

## Evaluation Driver Board for AT-NPC 3-level 12in1 IGBT module

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Device application Technology Dept.  
Semiconductor Sales Div.  
sales Group  
Fuji Electric co.,Ltd.

## ■ Summary

This evaluation board is used to drive the Fuji Electric's AT-NPC 3-level 12in1 module (Solder pin type). The board includes DC/DC converters, signal I/O connectors and the main I/O terminals. The IGBT&RB-IGBT are driven by the control signal obtained by supplying 15V from an external source.

## ■ Feature

- 1) The board includes a DC/DC converter.  
Gate drive is possible with a single 15V power supply.
- 2) The inputs are CMOS TTL compatible and can be driven by a 5V signal.
- 3) Operation of the 12in1 module can be verified through the main I/O terminals by connecting the DC supply, and load.
- 4) The board also features a check pin for IGBT gate voltage conformation.
- 5) The conventional IGBTs of the 12in1 module have a Short circuit protection function built in. (Feature unavailable for RB-IGBTs)

## ■ IGBT Modules

12MBI50VN-120-50

12MBI75VN-120-50

12MBI100VN-120-50

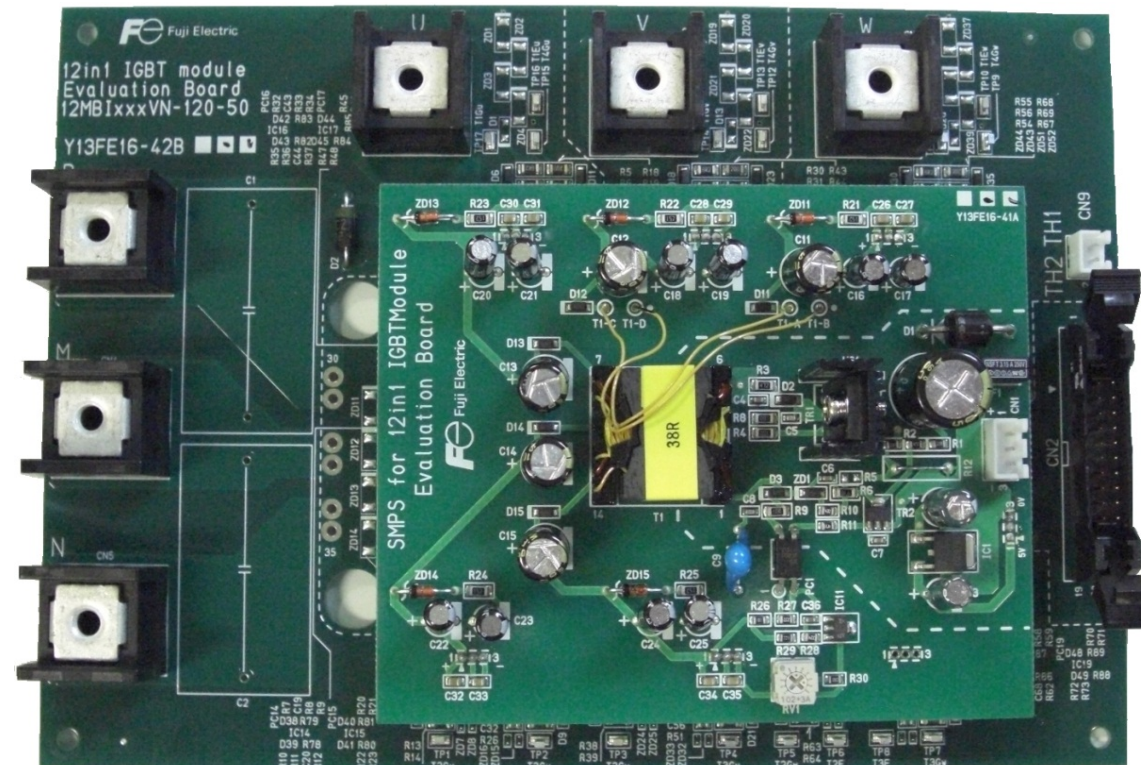
## ■ Warning/Notes/Caution

- 1) The driver board has been developed for evaluation purposes only, and does not have any commercial value.
- 2) This application note does not ensure to enforce the industrial property and other rights, such as license rights and license the enforcement rights.
- 3) The component values in this design are intended to aid in your design. Standard variations and operating environment induced variations are not taken into account. It is strongly advised that you verify and account for these variations.

## ■ Board Dimensions

190 mm × 135 mm

(L × W)



# Electrical characteristics

Parameter		Value	Unit	Remarks
VDC(in)	Primary DC/DC voltage supply range	10~18	V	Recmended value 15V
Vout1	Output voltage from DC/DC converter	+17/-10	V	For IGBT drive supply
Vout2	Primary side control voltage	5	V	Non-isolation
Iout(DC)	DC output current	0.15	A	per 1 output. IGBT drive supply
Iout(peak)	Peak output current (t=1us)	10	A	per 2 output. IGBT drive supply
VLogicIN	PWM signals for High,low side IGBT and RB-IGBT	0/+5	V	Follow the specification of SN74HC04PW
VFAULT	FAULT detection output	0/+5	V	Follow the specification of ACPL-333J
IFault	FAULT detection output load current	8	mA	Follow the specification of ACPL-333J
Vout	IGBT drive voltage level for high,low side	+15/-10	V	
IG	MAX. peak output current	±2.5	A	Follow the specification of ACPL-333J
Pout	MAX. output power	1200	mW	Follow the specification of ACPL-333J
fsw	MAX PWM signal frequency	50	kHz	
tPDELAY	propagation delay time	200	ns	
tPDISTO	input to output propagation distortion	15	ns	
dmax	MAX. duty cycle	100	%	
VCES(IGBT)	MAX.collector-emitter voltage on IGBT	1200	V	
VCES(RB-IGBT)	MAX.collector-emitter voltage on RB-IGBT	600	V	
Top	operating temperature design target	-10~50	deg	
Tstg	Storage temperature design target	-30~80	deg	

Note:Other specifications follow specifications of SN74HC04PW and ACPL-333J

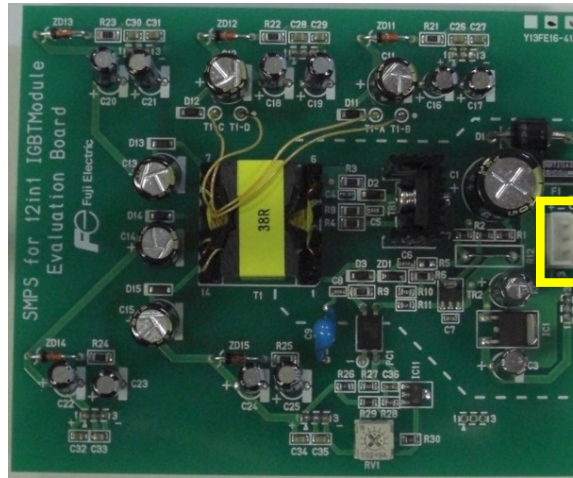
Data sheet No.

SN74HC04PW : sn74hc04.pdf (Texas Instruments Incorporated)

ACPL-333J : AV02-1087EN+DS+ACPL-333J+25Oct2012.pdf (Avago Technologies)

# I/O explanation of the evaluation board Fuji Electric Innovating Energy Technology

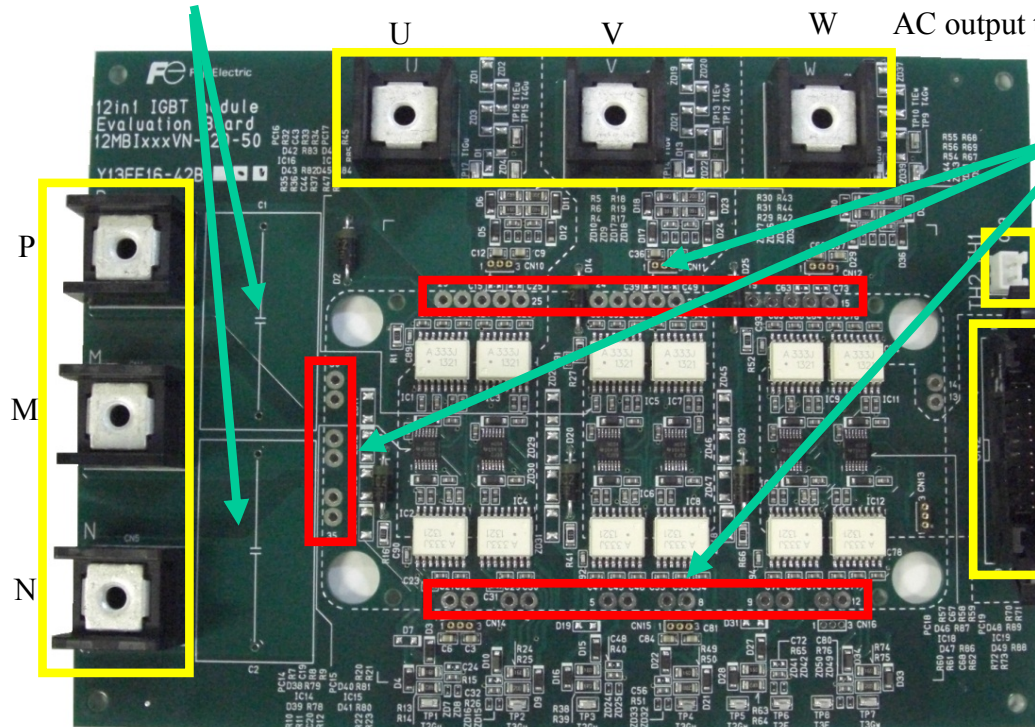
## DC/DC CONVERTER BOARD



DC input connector (15V/2A)

Snubber C  
Connected area  
Initial value:NC

## GDU BOARD



U V W AC output terminal

Main DC voltage  
Input terminal

Soldering area between  
board and IGBT module.

Thermistor connector

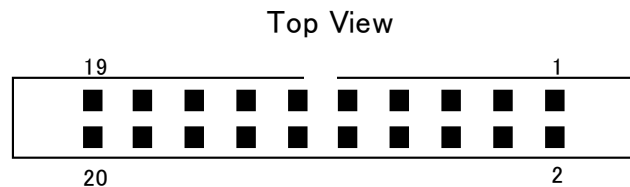
Signal input  
&  
Fault output  
connector

Note: The mounting screw of the main terminal,  
please use **M5** size.

# Input & output connector pin assign

Input and output for connector(CN2)

PIN	
1	Fault detection output W phase low side IGBT(T2W)
2	Fault detection output V phase low side IGBT(T2V)
3	Fault detection output U phase low side IGBT(T2U)
4	Fault detection output W phase high side IGBT(T1W)
5	Fault detection output V phase high side IGBT(T1V)
6	Fault detection output U phase high side IGBT(T1U)
7	GND
8	GND
9	PWM signal for W phase RB-IGBT(T3W)
10	PWM signal for W phase RB-IGBT(T4W)
11	PWM signal for W phase low side IGBT(T2W)
12	PWM signal for W phase high side IGBT(T1W)
13	PWM signal for V phase RB-IGBT(T3V)
14	PWM signal for V phase RB-IGBT(T4V)
15	PWM signal for V phase low side IGBT(T2V)
16	PWM signal for V phase high side IGBT(T1V)
17	PWM signal for U phase RB-IGBT(T3U)
18	PWM signal for U phase RB-IGBT(T4U)
19	PWM signal for U phase low side IGBT(T2U)
20	PWM signal for U phase high side IGBT(T1U)

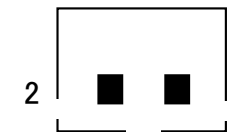


The connector is a XG4M-2030T(omron) or equivalent.

Output for connector(CN9)

PIN	
1	TH1
2	TH2

Top View

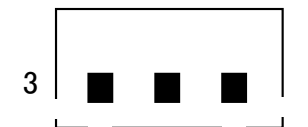


The connector is a XHP-2(JST) or equivalent.

Input for DC/DC converter connector

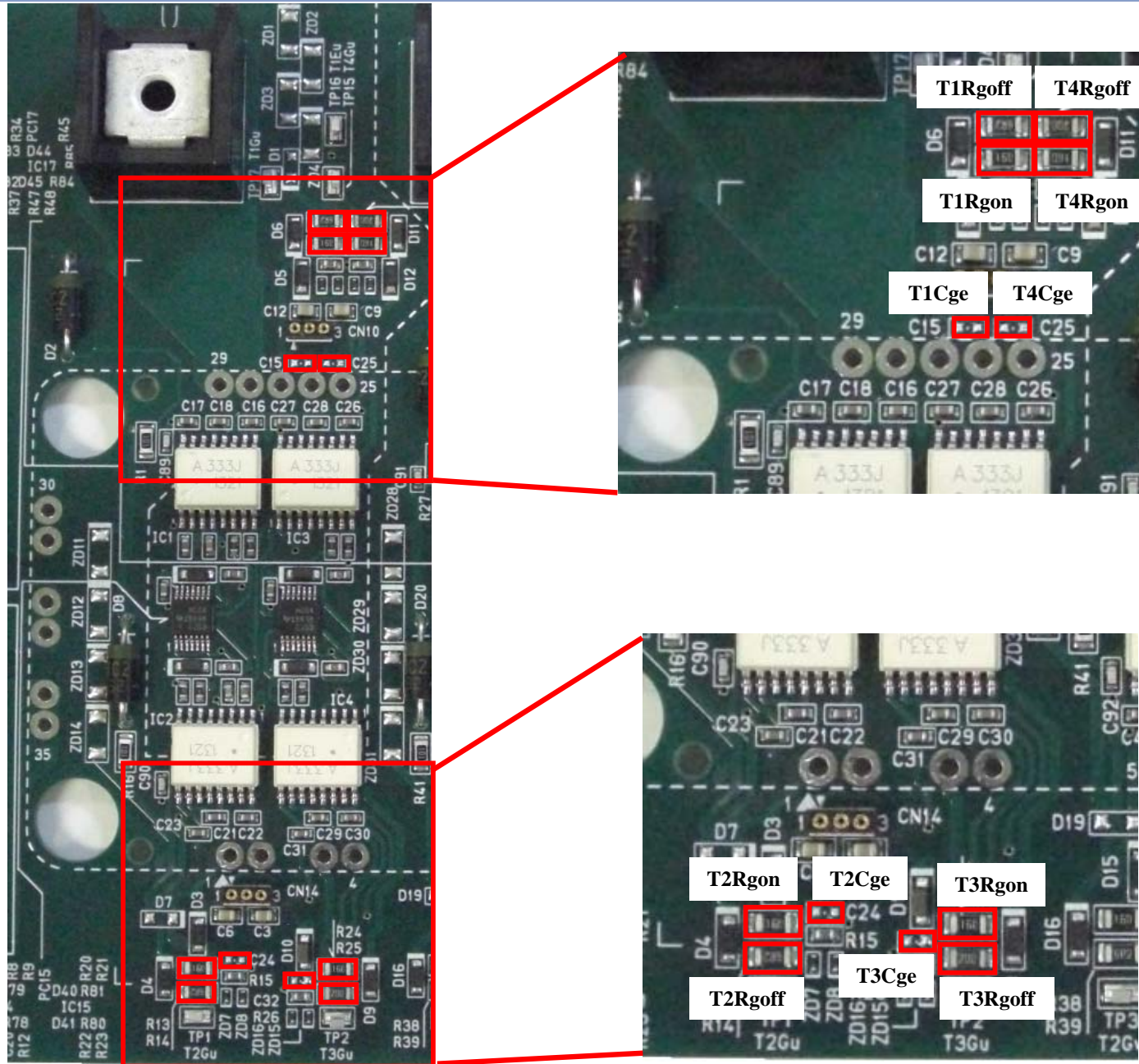
PIN	
1	VDC
2	NC
3	GND

Top View



The connector is a XHP-3(JST) or equivalent.

# Gate peripheral circuit



Please adjust Rgon, Rgoff and Cge by a circuit condition.

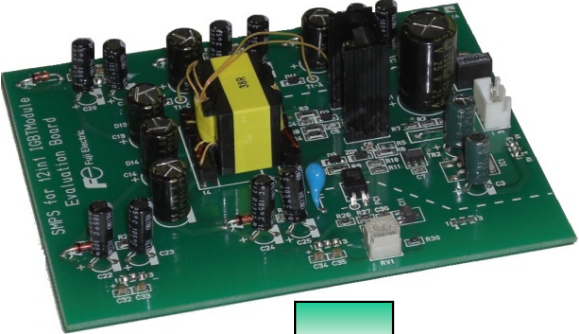
Initial value

	Rgon(Ω)	Rgoff(Ω)
T1, T2	16	6.2
T3, T4	16	20

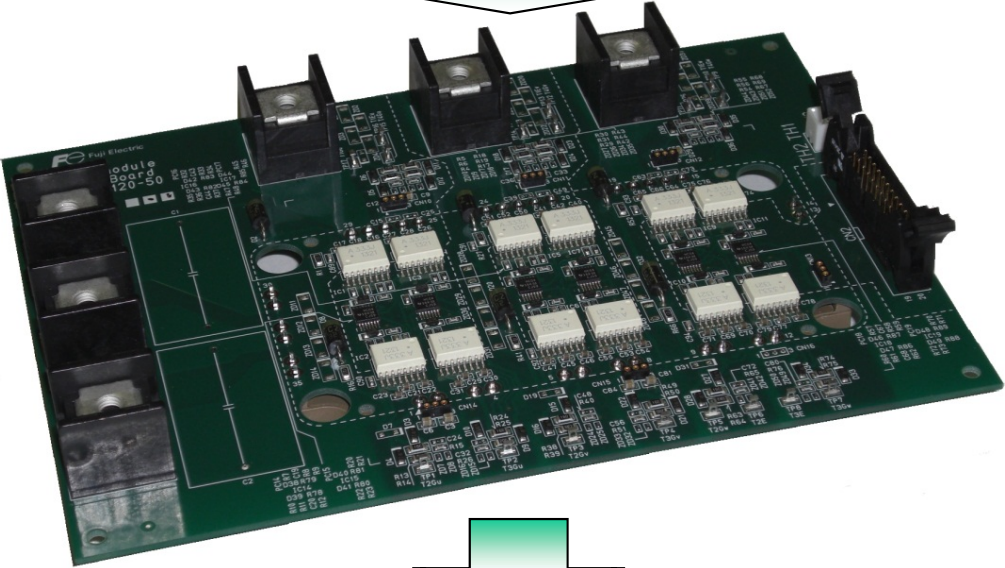
Cge=No connection

# Assembling procedure

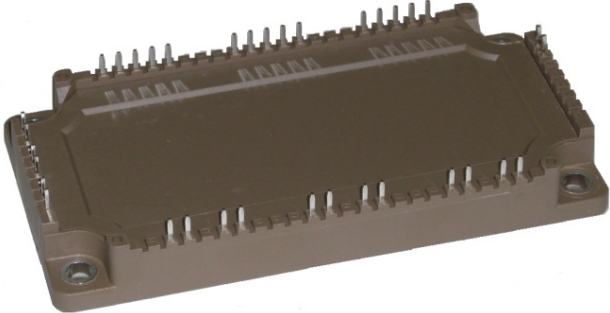
**DC/DC CONVERTER BOARD**



**IGBT BOARD**



**IGBT Module**



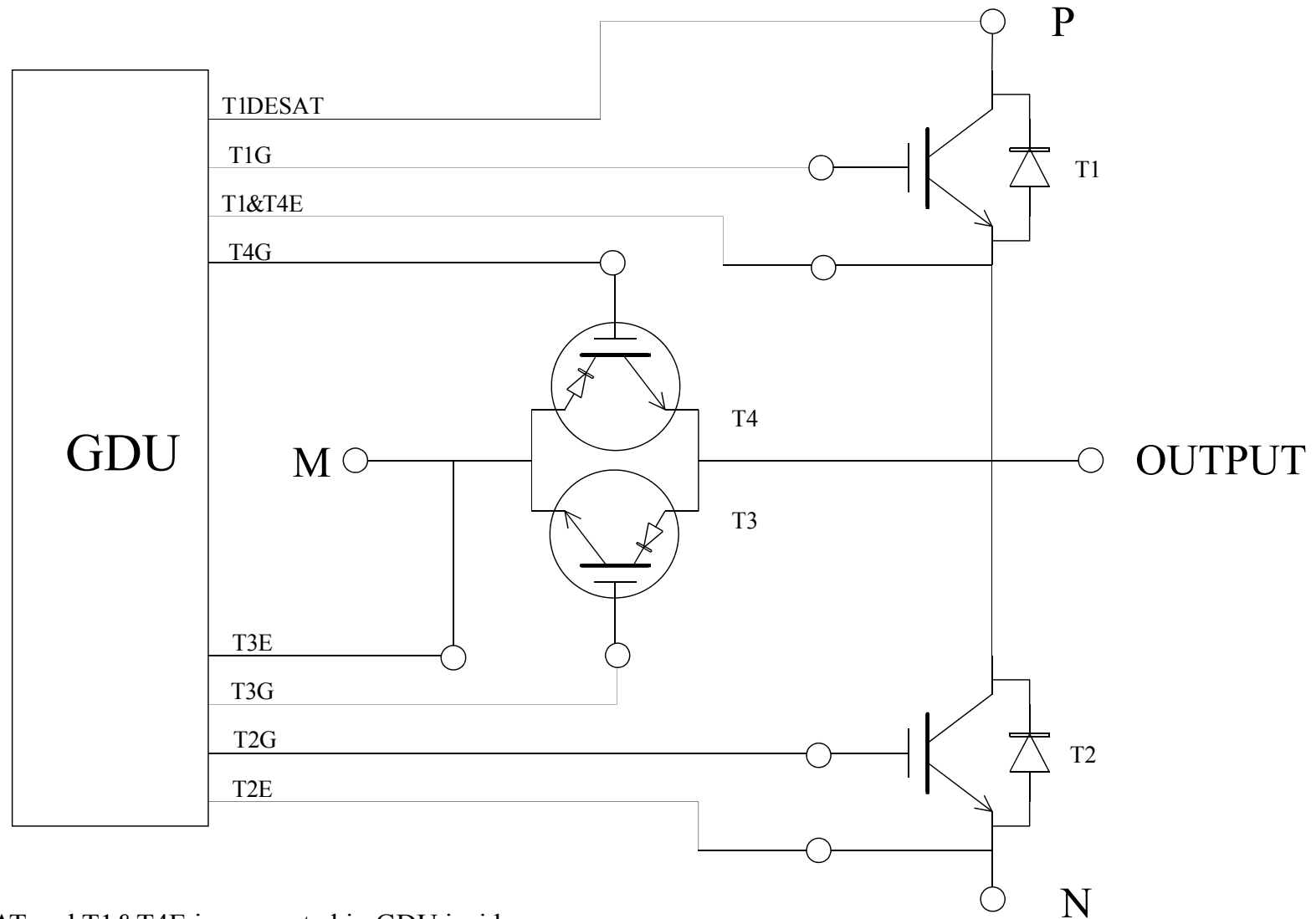
Assembling procedure

1. Insert the IGBT module in GDU board.
2. Solder the IGBT module's terminal and GDU board.
3. Mount the IGBT module on a heat sink.
4. Insert DC/DC converter board in GDU board.
5. The cable for control signal, the load, the external power supply and main DC power supply are connected to the GDU board and DC/DC converter board.

Power on procedure

1. Turn on the external power supply (15V).  
Recommended external power supply output is  $V_o=15V$ ;  $I_o \geq 2A$ .
2. When the DC/DC converter output becomes stable, turn on the main power supply.
3. Finally apply the control signal.

# GDU & IGBT module connection (1 phase)



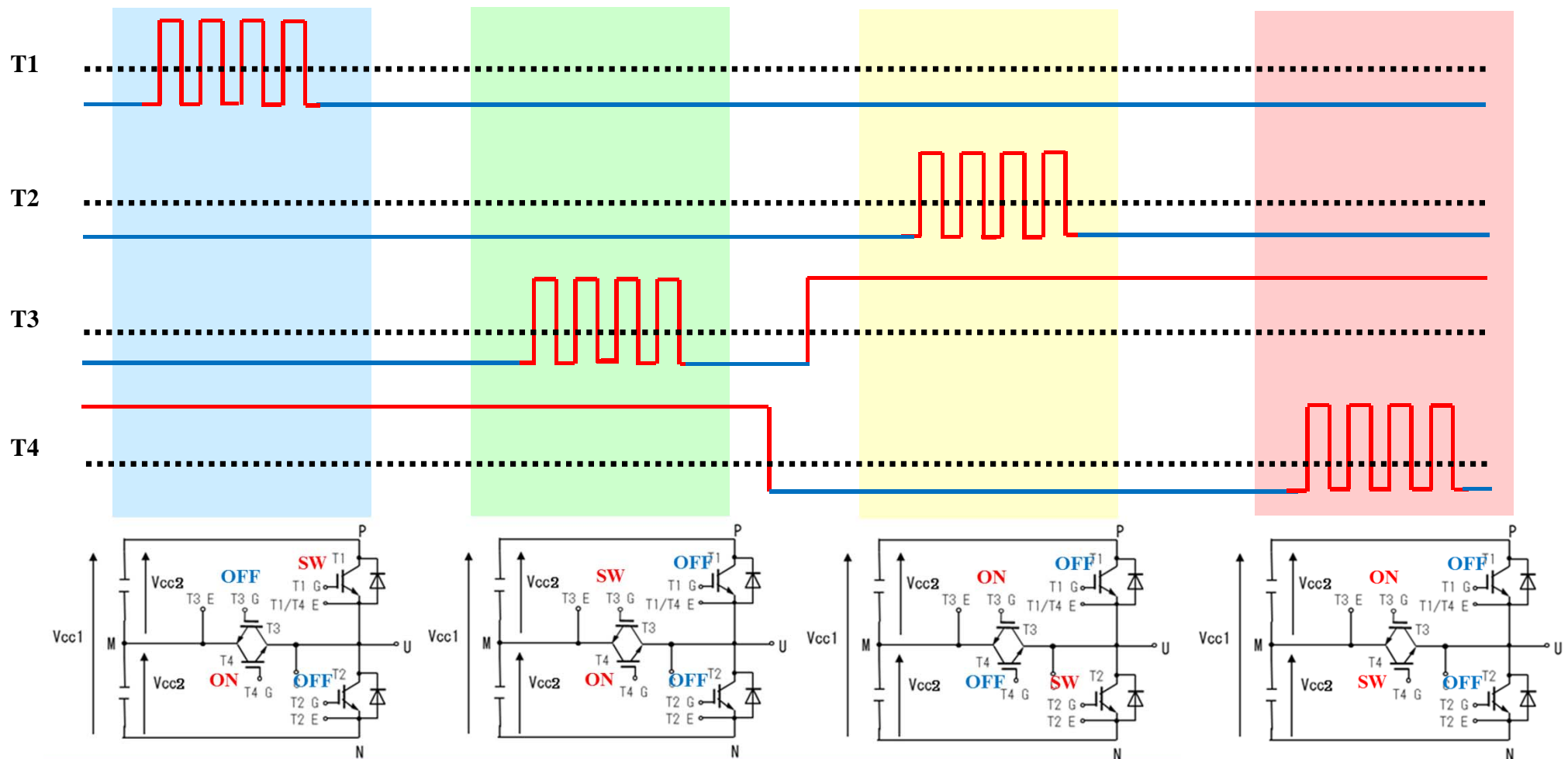
T2DESAT and T1&T4E is connected in GDU inside



# Operation of AT-NPC 3-level IGBT module

SW mode	A	B	A	B
T1	SW	OFF	OFF	OFF
T2	OFF	OFF	SW	OFF
T3	OFF	SW	ON	ON
T4	ON	ON	OFF	SW

SW: Connect to drive circuit and input gate signal  
 ON: Bias voltage of gate +15V  
 OFF: Reverse bias voltage of gate -10V  
 $V_{cc2} = V_{cc1}/2$

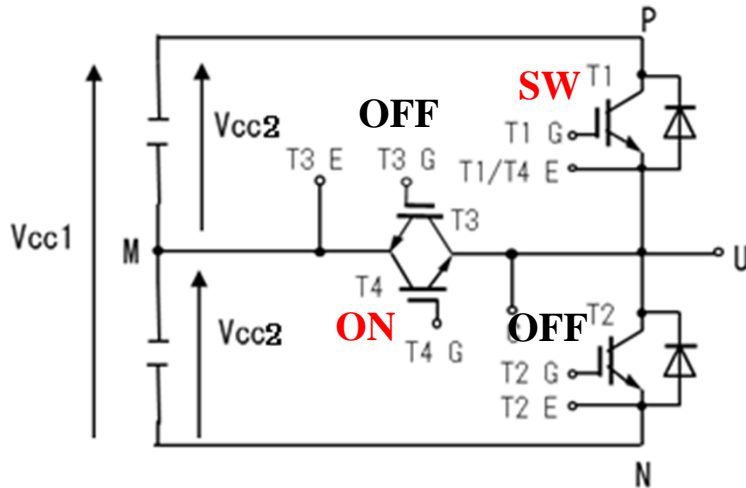


# Switching waveform of main IGBT(A-mode)

Module: 12MBI100VN-120-50

Measured conditions:  $V_{cc2}=300V$ ,  $I_c=100A$ ,  $T_j=125^{\circ}C$ ,  $V_{GE}=+15V/-10V$

	$R_{gon}(\Omega)$	$R_{goff}(\Omega)$
T1,T2	16	6.2
T3,T4	16	20



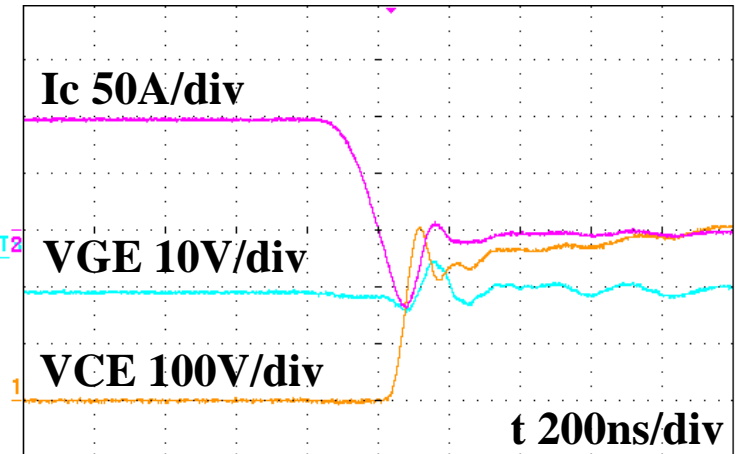
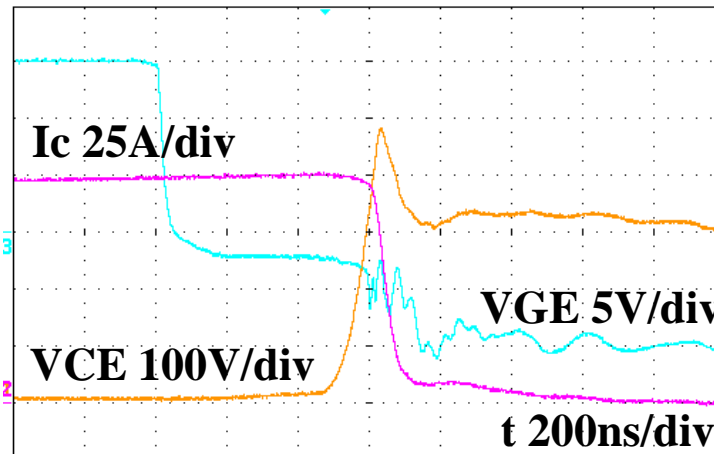
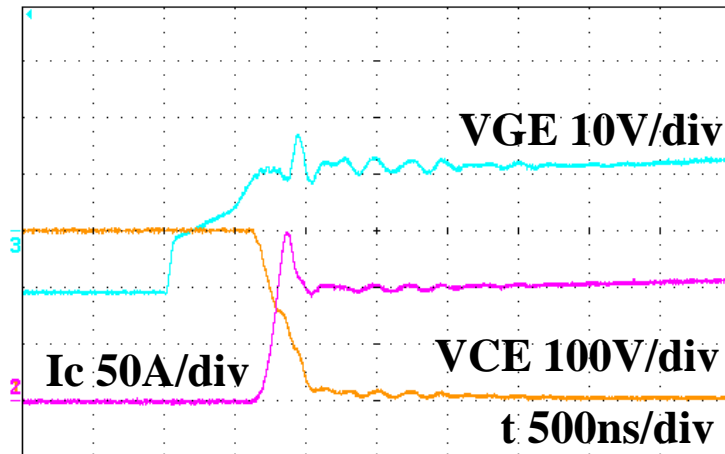
SW mode	Load L	T1	T2	T3	T4
A	M-U	<b>SW</b>	OFF	OFF	<b>ON</b>
	M-U	OFF	<b>SW</b>	<b>ON</b>	OFF
B	P-U	OFF	OFF	<b>SW</b>	<b>ON</b>
	U-N	OFF	OFF	<b>ON</b>	<b>SW</b>

SW: Connect to drive circuit and input gate signal  
 ON: Bias voltage of gate +15V  
 OFF: Reverse bias voltage of gate -10V  
 $V_{cc2}=V_{cc1}/2$

**ton**

**toff**

**trr**

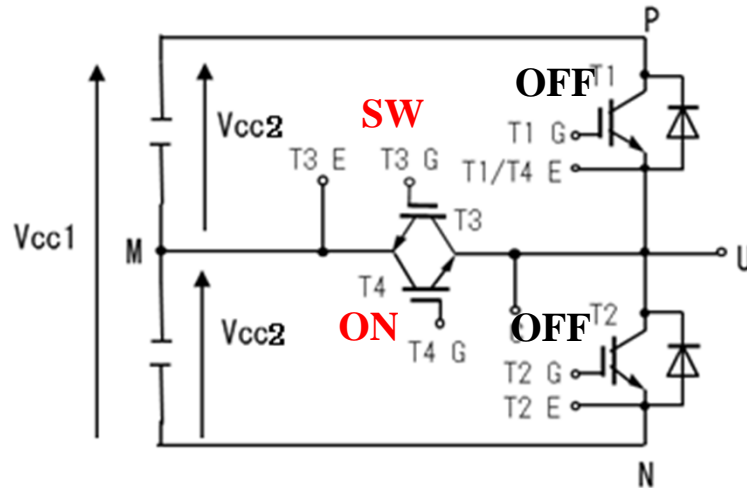


# Switching waveform of RB-IGBT(B-mode)

Module: 12MBI100VN-120-50

Measured conditions:  $V_{cc2}=300V$ ,  $I_c=100A$ ,  $T_j=125^\circ C$ ,  $V_{GE}=+15V/-10V$

	Rgon( $\Omega$ )	Rgoff( $\Omega$ )
T1,T2	16	6.2
T3,T4	16	20



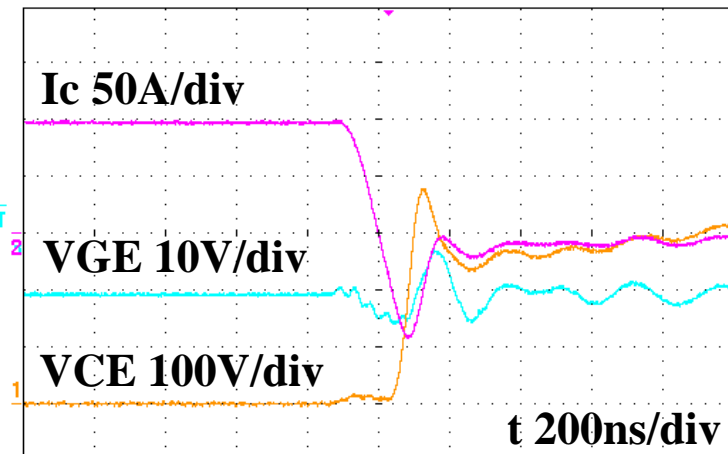
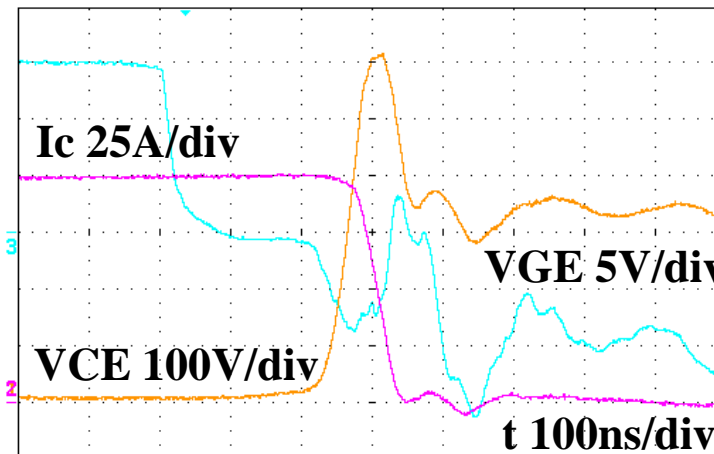
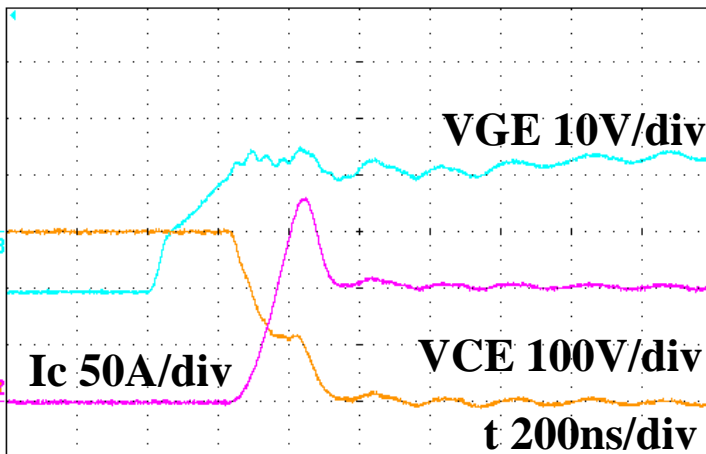
SW mode	Load L	T1	T2	T3	T4
A	M-U	SW	OFF	OFF	ON
	M-U	OFF	SW	ON	OFF
B	P-U	OFF	OFF	SW	ON
	U-N	OFF	OFF	ON	SW

SW: Connect to drive circuit and input gate signal  
 ON: Bias voltage of gate +15V  
 OFF: Reverse bias voltage of gate -10V  
 $V_{cc2}=V_{cc1}/2$

**ton**

**toff**

**trr**

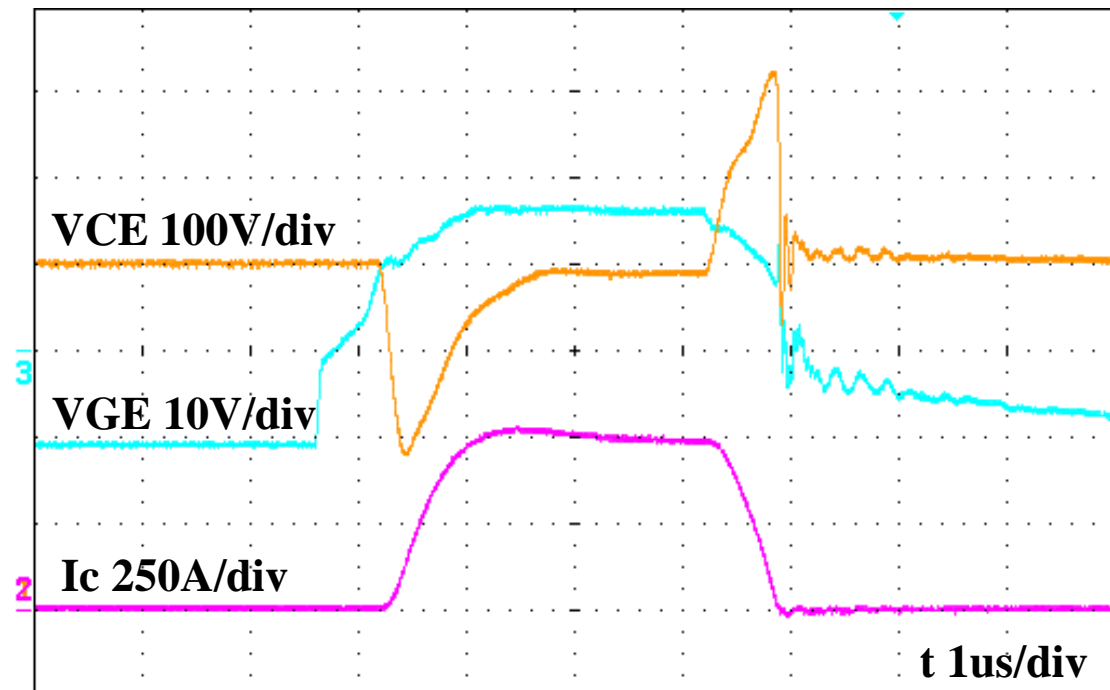


# Short circuit protection

Module: 12MBI100VN-120-50

Measured conditions:  $V_{cc2}=400V$ ,  $T_j=125^{\circ}C$ ,  $V_{GE}=+15V/-10V$

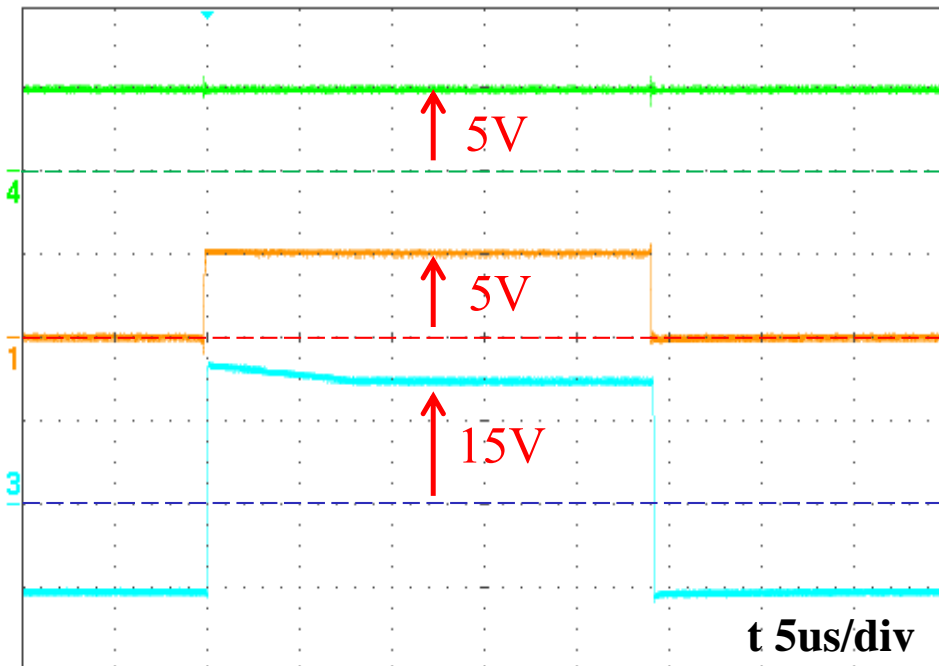
	$R_{gon}(\Omega)$	$R_{goff}(\Omega)$
T1,T2	16	6.2
T3,T4	16	20



The T1 and T2 gate driver circuit has a built-in function of short-circuit protection. The DESAT pin monitors a short circuit. When a DESAT fault is detected, the IGBT is turned off softly. Please refer the datasheet for AVAGO ACPL-333J for more detail.

# FAULT output

## Before short circuit detection



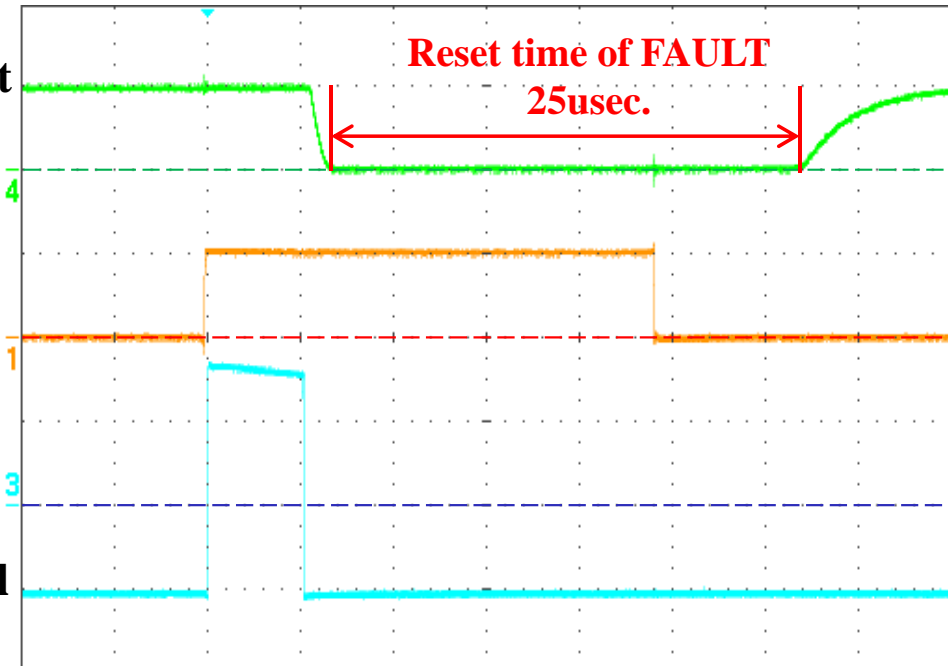
FAULT output  
5V/div

Input signal  
5V/div

Output signal  
10V/div

t 5us/div

## After short circuit detection



Reset time of FAULT  
25usec.

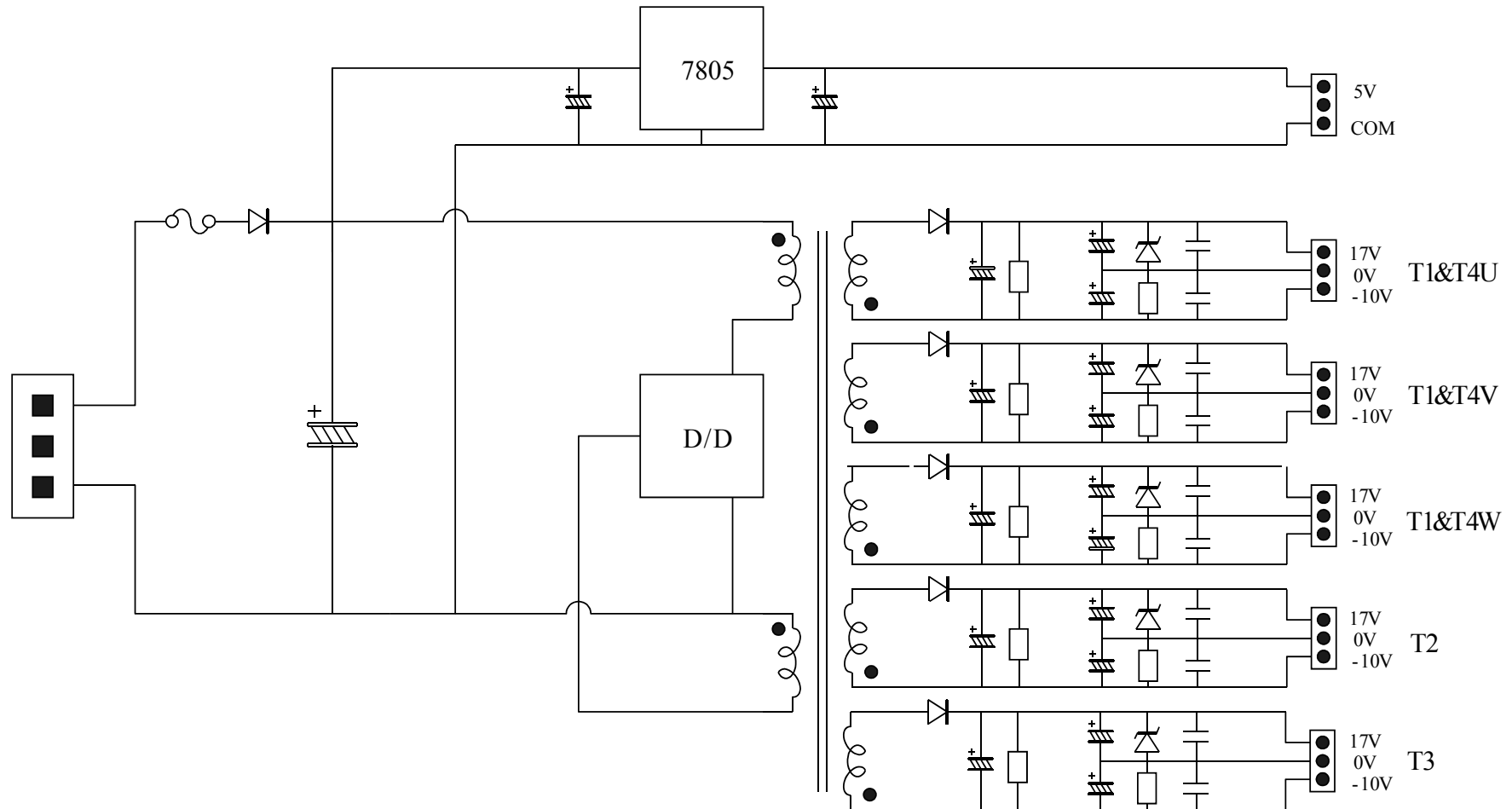
FAULT output, PWM input and IGBT gate-emitter voltage waveforms when a DESAT fault is detected are shown in the above figures.

When the DESAT fault is detected, the IGBT is turned off and FAULT output switches from high to low.

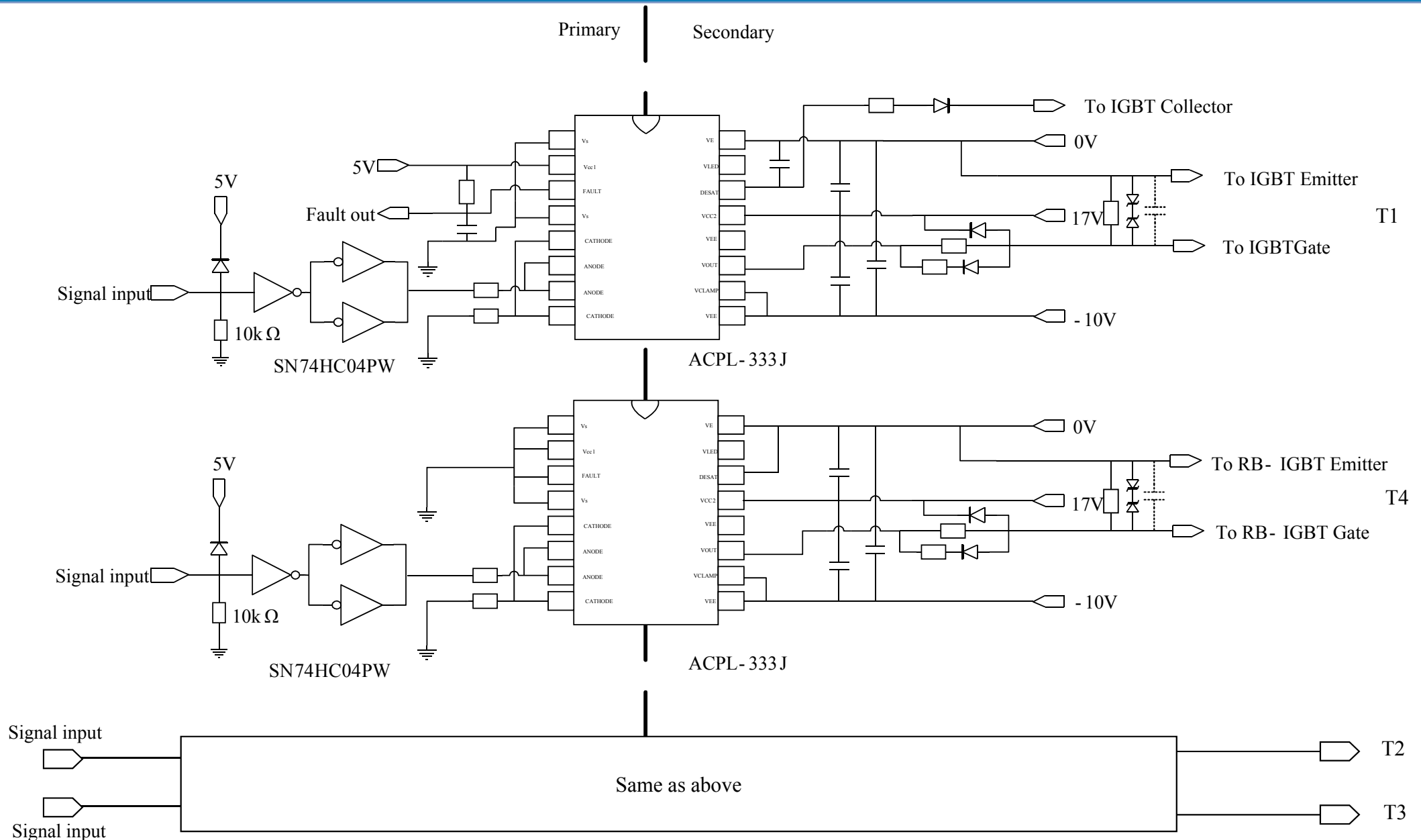
The driver automatically reset FAULT output after a fixed mute time of 25usec(typical).

Please refer the datasheet for AVAGO ACPL-333J for more detail.

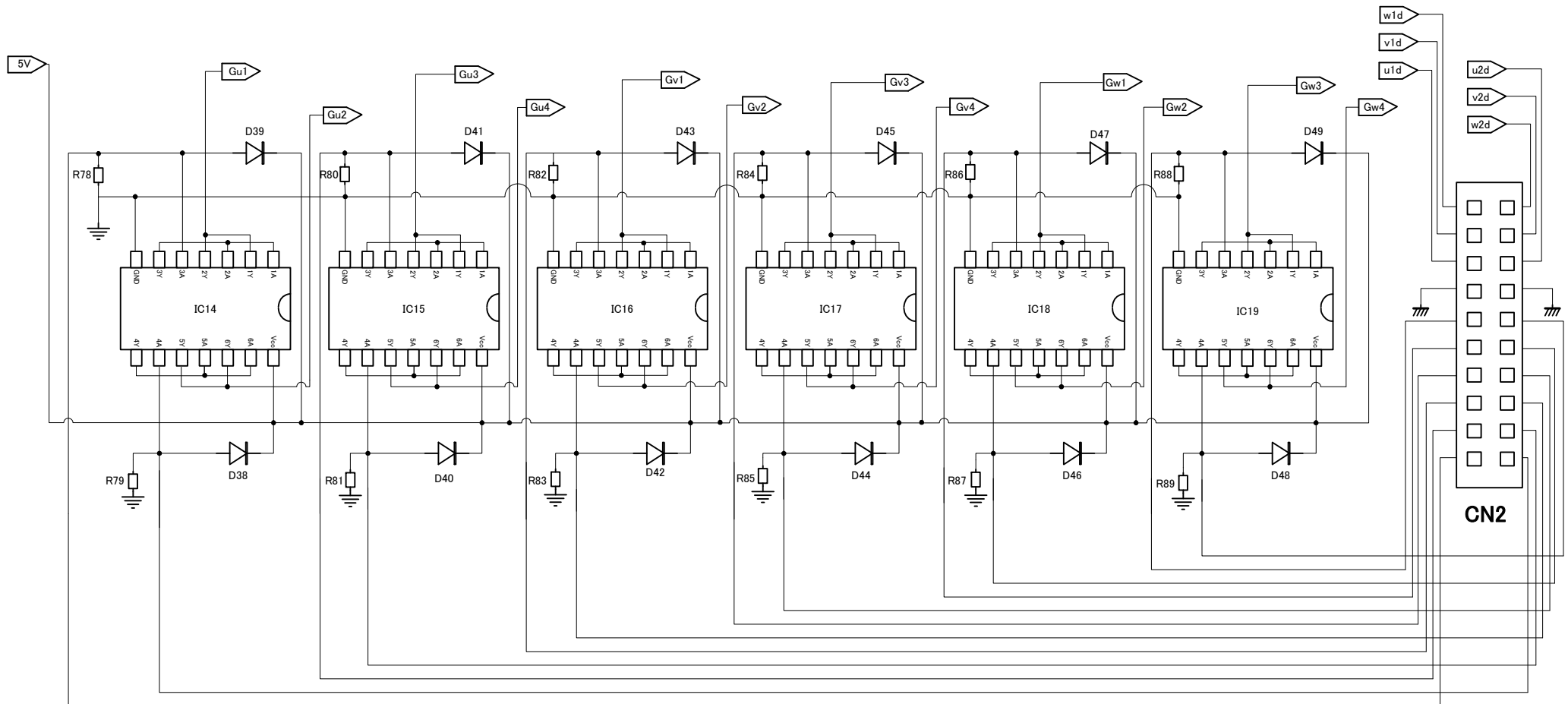
# Schematic diagram of DC/DC converter



# Schematic diagram of GDU input/output circuit (1 phase)

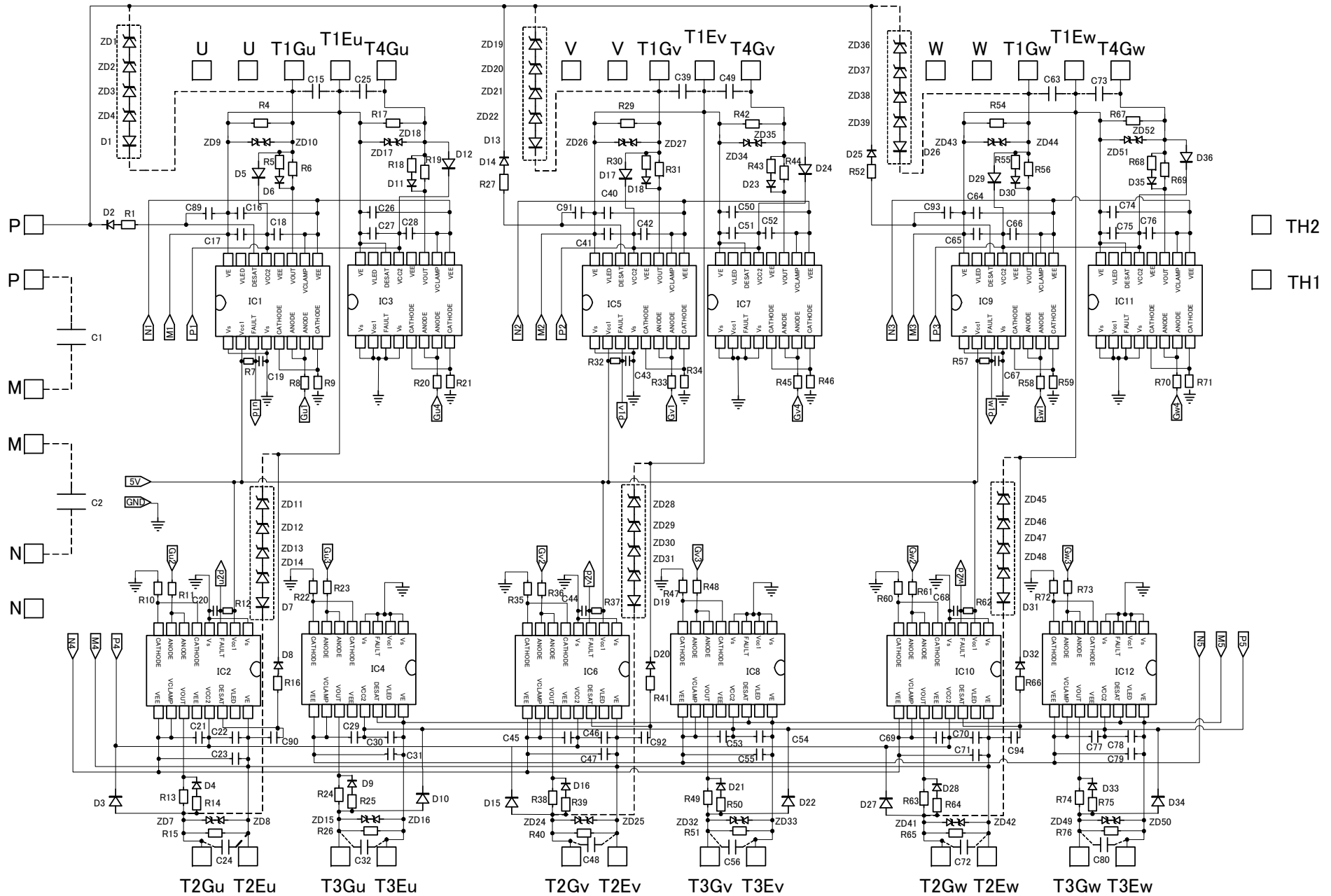


# Schematic diagram of pulse input circuit





# Schematic diagram of gate driver circuit



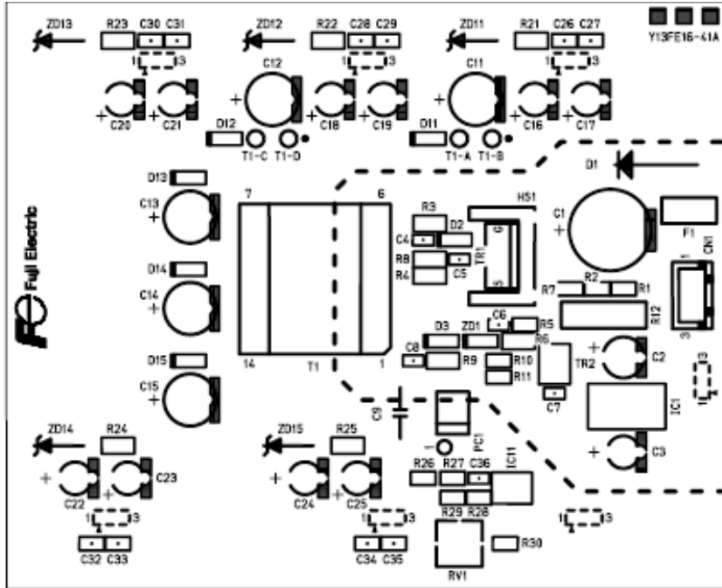
# BOM(DC/DC converter board)

Type	Q'ty	Value/Device	Package size	Part Name	Recommended Manufacturer	Assembled	Remarks
Transformer	1	Y13FE16-61A	PQ20/16	T1	ORIGINAL		
Capacitor	1	1000pF		C9			
Capacitor	1	470pF	1608	C5			
Capacitor	1	47pF	1608	C8			
Capacitor	2	2200pF	1608	C6,C7			
Capacitor	2	0.1uF	1608	C4,C36			
Capacitor	10	2.2uF	2125	C26,C27,C28,C29,C30,C31, C32,C33,C34,C35			
Capacitor	1	1500uF/25V	12.5*25	C1			
Capacitor	1	100uF/25V	6.3*11	C2			
Capacitor	5	100uF/50V	8*11.5	C11,C12,C13,C14,C15			
Capacitor	1	100uF/10V	5*11	C3			
Capacitor	10	22uF/50V	5*11	C16,C17,C18,C19,C20,C21, C22,C23,C24,C25			
Resistor	1	0		R12			Jumper
Resistor	3	10R,1/4W	3216	R4,R8,R9			
Resistor	5	1.5K,1/4W	3216	R21,R22,R23,R24,R25			
Resistor	1	47R,1/4W	3216	R6			
Resistor	1	4.7K,1/4W	3216	R3			
Resistor	1	1K,1/8W	2125	R26			
Resistor	1	10K,1/8W	2125	R7			
Resistor	1	2K,1/8W	2125	R30			
Resistor	1	2.2K,1/8W	2125	R27			
Resistor	1	22K,1/8W	2125	R29			
Resistor	1	220K,1/8W	2125	R28			
Resistor	1	4.3K,1/8W	2125	R10			
Resistor	1	470R,1/8W	2125	R11			
Resistor	1	4.7K,1/8W	2125	R2			
Resistor	1	8.2K,1/8W	2125	R1			
Resistor	4	22K,1/8W	2125	X1,X2,X3,X4			Discharge resistor
Resistor	1			RV1			Variable resistor
Diode	7	200V/1A		D2,D3,D11,D12,D13,D14,D15			
Diode	1	40V/5A	ERC81S-004	D1	Fuji Electric Co.,Ltd.		
Transistor	1	50V/2A		TR2			
MOSFET	1	100V/73A	2SK3587-01MR	TR1	Fuji Electric Co.,Ltd.		
Zener diode	1	2.2V/200mW	MMSZ4680T1G	ZD1			
Zener diode	5	16V/1.3W	BZV85-C16,133	ZD11,ZD12,ZD13,ZD14,ZD15			
IC	1		TA7805F	IC1			
IC	1		TA76431F	IC11			
PC	1		TLP781F	PC1			
Fuse	1		SLT250V3.15A	F1			
Connecter	1		B3B-XH-A	CN1			
Connecter	6		MX-17-8	CN11,CN12,CN13,CN14, CN15,CN16			
Heatsink	1		S19225-BP				
Screw	1		φ3mm*8mm				
PCB	1		Y13FE16-41A				

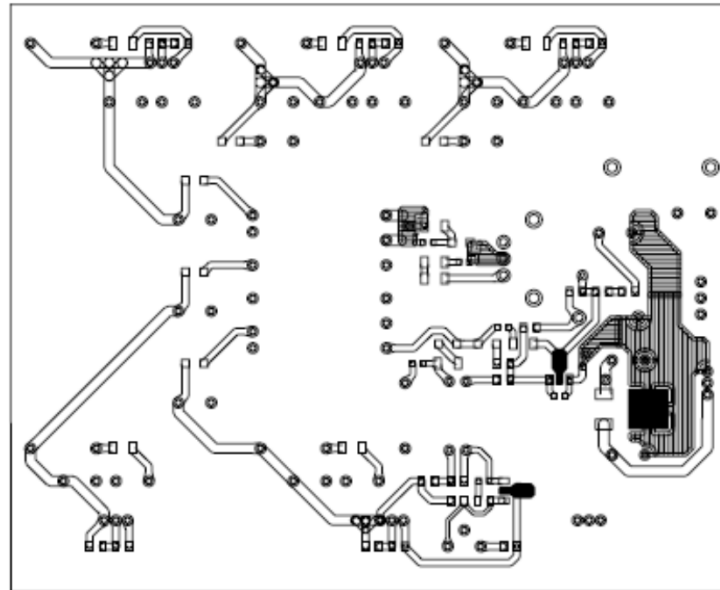
# BOM(GDU board)

Type	Q'ty	Value/Device	Package size	Part Name	Recommended Manufacturer	Assembled	Remarks
Resistor	6	6R2	3216	R5,R14,R25,R30,R39,R64			
Resistor	12	16R	3216	R6,R13,R19,R24,R31,R38,R44,R,49,R55,R,63,R69,R74			
Resistor	6	20R	3216	R18,R43,R50,R56,R68,R75			
Resistor	6	100R	3216	R1,R16,R27,R41,R52,R66			
Resistor	24	180R	1608	R8,R9,R10,R11,R20,R21,R23,R33,R34,R35,R36,R45,R46,R47,R48,R58,R59,R60,R61,R70,R71,R72,R73			
Resistor	12	10K	1608	R78,R79,R80,R81,R82,R83,R84,R85,R86,R87,R88,R89			
Resistor	6	2.2K	1608	R7,R12,R32,R37,R57,R62			
Resistor	12	47K	1608	R4,R15,R17,R26,R29,R40,R42,R51,R54,			
Capacitor	2	Snubber		C1,C2		no	
Capacitor	12	Cge	1608	C15,C24,C25,C32,C39,C48,C49,C56,C63,C72,C73,C80		no	
Capacitor	6	100pF	1608	C89,C90,C91,C92,C93,C94			
Capacitor	6	1000pF	1608	C19,C20,C43,C44,C67,C68			
Capacitor	36	0.1uF	1608	C16,C17,C18,C21,C22,C23,C26,C27,C28,C29,C30,C31,C40,C41,C42,C45,C46,C47,C50,C51,C52,C53,C54,C55,C64,C65,C66,C69,C70,C71,C74,C75,C76,C77,C78,C79			
Capacitor	10	2.2uF	1608	C3,C6,C9,C12,C33,C36,C57,C60,C81,C84			
Diode	36	CRS12		D3,D4,D5,D6,D9,D10,D11,D12,D15,D16,D17,D18,D21,D22,D23,D24,D27,D28,D29,D30,D33,D34,D35,D36,D38,D39,D40,D41,D42,D43,D44,D45,D46,D47,D48,D49			
Diode	6			D1,D7,D13,D19D26,D31		no	
Diode	6	RC2		D2,D8,D14,D20,D25,D32			
Zener diode	24			ZD1,ZD2,ZD3,ZD4,ZD11,ZD12,ZD13,ZD14,ZD19,ZD20,ZD21,ZD22,ZD28,ZD29,ZD30,ZD31,ZD36,ZD37,ZD38,ZD39,ZD45,ZD46,ZD47,ZD48		no	For active clamp (Not use)
Zener diode	24	DF2S24F		ZD7,ZD8,ZD9,ZD10,ZD15,ZD16,ZD17,ZD18,ZD24,ZD25,ZD26,ZD27,ZD32,ZD33,ZD34,ZD35,ZD41,ZD42,ZD43,ZD44,ZD49,ZD50,ZD51,ZD52			
IC	12	ACPL-333J		IC1,IC2,IC3,IC4,IC5,IC6,IC7,IC8,IC9,IC10,IC11,IC12	Avago Technologies		
IC	6	SN74HC04PW		IC14,IC15,IC16,IC17,IC18,IC19			Hex Inverter
CONNECTER	1	XG4A-2031		CN2			
CONNECTER	6	OP-910		CN3,CN4,CN5,CN6,CN7,CN8			
CONNECTER	1	B2B-XH-A		CN9			
CONNECTER	6	PM-17-3P		CN10,CN11,CN12,CN13,CN14,CN15			
TERMINAL	17	HK-2		TP1,TP2,TP3,TP4,TP5,TP6,TP7,TP8,TP9,TP10,TP11,TP12,TP13,TP14,TP15,TP16,TP17			
PCB	1	Y13FE16-42B					

# DC/DC converter board pattern layout Fuji Electric Innovating Energy Technology

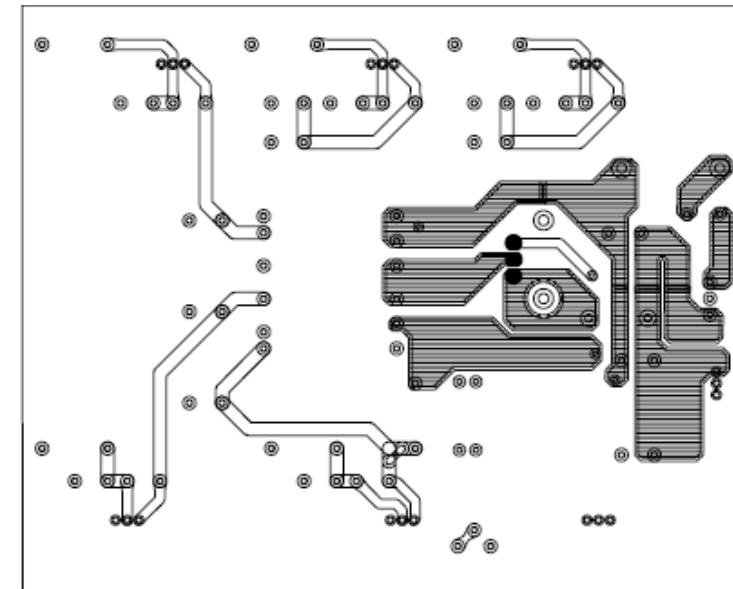


Assembly drawing

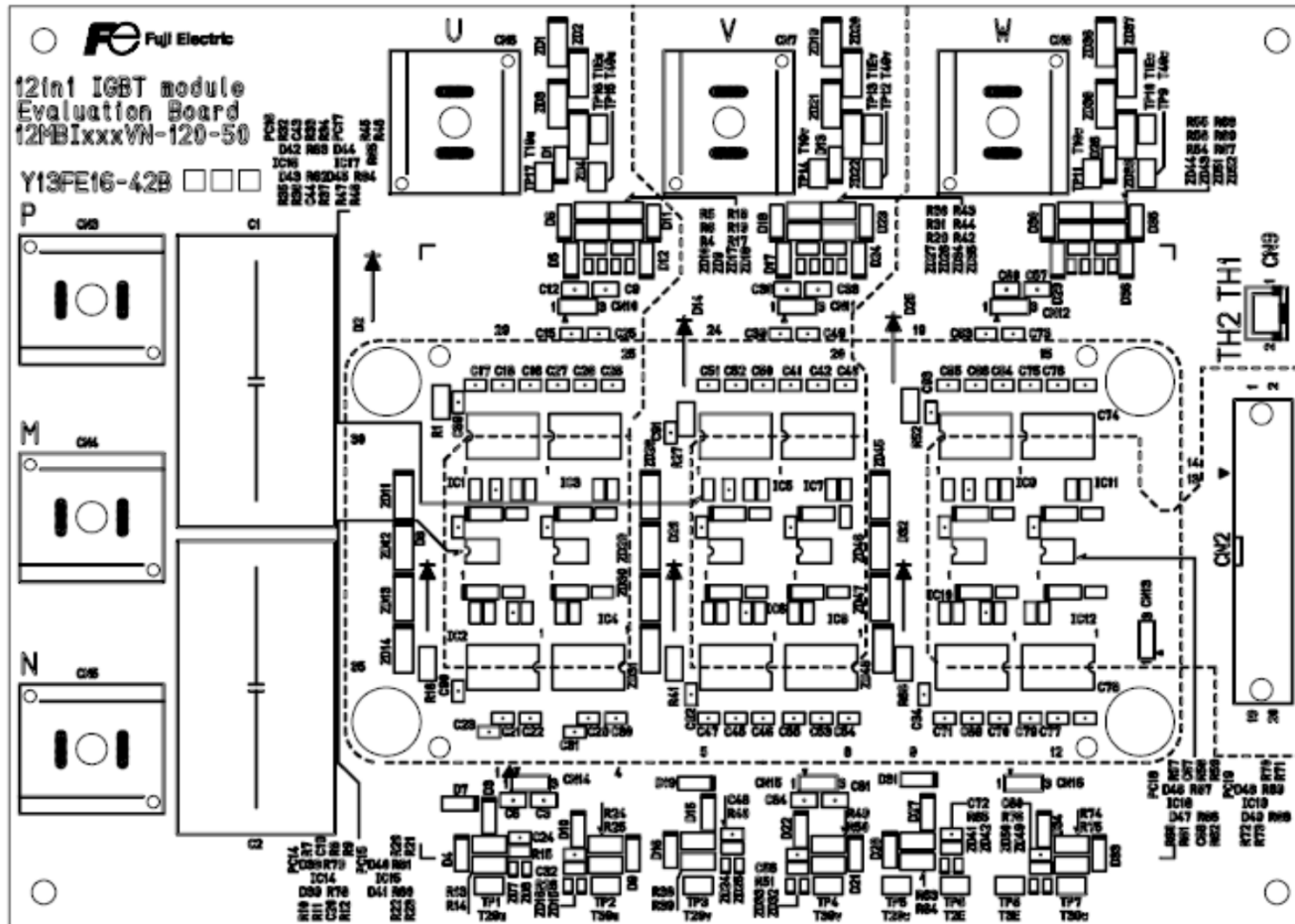


Top layer pattern

Bottom layer pattern

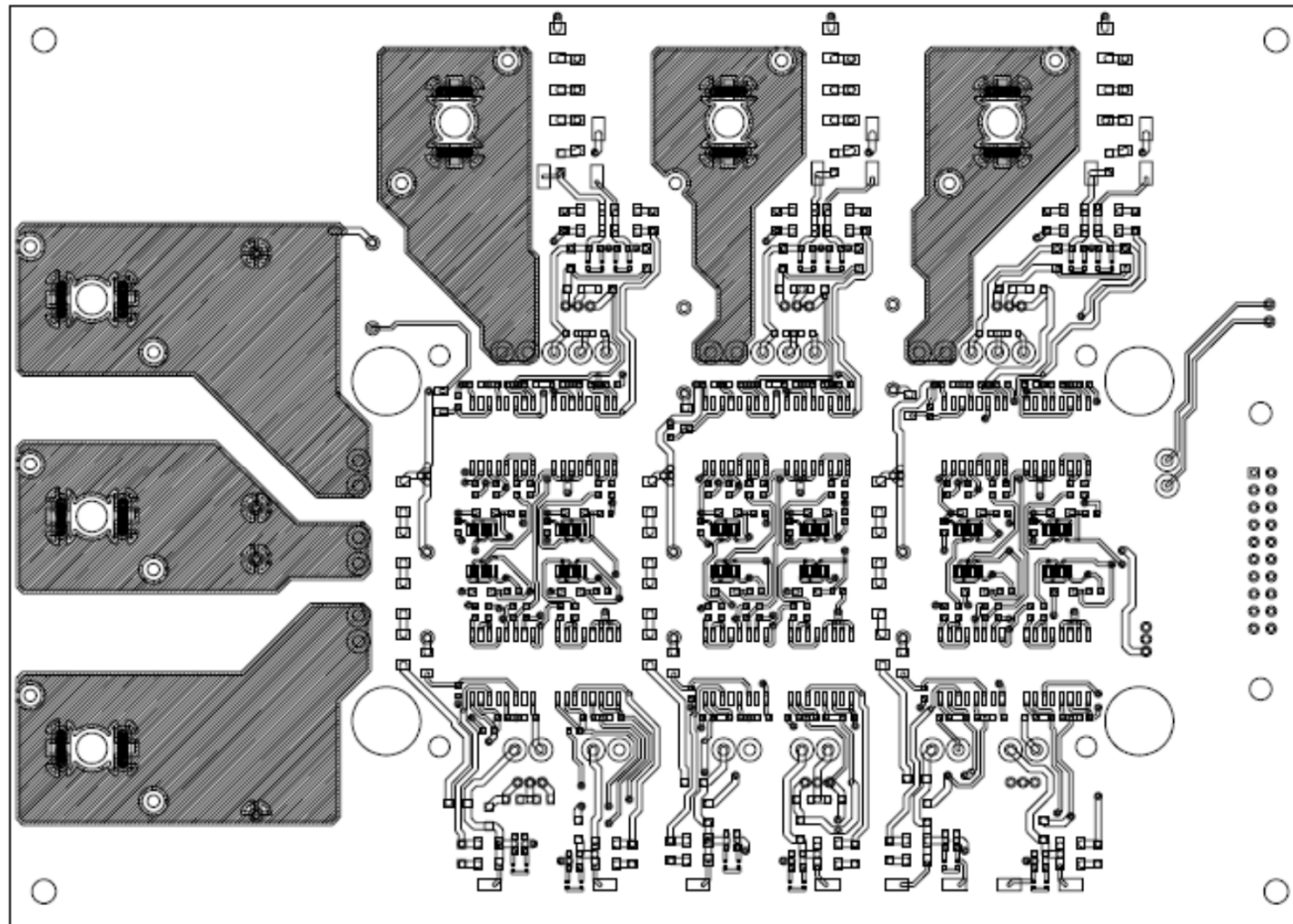


# GDU board pattern layout 1



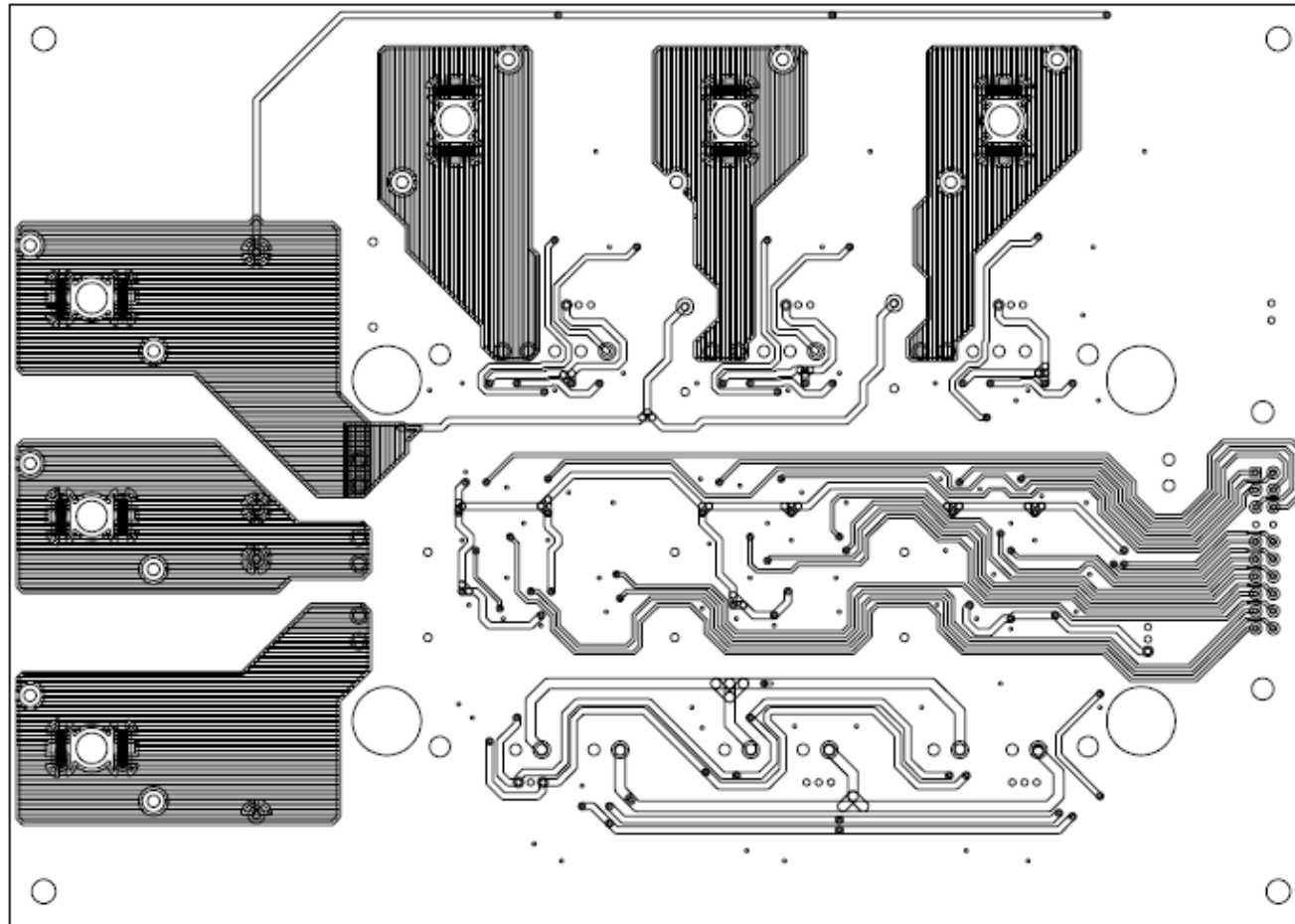
Assembly drawing

# GDU board pattern layout 2



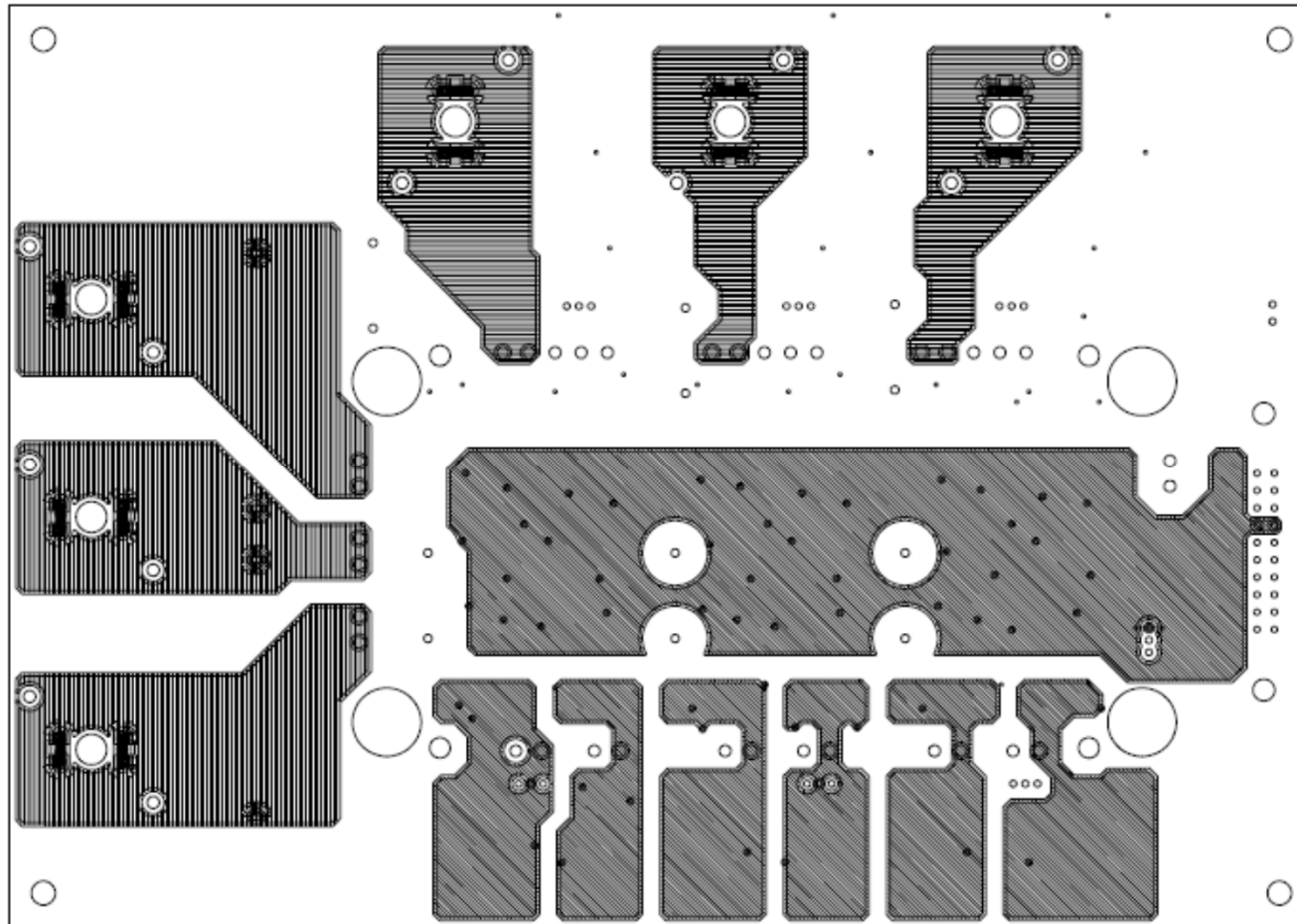
Top layer pattern

# GDU board pattern layout 3



Second layer pattern

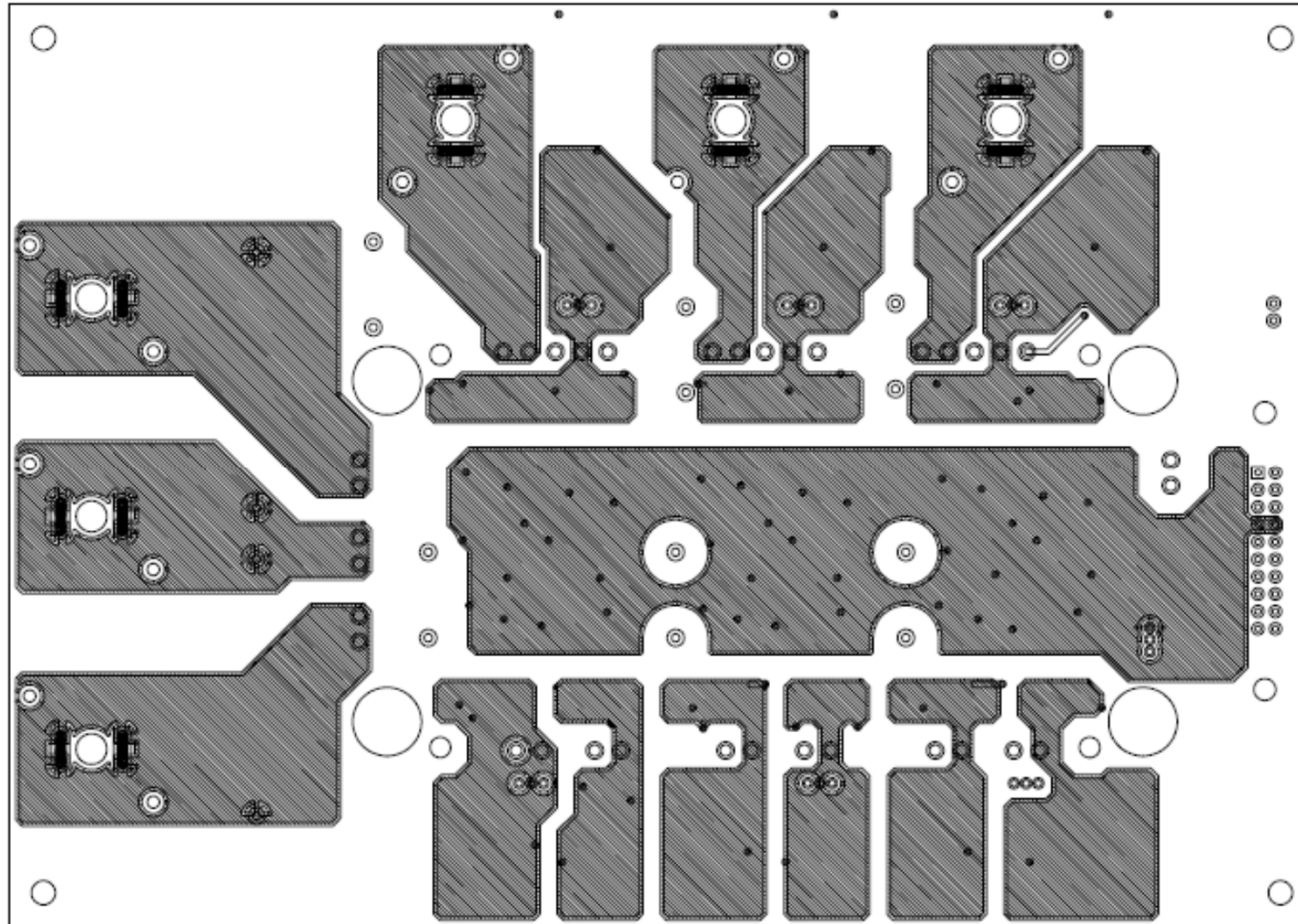
# GDU board pattern layout 4



Third layer pattern

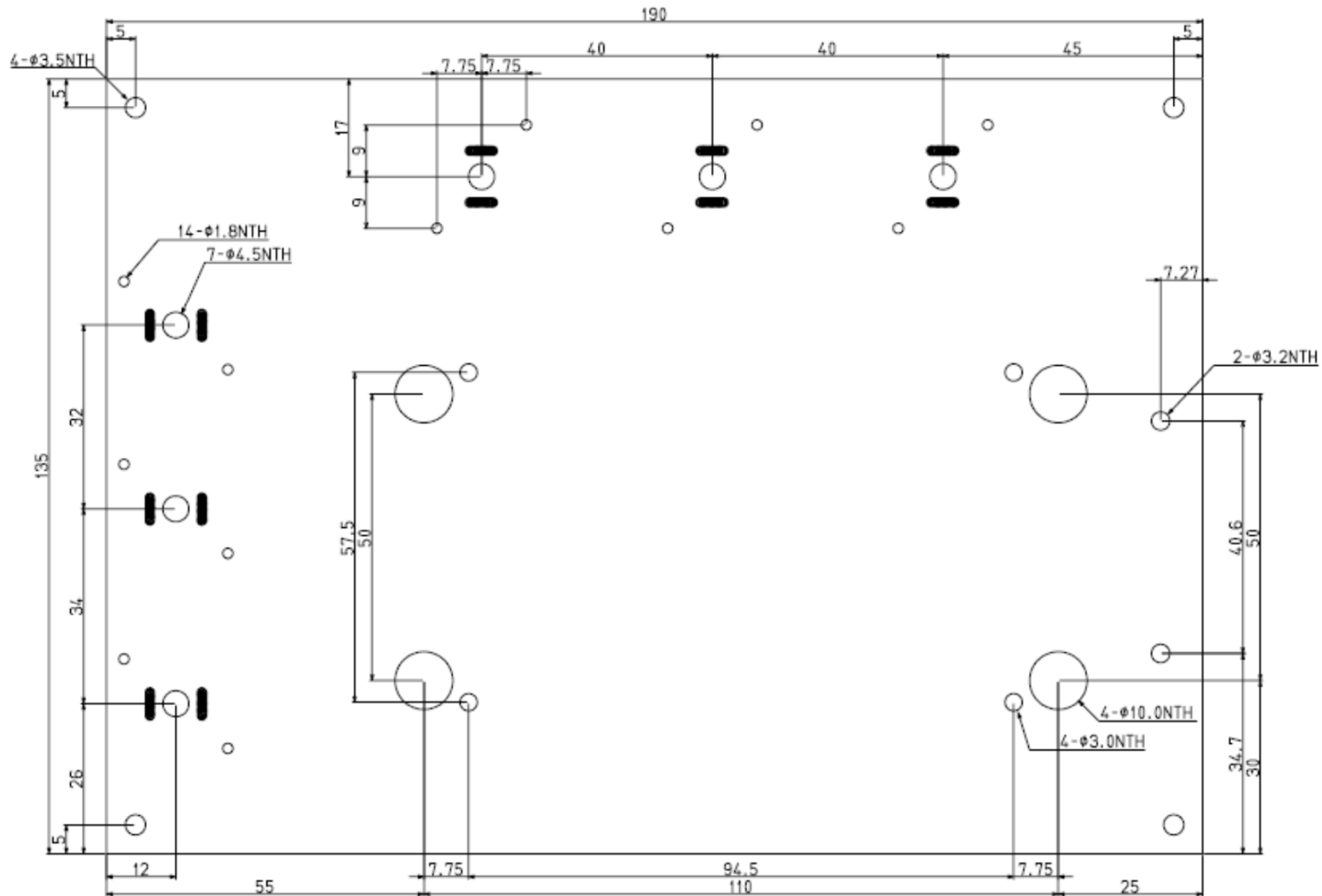


# GDU board pattern layout 5



Bottom layer pattern

# GDU board pattern layout 6



Board dimensions

Unit:mm