

AN2007-05

2ED300E17-SFO

Evaluation Board for 2ED300C17-S/-ST
IGBT driver

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IFAG AIM PMD ID AE



Never stop thinking

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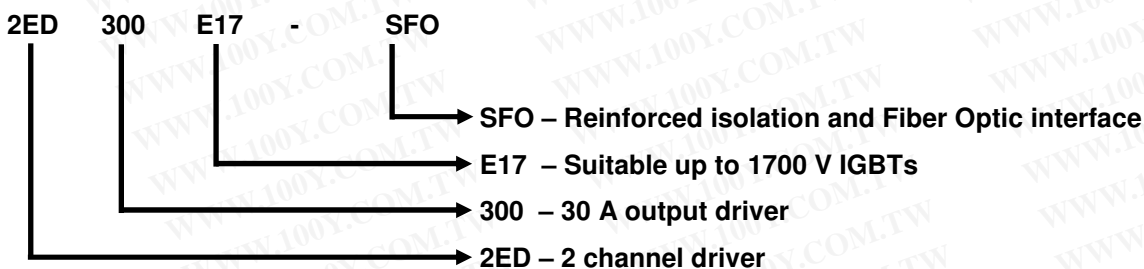
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Part number explanation:



1 Introduction

The 2ED300E17-SFO evaluation board shown in Figure 1 offers basic support for the EiceDRIVER™ 2ED300C17-S and 2ED300C17-ST IGBT drivers. Enabling embedded driver's functions the evaluation board can be used as platform when power electronic system employing Infineon IGBT modules in 600V, 1200V and 1700V class is being designed. This evaluation board is especially useful together with MA300E12 or MA300E17 as another evaluation boards dedicated to PrimePACK™ modules in 1200 V and 1700 V voltage class. Exhaustive information about the universal driver set dedicated for PrimePACK™ modules is available in AN2007-06.

The 2ED300E17-SFO evaluation board is 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 production according to his specific requirements.

The design of the 2ED300E17-SFO was performed with respect to the environmental conditions described in 2ED300C17-S /-ST EiceDRIVER™ datasheet. The requirements for leadfree reflow soldering have been considered when components were selected. The design was tested as described in this documentation but not qualified regarding manufacturing and operation in 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.

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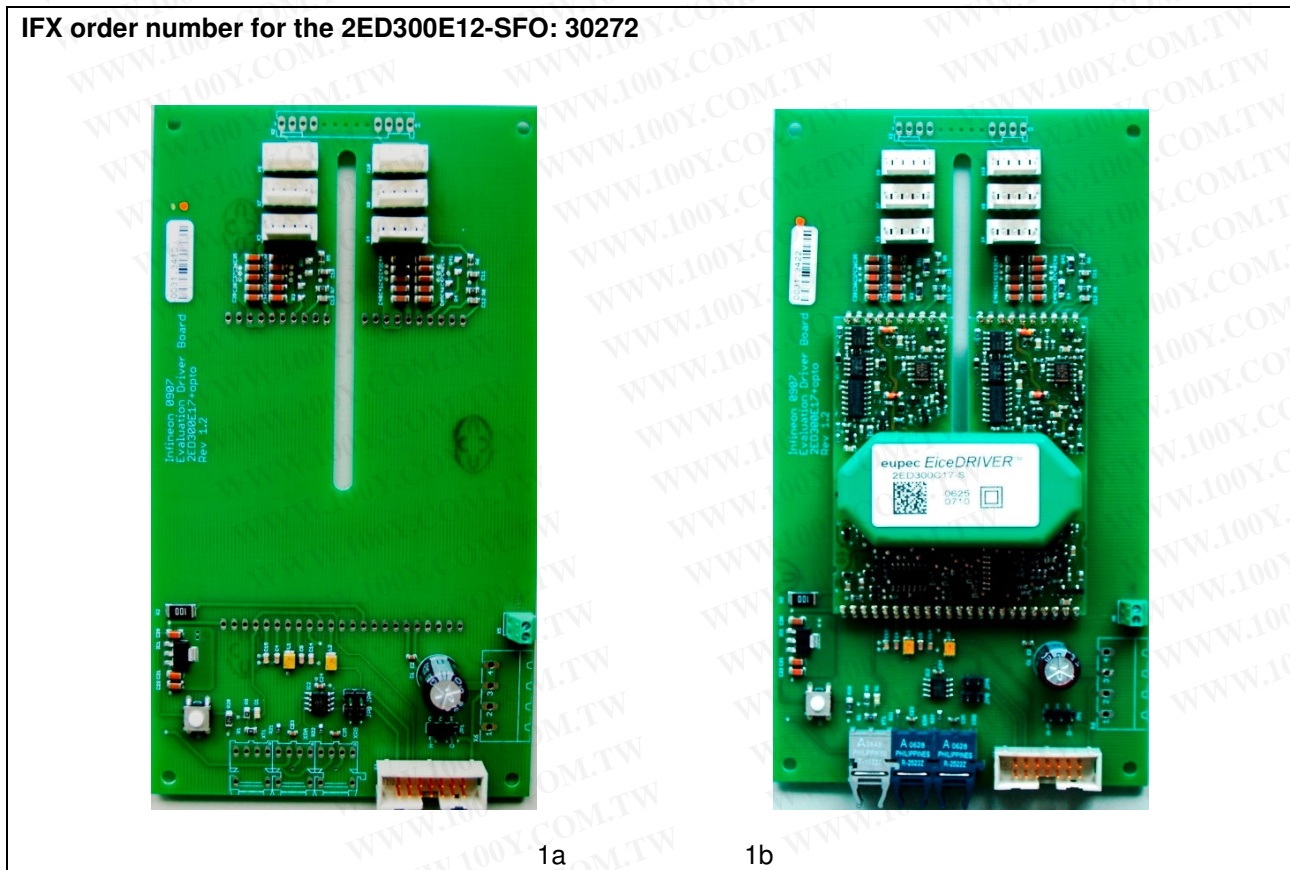


Figure 1 The 2ED300E17-SFO Evaluation Board - 1a, assembled with 2ED300C17-S EiceDRIVER™ and Fiber Optic devices – 1b

2 Design features

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

2.1 Main features

The 2ED300E17-SFO evaluation board offers the following features:

- Dual channel IGBT driver together with 2ED300C17-S /-ST EiceDRIVER™
- Electrically suitable for 600 V, 1200 V and 1700 V IGBT modules like: IHM, 62mm, EconoDUAL™, EconoPACK+™
- Electrically and mechanically suitable for PrimePACK™ modules family when used with MA300E12 or MA300E17
- Electrical and optical interface
- Under Voltage Lockout
- Short circuit protection
- PCB is designed to fulfil the requirements of IEC61800-5-1, pollution degree 2, overvoltage category III

2.2 Key data

All values given in the table bellow are typical values, measured at $T_A = 25\text{ °C}$

Table 1 General key data and characteristic values

Parameter	Value	Unit
V_{DC} – primary DC voltage supply	+15 (±1)	V
I_{DC} – primary DC current drawn (idle mode)	100	mA
f_s – max. PWM signal frequency for A and B channel ¹	60	kHz
T_{op} – operating temperature (design target)	-40...+85	°C
T_{sto} – storage temperature (design target)	-40...+85	°C

Table 2 Key data and characteristic values for electrical interface

Parameter	Value	Unit
$V_{IN A} / V_{IN B}$ – PWM signals for A and B driver channel (active high)	0 / + V_{DC}	V
V_{FAULT} – FAULT detection output (active high)	0 / + V_{DC}	V
I_{FAULT} – max. FAULT detection output load current (open collector output)	20	mA
V_{RST} – reset input (active high)	0 / + V_{DC}	V

Table 3 Key data and characteristic values for optical interface

Parameter	Value	Unit
PWM signals for A and B driver channel (IGBT ON command)	Light ON	--
FAULT detection output (fault report)	Light ON	--

¹ Given switching frequency is limited by driver capabilities. The maximum switching frequency for every IGBT module type should be calculated separately. Limitation factors are: max. DC/DC output power of 4 W per channel and max. PCB board temperature measured around gate resistors placed on separated board close to IGBT module.

2.3 Pin assignment

All external driver electrical control signals should be applied to connector X1 as shown on Fig. 2 and listed in Table 4. Needed voltage power supply for a driver can be connected to X1 but also to X6 or X5 when convenient (Table 5).

Connector X2 offers 2ED300C17-S /-ST EiceDRIVER™ necessary signals to drive an IGBT module with minimum number of required external components. The necessary circuit and functionality describes chapter 3.5 and control signals are listed in Table 6. This basic circuit is universal and together with 2ED300C17-S EiceDRIVER™ can be used for medium and high power modules when V_{CES} module voltage is lower than 1700V.

Connectors: X3, X7, X9 and respectively X4, X8, X10 are in parallel. In practice an additional circuit containing at least amplifier for an IGBT gate signal must be used. This function and additional like: Active Clamping which keeps temporary V_{CE} overvoltages bellow V_{CES} , V_{CE} desaturation diodes as part of short circuit protection schema, gate resistors and others are successfully implemented into MA300E12 and MA300E17 evaluation boards. As can be simply concluded the MA300EXX boards are electrically fitting to signals described in Table 7 and give working platform when PrimePACK™ modules are driven. Chapter 3.8 presents more general information how system consisting of 2ED300E17-SFO adapter board together with 2ED300C17-S EideDRIVER™ and MA300EXX can be practically utilized. Separated AN2007-06 describes MA300XX in details and gives practical hints on the topic.

Table 4 2ED300E17-SFO and the control signals for connector X1

Pin	Label	Function
X1.1, X1.6, X1.7, X1.13 X1.14	n.c.	Not Connected
X1.2	IN B	PWM signal for channel B
X1.3	/FAULT	Fault detection output for combined for channel A and B
X1.4	IN A	PWM signal for channel A
X1.5	RESET	Reset signal for channel A and B
X1.8, X1.9	V_{DC}	Primary voltage supply for DC/DC converter
X1.10, X1.11	GND	Primary ground for DC/DC converter and control singals
X1.12	Modus	Half-bridge or direct mode selection

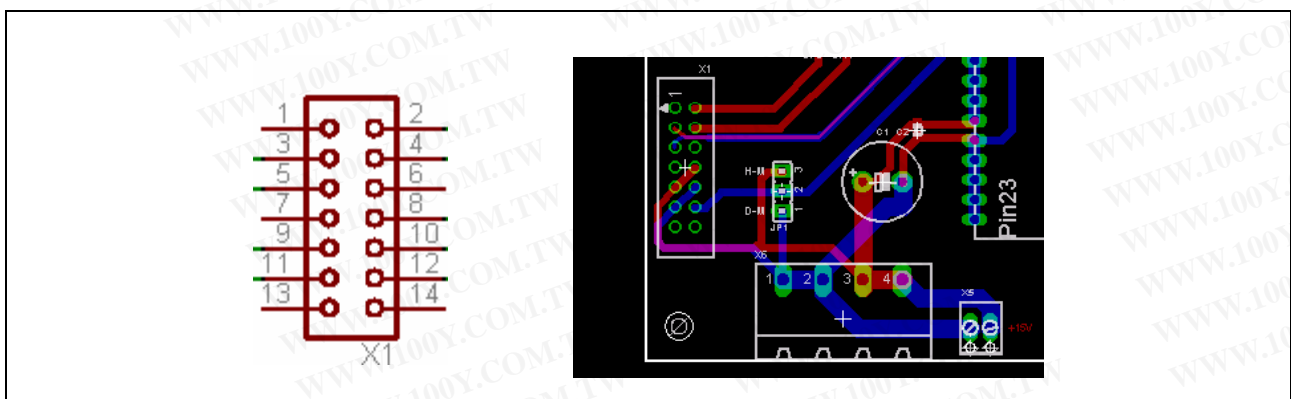


Figure 2 The 2ED300E17-SFO Evaluation Driver Board pin assignment for the driver control signals and DC/DC voltage power supply

Table 5 Additional power supply of 2ED300E17-SFO (connector X5 and X6)

Pin	Label	Function
X5.1, X6.1, X6.2	GND	Primary ground for DC/DC converter
X5.2, X6.3, X6.4	V_{DC}	Primary voltage supply for DC/DC converter

Table 6 2ED300E17-SFO and connection to IGBT (connector X2)

Pin	Label	Function
X2.1	V_{CE sat} A	Desaturation voltage monitoring input – channel A
X2.2	Gate A	Driver output to IGBT gate via an external gate resistor – channel A
X2.3	COM A	Auxiliary emitter – channel A
X2.4	Sense A	Control input for 'Soft Shut Down' or 'Active Clamping' – channel A
X2.5, X2.6, X2.7, X2.8, X2.9,	n.c.	Not Connected
X2.10	V_{CE sat} B	Desaturation voltage monitoring input – channel B
X2.11	Gate B	Driver output to IGBT gate via an external gate resistor – channel B
X2.12	COM B	Auxiliary emitter – channel B
X2.13	Sense B	Control input for 'Soft Shut Down' or 'Active Clamping' – channel B

Table 7 2ED300E17-SFO and connection to MA300Exx

Pin	Label	Function
X3.1, X7.1, X9.1	VA+	Isolated power supply, positive voltage – channel A (+15V)
X3.2, X7.2, X9.2	COMA	Auxiliary emitter – channel A
X3.3, X7.3, X9.3	VA-	Isolated power supply, negative voltage – channel A (-15V)
X3.4, X7.4, X9.4	Sense A	Gate - emitter signal source – channel A
X3.5, X7.5, X9.5	V_{CE sat} A	Desaturation voltage monitoring input – channel A
X4.1, X8.1, X10.1	VB+	Isolated power supply, positive voltage – channel B (+15V)
X4.2, X8.2, X10.2	COMB	Auxiliary emitter – channel B
X4.3, X8.3, X10.3	VB-	Isolated power supply, negative voltage – channel B (-15V)
X4.4, X8.4, X10.4	Sense B	Gate – emitter signal source – channel B
X4.5, X8.5, X10.5	V_{CE sat} B	Desaturation voltage monitoring input – channel B

2.4 Mechanical dimensions of the 2ED300E17-SFO Evaluation Board

The 2ED300E17-SFO outline assembled with driver is shown in Figure 3.

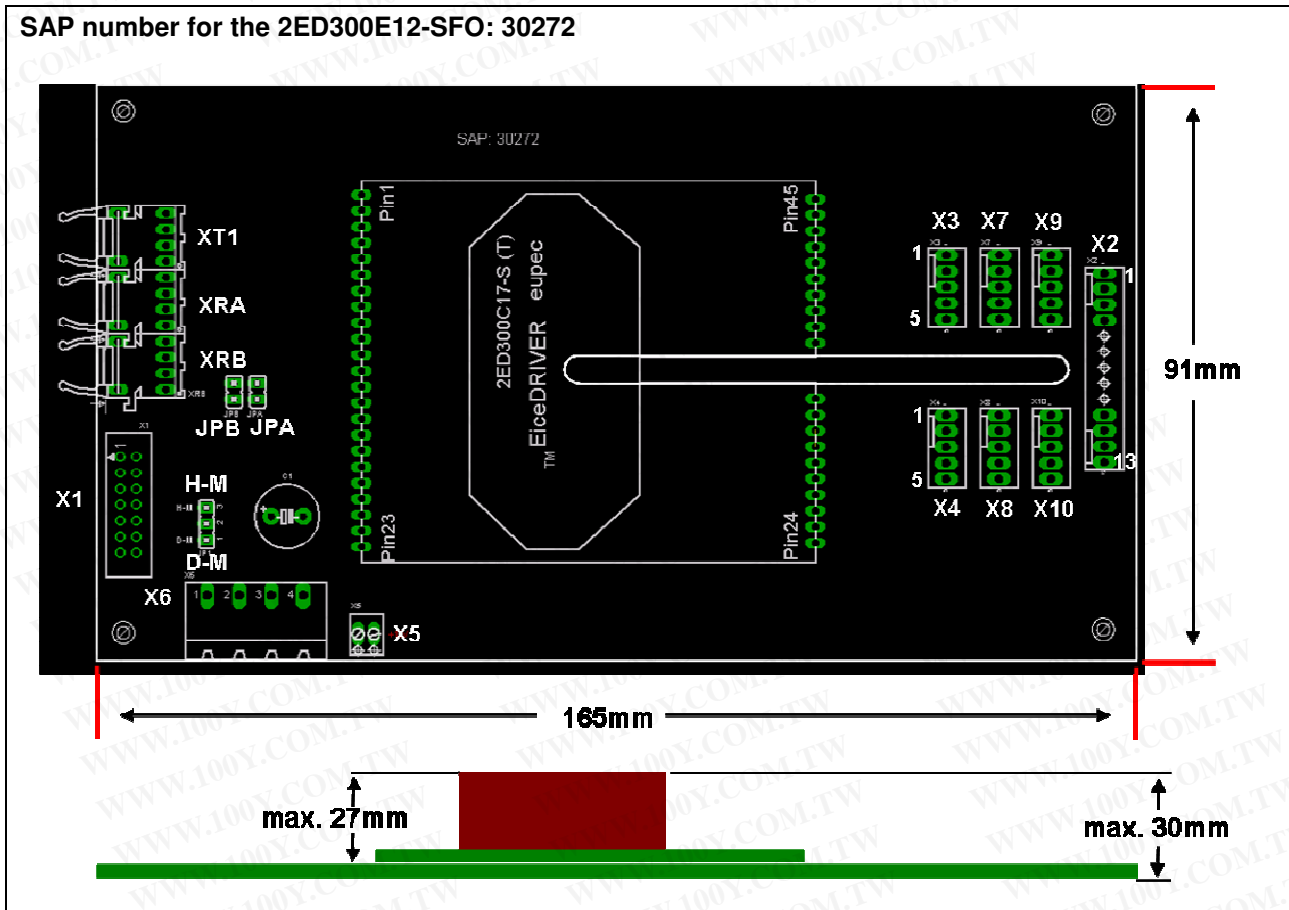


Figure 3 Dimensions of the 2ED300E17-SFO

3 Application Note

The following chapter describes functionality of the 2ED300E17-SFO in combination with 2ED300C17-S /-ST EiceDRIVER™ in details.

3.1 Power Supply

The 2ED300E17-SFO provides +5V DC regulated voltage needed for fiber optic devices but also supplies the 2ED300C17-S /-ST EiceDRIVER™. In order to get the EiceDRIVER™ properly working the external DC voltage source must fulfill requirements mentioned in chapter 2.3 and Table 1.

3.2 Input logic – PWM signals

The evaluation board offers two independent control interfaces: electrical and optical. The way of communication with the EiceDRIVER™ can be selected by customer accordingly to the individual needs.

Electrical interface is simply activated by applying suitable signals¹ to appropriate pins in connector X1 as described in chapter 2.4, Table 4 and Table 5. Jumpers JPA and JPB visible on Figure 3 in that mode must be open.

When IGBT is driven using optical interface the fiber optic cables should be connected to receiver XRA in order to drive channel A and respectively XRB to drive channel B. Jumpers JPA and JPB in that case must be closed (Figure 3). No electrical signals except power supply connected to X1 are needed. Other connections should be removed. Keeping power supply connected to X5 or X6 and leaving X1 completely unconnected seems to be the easiest solution.

3.3 Fault output and Reset

When the driver detects IGBT short circuit or V_{GE} drops below acceptable value the controlled IGBT will be switched off safely and a fault will be reported. The event is additionally indicated by lighting diode D1. Voltage on X1.3 changes from V_{DC} level to around 1V and diode in transmitter XT1 is switched on.

Regardless PWM signals the IGBT stays off and fault is indicated. In order to get driver operating again the driver must be reseted in one of three possible ways:

- Pressing switch S1
- Apply voltage with a positive edge greater than 10V (max. V_{DC}) to X1.5
- Keeping PWM signals on “low” level for more than 60ms

Keeping the switch S1 pressed long time may lead to permanent IGBT destruction when the reason for short circuit or low V_{GE} remains.

Reseting procedure is needed always after fault indication.

¹ Detailed requirements for the electrical input interface are described in 2ED300C17-S /-ST datasheet available on www.infineon.com website.

3.4 Direct or Half-bridge mode selection

Two operation modes for the 2ED300C17-S EiceDRIVER™ are possible:

- Direct mode – means that both channels A and B are working accordingly to PWM signals. It is possible to switch on both channels A and B at the same time. This operation mode can be activated by setting the JP1 jumper on position marked as D-M (shorting pins 1 and 2 on Figure 3). When jumper JP1 is used there is no need to short X1.12 to GND of power supply
- Half-bridge mode is especially useful when IGBTs are driven in half bridge configuration. By proper selection of capacitor values C4 and C5 the required dead time between channels A and B can be provided. This operation mode can be activated by setting the JP1 jumper on position marked as H-M (shorting pins 2 and 3 on Figure 3). When jumper JP1 is used there is no need to short X1.12 to V_{DC}. Table 8 shows how dead time depends on these capacitors value. The dead time with not connected capacitors is 1,6µs.

Table 8 Dead time settings

C4 and C5	n.c.	47pF	100pF	220pF	330pF	470pF	1nF
Dead time	1,6µs	2µs	2,4µs	3,4µs	4,3µs	5,4µs	9,6µs

The 2ED300E17-SFO is already equipped with C4=C5=470pF meaning that when JP1 is on position H-M than interlocking time between channel A and B will reach 5,4µs.

3.5 SSD – ‘Soft Shut Down’

The ‘Soft Shut Down’ function secures an IGBT module when short circuit current is being switched off. This function is widely described in 2ED300C17-S EiceDRIVER™ application note (chapter 3.8). Resistor called R_{SSD} in the 2ED300E17-SFO is called R3, R31 (are in parallel) for channel A and R4, R41 (are in parallel) for channel B and should be selected accordingly to module type.

These resistors originally are not soldered. In order to provide the correct SSD function resistors R3, R31, R4 and R41 must be properly calculated. The calculation example is shown bellow:

$$\frac{R_{SSD}}{k\Omega} = \frac{346,8}{\frac{Q_g \cdot 16,8}{\mu C} - 51} \quad (1)$$

where:

Q_g – gate charge of selected IGBT module type

Due to resistors parallel connection the final value gives formula 3.

$$R3 = R31 = R4 = R41 = 2 \cdot R_{SSD} \quad (2)$$

When PrimePACK™ modules are used than Table 9 shows already calculated R_{SSD} resistors values.

Table 9 R_{SSD} settings

Module type	R3, R31, R4, R41 (1206 package) proposed values
FF650R17IE4	10 kΩ
FF1000R17IE4	5,6 kΩ
FF600R12IP4 / FF600R12IE4	22 kΩ
FF900R12IP4 / FF900R12IP4D	8k2 kΩ
FF1400R12IP4	4k7 kΩ

3.6 Reference curve and and trigger suppression

Correct short circuit operation requires also proper short circuit detection. The issue has been described in 2ED300C17-S EiceDRIVER™ in chapter 3.7.

Passive components like C_{SA} , R_{SA} , C_{SB} , R_{SB} are responsible for suitable 'blanking time' and set up the V_{CE} desaturation threshold voltage. In 2ED300E17-SFO adapter board these passive components are respectively named as C12, R7 - channel A and C13, R8 – channel B.

Additional ones responsible for trigger suppression are C_{VCE} and R_{VCE} and their equivalents in 2ED300E17-SFO are C10, R5 – channel A and C11, R6 – channel B.

All components mentioned in this chapter are soldered into 2ED300E17-SFO and their values as default are listed below:

C12=C13= 560pF

R7=R8= 22k Ω

C10=C11=1nF

R5=R6=470 Ω

It has to be noticed that those values may not be proper for all IGBT modules driven by this adapter board.

3.7 The minimum circuit for proper X2 utilisation

The 2ED300E17-SFO evaluation board together with 2ED300C17-S EiceDRIVER™ makes system able to drive various Infineon IGBT modules. Connector X2 provides needed functions nevertheless basic circuit shown on Figure 4 is required.

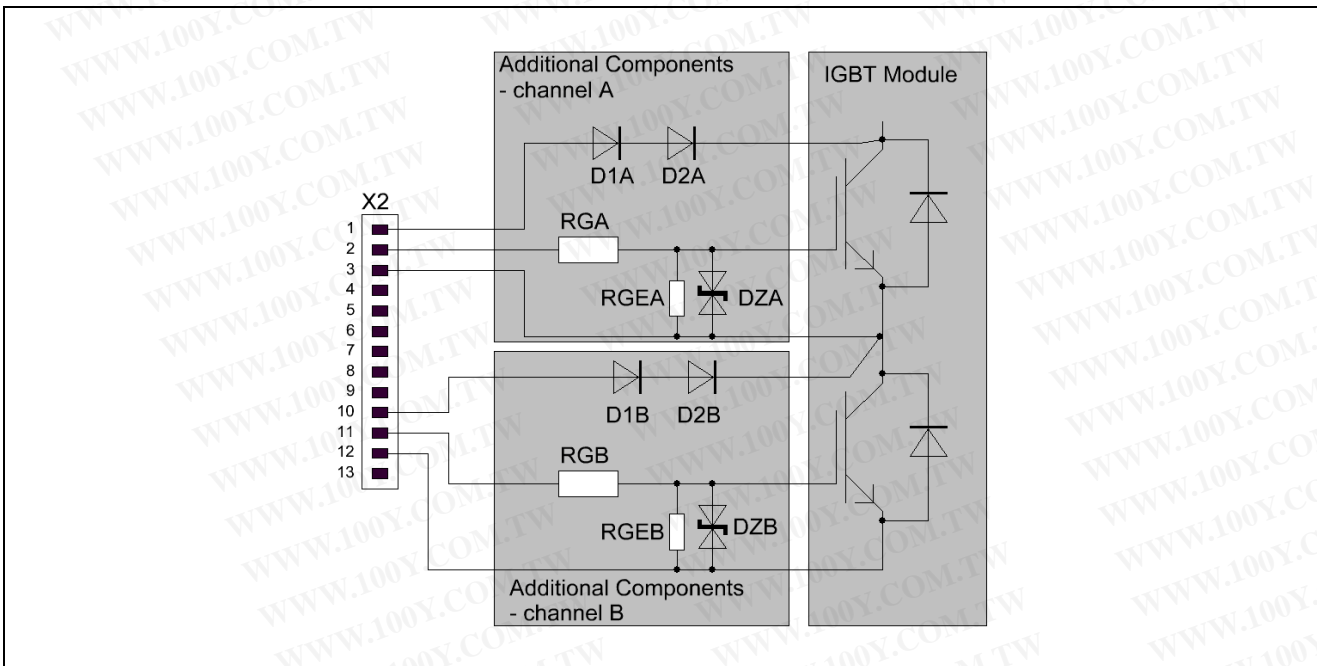


Figure 4 Additional components needed for driving IGBT module

Practical selection for parts visible on Figure 4 is described in 2ED300C17-S EiceDRIVER™ application note chapter 3.6.

3.8 Operation with MA300E12 or MA300E17

As mentioned in introduction of this application note the 2ED300E17-S evaluation board is prepared for easy usage together with MA300Exx. To operate the MA300Exx it should be screwed to the PrimePACK™ module and connected by simple cable to one pair of 2ED300E17-SFO connectors e.g. X9 and X11. Parallel IGBT module operation is also possible and maximum number of them in configuration presented on Figure 5 is three. Additional aluminium capacitors with minimum value of 100µF/35V connected in parallel across C30, C35 and C40, C45 for module proper operation is required.

Table 9 presents resistors value needed for correct short circuit protection. When parallel module operation is intended those resistors values must be recalculated accordingly to exaplmne given in chapter 3.5.

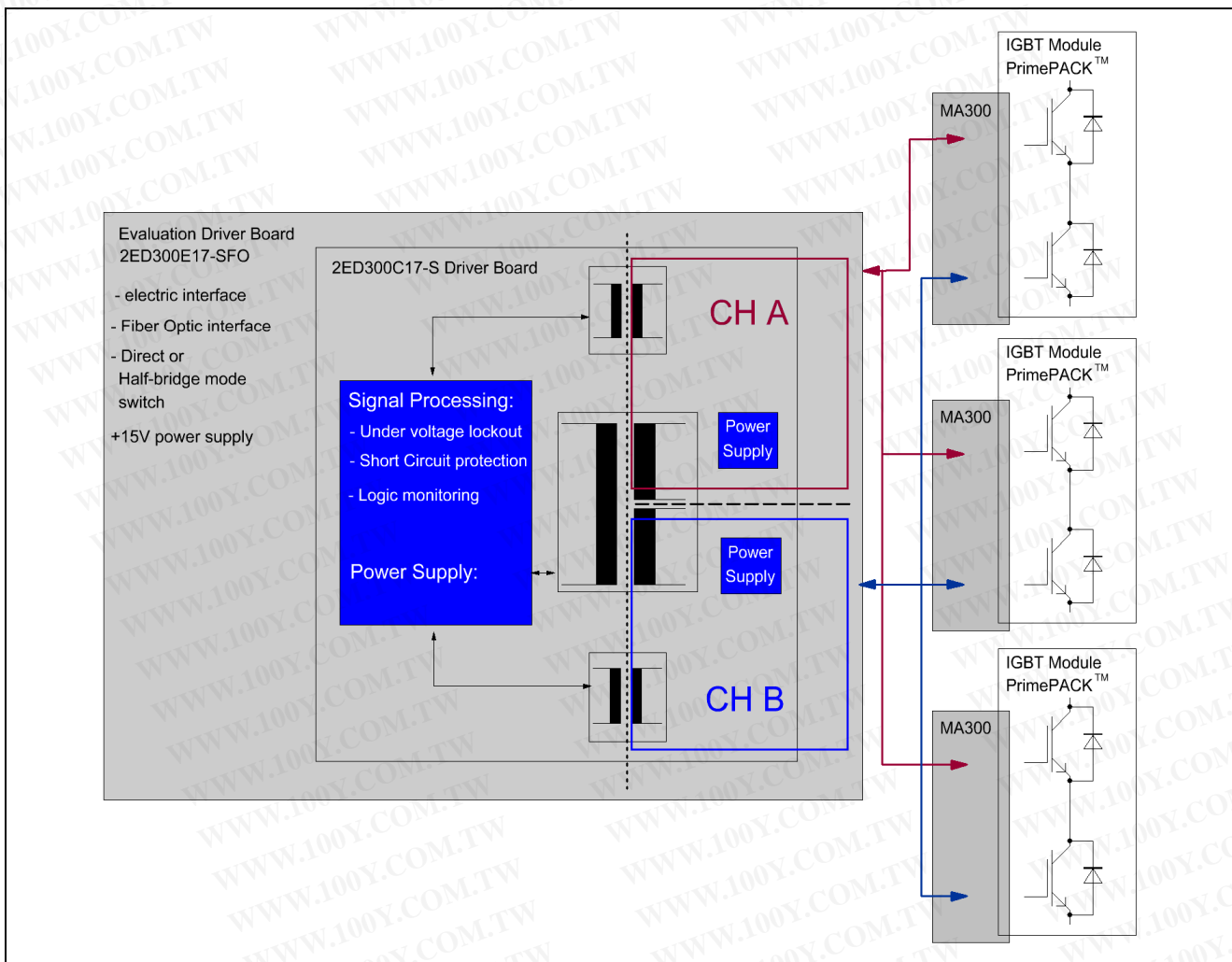


Figure 5 Driver set for parallel PrimePACK™ IGBT module operation

4 Schematic, Layout and Bill of Material

To meet the individual customer requirement and make the evaluation board useful for development or modification, all necessary technical data like schematic, layout and components are included in this chapter.

4.1 Schematic

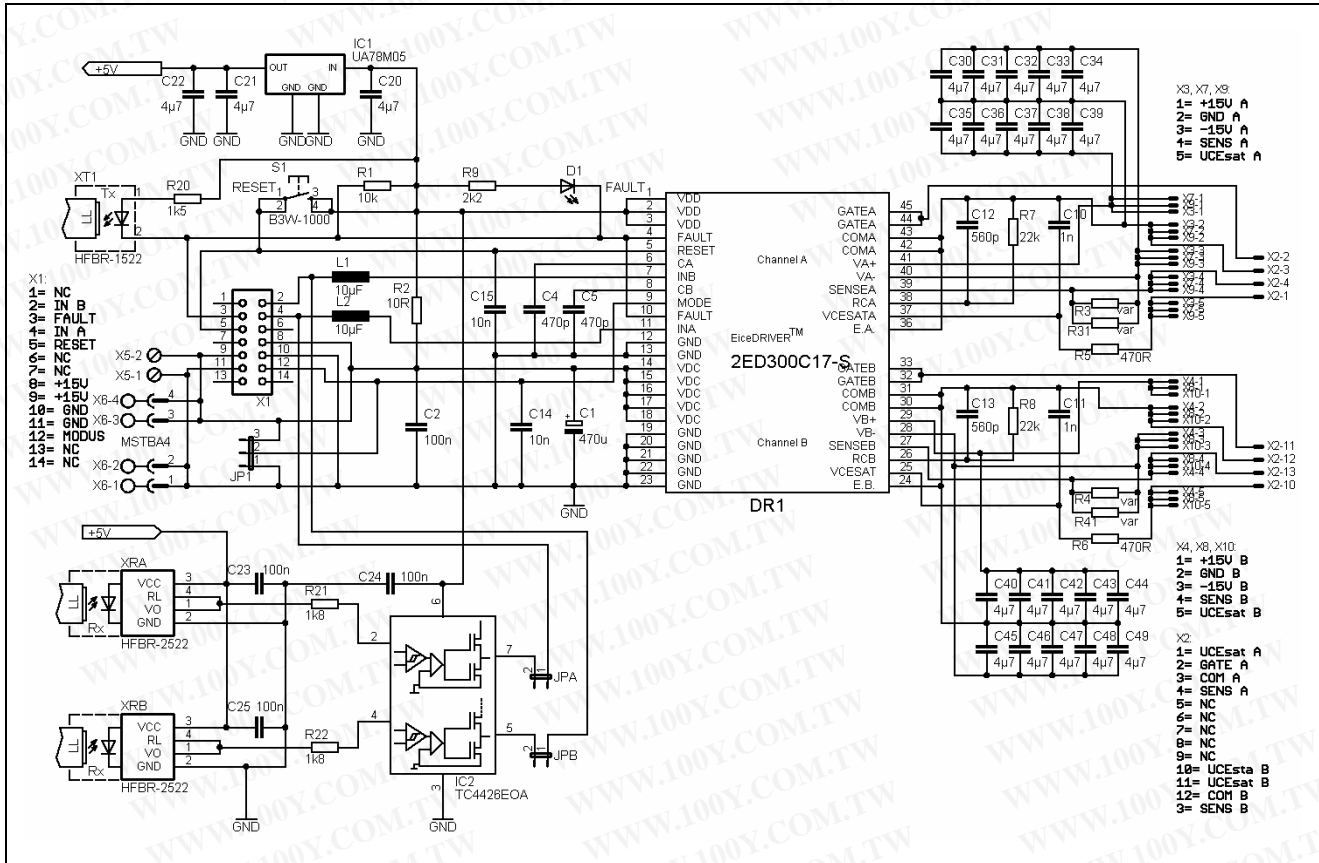


Figure 6 The 2ED300E17-SFO schematic

4.2 Assembly drawing

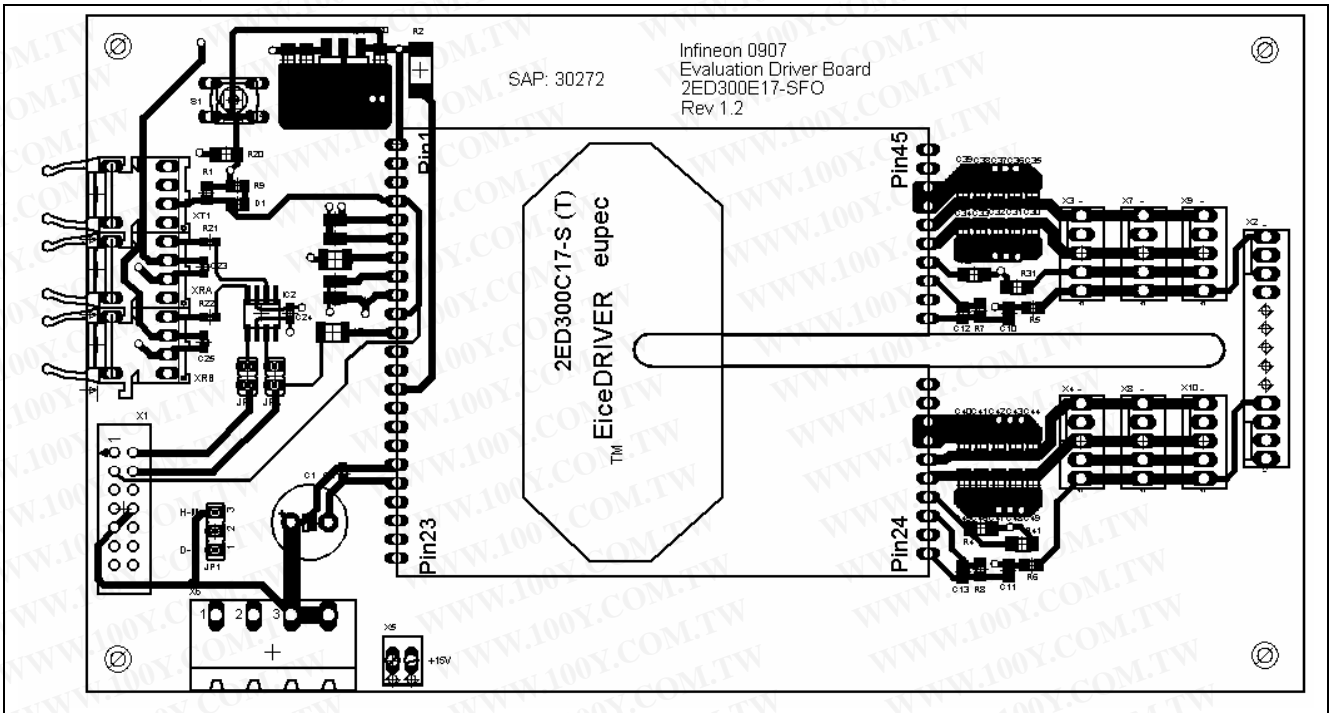


Figure 7 Assembly drawing of the 2ED300E17-SFO adapter board

4.3 Layout

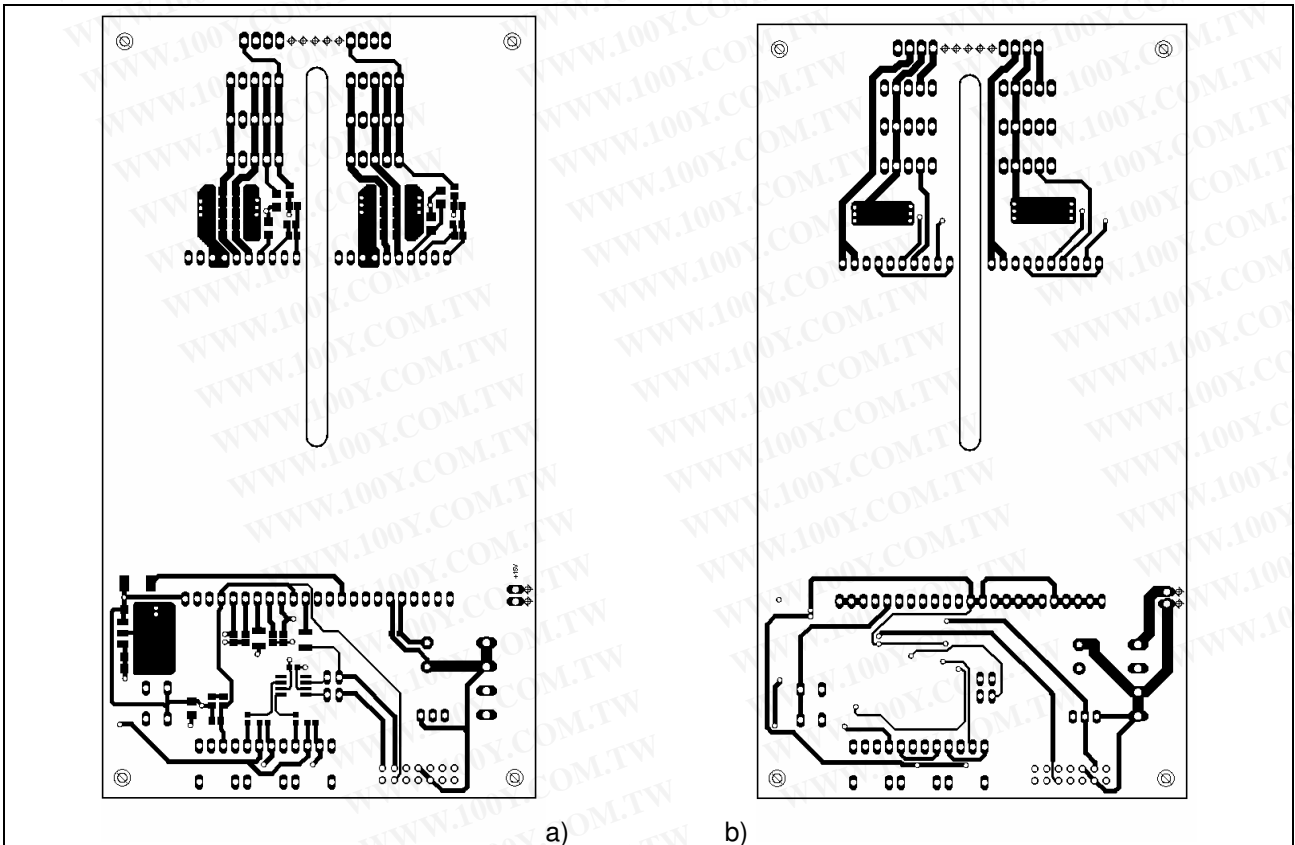


Figure 8 2ED300E17-SFO adapter board – a) Top layer and b) Layer 2

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Page Schematic, Layout and Bill of Material

4.4 Bill of Material

The bill of material not only includes a part list, but also assembly notes.

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

Table 10 Bill of Material for 2ED300E17-SFO adapter board

Type	Value / Type	Package EIA	QTY	Name Part	Recommended Manufacturer	Assembly
Resistor	variable	1206	4	R3, R4, R31, R41	no special	no
Resistor	10k	0805	1	R1	no special	yes
Resistor	10R	2512	1	R2	no special	yes
Resistor	470	0805	2	R5, R6	no special	yes
Resistor	22k	0805	2	R7, R8	no special	yes
Resistor	2k2	0805	1	R9	no special	yes
Resistor	1k5	1206	1	R20	no special	yes
Resistor	1k8	0605	2	R21, R22	no special	yes
Capacitor	470p/50V/CO G	0805	2	C4, C5	no special	yes
Capacitor	560p/50V/CO G	0805	2	C12, C13	no special	yes
Capacitor	1n/50V/COG	0805	2	C10, C11	no special	yes
Capacitor	10n/50V/X7R	0805	2	C14, C15	no special	yes
Capacitor	100n/50V7R X	0805	4	C2, C23, C24, C25	no special	yes
Capacitor	4 μ 7/25V/X7R	1206	23	C20, C21, C22, C30, C31, C32, C33, C34, C35, C36, C37, C38, C39, C40, C41, C42, C43, C44, C45, C46, C47, C48, C49	Murata	yes
Capacitor	470 μ /35V	CPOL-EUE-10.5	4	C1	no special	yes
Inductor	10 μ H	1210	2	L1, L2	Murata	yes
Semiconductor	TC4426EOA	SO8	1	IC2	Microchip	yes
Semiconductor	UA78M05CD CYG3	SOT223	1	IC1	no special	yes
Semiconductor	HFBR-2522Z		2	XRA, XRB	AVAGO	no
Semiconductor	HFBR-1521Z		1	XT1	AVAGO	no
Semiconductor	LED	0805	1	D1		yes
Jumper	3-pol	JP2	2	JPA, JPB		yes
Jumper	2-pol	JP1	1	JP1		yes
Connector	6-64 /14 pole		1	X1	Harting	yes
Connector	13-pol		1	X2	Molex	no
Connector	6410-5A		2	X3, X4	Molex	yes
Connector	6410-5A		4	X7, X8, X9, X10	Molex	yes
Connector	MPT 05/2 2,54mm	2POL2.5 4	1	X5	Phoenix	yes
Connector	MSTBA 2.5/4-G-5.08		1	X6	Phoenix	no
Switch	B3W-1000	B3W-1000	1	S1	Omron	yes
Driver	2ED300C17-S		1	DR1	Infineon	no