2ED300E17-SFO, one 2ED300E17-S/-ST driver board and the MA40xExx module adapter boards can be used for driving one IHM module or up to three paralleled IHM modules as sketched in Figure 10. In this case all the IHM modules have dedicated MA40xExx boards connected to the 2ED300E17-SFO adapter board. It must be noted that $R_{SSD}$ in every case should be selected according to AN2007-05 chapter 3.5.

![Figure 10](connections.png)  
*Connections between three MA40xExx and one 2ED300E17-SFO operating three IHM-Modules in parallel connection*
4 Schematic and Layout

To meet the individual customer requirements and to make the evaluation board a basis for further development or modification, all necessary technical data including schematics, PCB layout and components are included in this chapter.

4.1 Schematic

Figure 11 The MA40xExx – booster stage

Figure 12 The MA40xExx – IGBT connections

Figure 13 The MA40xExx – connectors
4.2 Assembly drawing

Basic circuit and layout for the MA400E12 or E17 and MA401E12 or E17 are similar. To adapt the board to the proper voltage rating the active clamping diodes have to be chosen according to Table 3. Figure 14 gives an overview of the assembly of the MA400E12 Adapter board.

Table 3 Assembly of Active clamping diodes on the MA400Exx board

<table>
<thead>
<tr>
<th>Board Names</th>
<th>Assembled diodes</th>
<th>Types of assembled diodes</th>
</tr>
</thead>
<tbody>
<tr>
<td>MA40xE12_EVAL</td>
<td>ZD1, ZD2, ZD3, ZD4</td>
<td>SMJC188A</td>
</tr>
<tr>
<td>MAx0xE17_EVAL</td>
<td>ZD1, ZD2, ZD3</td>
<td>1.5SMC440A</td>
</tr>
<tr>
<td></td>
<td>ZD4</td>
<td>Shorted by wire or 0R resistor</td>
</tr>
</tbody>
</table>

Figure 14 The MA400E12 – assembly drawing

4.3 Layout

Figure 15 The MA400E12 – Top layer
4.4 **Bill of Material – MA400E12_EVAL / MA401E12_EVAL**

The bill of material includes a part list as well as assembly notes. The tolerances for resistors should be less or equal to ±1 %, for capacitors of the type C0G less or equal to ±5 % and for capacitors of the type X7R less or equal to ±10 %.

<table>
<thead>
<tr>
<th>Type</th>
<th>Value / Type</th>
<th>Package size</th>
<th>QTY</th>
<th>Name Part</th>
<th>Recommended Manufacturer</th>
<th>Assembly</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resistor</td>
<td>see chapter 3.2*</td>
<td>2512</td>
<td>9</td>
<td>R1, R2, R3, R4, R5, R6, R7, R8, R28</td>
<td>special pulse resistors</td>
<td>no</td>
</tr>
<tr>
<td>Resistor</td>
<td>10k</td>
<td>1206</td>
<td>1</td>
<td>R9</td>
<td>no special</td>
<td>yes</td>
</tr>
<tr>
<td>Resistor</td>
<td>1R</td>
<td>1206</td>
<td>4</td>
<td>R11, R12, R22, R27</td>
<td>special pulse resistors</td>
<td>yes</td>
</tr>
<tr>
<td>Resistor</td>
<td>10R</td>
<td>1206</td>
<td>1</td>
<td>R21</td>
<td>no special</td>
<td>yes</td>
</tr>
<tr>
<td>Resistor</td>
<td>10R</td>
<td>0603</td>
<td>6</td>
<td>R17, R18, R19, R20, R25, R26</td>
<td>no special</td>
<td>yes</td>
</tr>
<tr>
<td>Resistor</td>
<td>27R</td>
<td>0603</td>
<td>6</td>
<td>R13, R14, R15, R16, R23, R24</td>
<td>no special</td>
<td>yes</td>
</tr>
<tr>
<td>Capacitor</td>
<td>variable</td>
<td>0805</td>
<td>2</td>
<td>C17, C217</td>
<td>no special</td>
<td>no</td>
</tr>
<tr>
<td>Capacitor</td>
<td>variable</td>
<td>C2220</td>
<td>1</td>
<td>C9</td>
<td>optional</td>
<td>no</td>
</tr>
<tr>
<td>Capacitor</td>
<td>4µ7/25V/X7R</td>
<td>1206</td>
<td>24</td>
<td>C1, C2, C3, C4, C5, C6, C7, C8, C21, C22, C23, C24, C25, C26, C27, C28, C29, C30, C11, C12, C13, C14, C15, C216</td>
<td>Murata</td>
<td>yes</td>
</tr>
<tr>
<td>Semiconductor</td>
<td>ZXTN2010Z</td>
<td>SOT89</td>
<td>6</td>
<td>T1, T2, T3, T4, T5, T6</td>
<td>Diodes</td>
<td>yes</td>
</tr>
<tr>
<td>Semiconductor</td>
<td>ZXTP20122</td>
<td>SOT89</td>
<td>6</td>
<td>T7, T8, T9, T10, T11, T12</td>
<td>Diodes</td>
<td>yes</td>
</tr>
<tr>
<td>Semiconductor</td>
<td>ES1B (see chapter 3.2)</td>
<td>DO214AC</td>
<td>4</td>
<td>D5, D6, D25, D26</td>
<td>Vishay</td>
<td>no</td>
</tr>
<tr>
<td>Semiconductor</td>
<td>ES1B</td>
<td>DO214AC</td>
<td>4</td>
<td>D21, D22, D23, D25</td>
<td>Vishay</td>
<td>yes</td>
</tr>
<tr>
<td>Semiconductor</td>
<td>STTH112U</td>
<td>SMB</td>
<td>1</td>
<td>D24</td>
<td>STM</td>
<td>yes</td>
</tr>
<tr>
<td>Semiconductor</td>
<td>SMCJ188A</td>
<td>SMC</td>
<td>4</td>
<td>ZD1, ZD2, ZD3, ZD4</td>
<td>Vishay</td>
<td>yes</td>
</tr>
<tr>
<td>Connector</td>
<td>6410-5A</td>
<td>1</td>
<td></td>
<td>X2</td>
<td>Molex (22-27-2051)</td>
<td>yes</td>
</tr>
</tbody>
</table>
4.5 Bill of Material – MA400E17_EVAL / MA401E17_EVAL

The bill of material includes a part list as well as assembly notes.

The tolerances for resistors should be less or equal to ±1 %, for capacitors of the type C0G less or equal to ±5 % and for capacitors of the type X7R less or equal to ±10 %.

Table 5 Bill of Material for the MA400E17 adapter board

<table>
<thead>
<tr>
<th>Type</th>
<th>Value / Type</th>
<th>Package size imperial</th>
<th>QTY</th>
<th>Name Part</th>
<th>Recommended Manufacturer</th>
<th>Assembly</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resistor</td>
<td>see chapter 3.2*</td>
<td>2512</td>
<td>9</td>
<td>R1, R2, R3, R4, R5, R6, R7, R8, R28</td>
<td>special pulse resistors</td>
<td>no</td>
</tr>
<tr>
<td>Resistor</td>
<td>10k</td>
<td>1206</td>
<td>1</td>
<td>R9</td>
<td>no special</td>
<td>yes</td>
</tr>
<tr>
<td>Resistor</td>
<td>1R</td>
<td>1206</td>
<td>4</td>
<td>R11, R12, R22, R27</td>
<td>special pulse resistors</td>
<td>yes</td>
</tr>
<tr>
<td>Resistor</td>
<td>10R</td>
<td>0603</td>
<td>1</td>
<td>R21</td>
<td>no special</td>
<td>yes</td>
</tr>
<tr>
<td>Resistor</td>
<td>10R</td>
<td>0603</td>
<td>6</td>
<td>R17, R18, R19, R20, R25, R26</td>
<td>no special</td>
<td>yes</td>
</tr>
<tr>
<td>Resistor</td>
<td>27R</td>
<td>0603</td>
<td>6</td>
<td>R13, R14, R15, R16, R23, R24</td>
<td>no special</td>
<td>yes</td>
</tr>
<tr>
<td>Capacitor</td>
<td>variable</td>
<td>0805</td>
<td>2</td>
<td>C17, C217</td>
<td>no special</td>
<td>no</td>
</tr>
<tr>
<td>Capacitor</td>
<td>variable</td>
<td>C2220</td>
<td>1</td>
<td>C9</td>
<td>optional</td>
<td>no</td>
</tr>
<tr>
<td>Capacitor</td>
<td>4u7/25V/X7R</td>
<td>1206</td>
<td>24</td>
<td>C1, C2, C3, C4, C5, C6, C7, C8, C21, C22, C23, C24, C25, C26, C27, C28, C29, C30, C210, C211, C212, C213, C214, C215, C216</td>
<td>Murata</td>
<td>yes</td>
</tr>
<tr>
<td>Semiconductor</td>
<td>ZXTN2010Z</td>
<td>SOT89</td>
<td>6</td>
<td>T1, T2, T3, T4, T5, T6</td>
<td>Diodes</td>
<td>yes</td>
</tr>
<tr>
<td>Semiconductor</td>
<td>ZXTNP2012Z</td>
<td>SOT89</td>
<td>6</td>
<td>T7, T8, T9, T10, T11, T12</td>
<td>Diodes</td>
<td>yes</td>
</tr>
<tr>
<td>Semiconductor</td>
<td>ES1B (see chapter 3.2)</td>
<td>DO214AC</td>
<td>4</td>
<td>D5, D6, D25, D26</td>
<td>Vishay</td>
<td>no</td>
</tr>
<tr>
<td>Semiconductor</td>
<td>ES1B</td>
<td>DO214AC</td>
<td>4</td>
<td>D21, D22, D23, D25</td>
<td>Vishay</td>
<td>yes</td>
</tr>
<tr>
<td>Semiconductor</td>
<td>STTH112J</td>
<td>SMB</td>
<td>1</td>
<td>D24</td>
<td>STM</td>
<td>yes</td>
</tr>
<tr>
<td>Semiconductor</td>
<td>1.5SMC440A</td>
<td>SMC</td>
<td>3</td>
<td>ZD1, ZD2, ZD3</td>
<td>Vishay</td>
<td>yes</td>
</tr>
<tr>
<td>Semiconductor</td>
<td>SMC</td>
<td>1</td>
<td>ZD4 (Shorted by 0R)</td>
<td>Vishay</td>
<td>no</td>
<td></td>
</tr>
<tr>
<td>Connector</td>
<td>6410-5A</td>
<td>1</td>
<td>X2</td>
<td></td>
<td>Molex (22-27-2051)</td>
<td>yes</td>
</tr>
</tbody>
</table>

*Pulse power rated types
5 How to order Evaluation Driver Boards

Every Evaluation Driver Board has its own IFX order number and can be ordered via your Infineon Sales Partner.

Information can also be found at the Infineon Web Page: www.infineon.com

CAD-data for the board described here are available on request. The use of this data is subjected to the disclaimer given in this AN. Please contact: WAR-IGBT-Application@infineon.com

IFX order number for MA400E12: SP000879862
IFX order number for MA400E17: SP000879872
IFX order number for MA401E12: SP000880276
IFX order number for MA401E17: SP000880282
IFX order number for 2ED300E17-SFO: SP000355559
IFX order number for 2ED300C17-S: SP000359184
IFX order number for 2ED300C17-ST: SP000359188