APPLICATION DATA SHEET

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DUALTRANSFORMER IGBT DRIVE

The intelligent dual drive is a universal drive designed for switching any power IGBT up to 800 AMPS and 1200/1700 VOLTS. The high output current capability, up to $\pm$15 Amps peak, makes it ideal for driving large IGBT modules with no need for other components or interface stages.

INPUT STAGE

The input stage of the board has a SCHMITT trigger to eliminate spurious pulses and pull down resistors. This feature eliminates the need for extra protection for an unconnected input. The input level can be 5 or 15 volts selectable by jumpers J2 and J3. When jumper J2 is ON, the 5V input is selected whereas when jumper J3 is ON the 15V input is selected.

WARNING: DO NOT SELECT BOTH MODES AT THE SAME TIME: WHEN ONE OF THE JUMPERS J2, J3 IS ON THE OTHER ONE MUST BE OFF.

The IGBT drive has a top–bottom interlock circuitry that prevents two IGBT's in the same leg from being turned on at the same time. Due to the turn on/off times and the rising/falling times of the power semiconductors, one has to delay the turn-on of one IGBT before the gate charge of the other one is completely removed. The typical (factory set) dead time is around 3.5µsec, but it can be adjusted to any value between 0 to 10 µsec by changing capacitors C3 (for the top channel) and C4 (for the bottom channel), respectively. The location of these two capacitors is shown in Fig. 3. Increasing their value leads to an increase in the dead-time while reducing their value leads to a decrease in the dead-time. Typically the user has to select a dead time that is longer than the turn-off delay time plus falling time of the IGBT driven. However, most of today's digital signal processors or microcontrollers have the capability of delivering the PWM pulses with a dead-time eliminating the need for correcting the pulses on the IGBT drive. Thus, the user has the option of bypassing the onboard dead time circuitry, which minimizes the total input-output propagation delay. If the 15V input is selected then jumpers J1 (for the top signal) and J6 (for the bottom signal) in the ON position will result in no dead-time adjustment for the pulses. If the 5V input is selected, then jumpers J4 (for the top signal) and J7 (for the bottom signal) in the ON position will result in no dead-time adjustment for the pulses. If, on the other hand, the jumpers J1, J4 (for the top signal) and J6, J7 (for the bottom signal) are OFF and the jumpers J5 (for the top signal) and J8 (for the bottom signal) are ON, then the pulses are adjusted for dead time regardless of the input selection 5V or 15V.

THE POWER SUPPLY AND DC/DC CONVERTER

The input voltage of the drive is 15 volts $\pm$5%. Note that this voltage has a common ground with the PWM pulses. The input voltage is applied to a high frequency DC/DC converter that provides two isolated positive (15 volts) and negative voltages (-10 volts) for the two secondary sides of the drive. Although the ground is common, the board has dedicated pins that should be used for the PWM pulses and power, respectively.

SHORT CIRCUIT PROTECTION

The drive provides short circuit protection for both IGBT's of the half bridge by monitoring the collector-emitter voltage of each device (also known as desaturation protection). When the IGBT is on, the voltage drop between the collector-emitter is low (typically less than 3.5 to 6 volts for IGBT's up to 400Amps/1700 Volts). When the IGBT is off, this voltage is very high, and typically equals the voltage of the DC-link stage of the power converter. If the drive senses that the voltage across the IGBT is greater than a user preset value when the transistor is commanded on, then a short circuit condition has been detected and the transistor is immediately switched off with a fault signal being reported back to the control side to **OC_ERROR** pin. The user has the choice of selecting the open collector **OC_ERROR** signal as normally high or normally low. When the jumper J16 is ON and J15 is OFF, the fault signal is HIGH for a normal condition and LOW in case of a short circuit. When the jumper J16 is OFF and J15 is ON, the fault signal is LOW for a normal condition and HIGH in the case of a short-circuit.

WARNING: MAKE CERTAIN THAT J15 AND J16 ARE NEVER SIMULATANEOUSLY ON, HOWEVER ONE OF THEM MUST ALWAYS BE ON IN ORDER TO HAVE AN ERROR SIGNAL.

An external resistor must be used for the open collector fault signal **OC_ERROR** as depicted in Fig.1. The resistor can be connected to any external voltage between 5 and 40 volts, but the current must be limited to 20 mA. If the jumper J14 is ON, once a short circuit condition has been detected, the open collector transistor remains latched in the off state until the RESET input is pulled to ground. If the jumper J14 is OFF, then the error signal is not latched and the **OC_ERROR** signal is asserted only for as long as the fault condition exists. When jumpers J11 (for the top transistor) and J12 (for the bottom transistor) are ON the pulses are inhibited in the primary side of the drive in the event of a fault condition. When jumpers J11 (for the top transistor) and J12 (for the bottom transistor) are OFF, the pulses are NOT inhibited on the primary side of the drive in the event of a fault condition, and the user can decide when and how to stop the pulses. This feature may be used in case of a series/parallel use of IGBT's where all the devices may need to be turned off simultaneously in order to prevent a chain reaction that would destroy more than one IGBT in the series/parallel connection. This feature must also be selected in the secondary side: when J17 is OFF, the pulses are not turned off on the top secondary side in case of a short circuit. Similarly, when J18 is OFF the pulses are not turned off on the bottom side. In contrast, when J17 is ON, the pulses are turned off on the top secondary side in case of a short -circuit and similarly, when J18 is ON, the pulses are turned off on the bottom side. **Note that the jumpers J11, J12, J17 and J18 should ALL be either ON or OFF**. If ALL the jumpers are OFF, then the user has the responsibility to **QUICKLY (LESS THAN 10 µsec)** turn off all the pulses from the control unit in the event of an error signal. Failure to do so may lead to the destruction of the IGBT(s). For most common applications that do not involve series/parallel connection, the jumpers J14, J11, J12, J17 and J18 should all be ON.

In the case of a failure of the secondary side voltage, a 20Kohm and bi-directional 15V TVS (transient voltage suppressor) are connected across the gate-emitter to protect the IGBT. Note that the desaturation protection must remain disabled (blanking time) for a very short period of time right after the turn-on command in order to to allow the voltage to fall below the preset threshold. The blanking time (factory set to 3.5? sec) can also be selected by changing the values of capacitors C39 (for the top signal) and C45 (for the bottom signal) respectively, but it is not recommended to be less than 2-3? sec because it may falsely trigger the OC_ERROR signal. Increasing their value leads to an increase of the blanking time while reducing their value leads to a decrease of the blanking time. On the other hand, the IGBT's are generally rated for short circuit for a very short period of time, 10? sec, therefore, increasing the blanking time above this value may lead to the destruction of the IGBT in the case of a short-circuit. The short-circuit protection compares the voltage across the IGBT during ON time with a dynamic reference which is exponentially decaying during the blanking time and settles to a fixed threshold (factory set to 7V). If the ON voltage of the IGBT does not fall below this threshold after the blanking time has elapsed, a short circuit condition is detected and the OC_ERROR signal is asserted. It is possible to modify the short-circuit detection threshold by changing the resistors R47 (for the top signal) and R59 (for the bottom signal), respectively. Increasing their value leads to a decrease of the threshold level while reducing their value leads to an increase of the threshold level.

UNDERVOLTAGE LOCKOUT FEATURE

Another feature of the drive is the undervoltage lockout that is designed to prevent the application of insufficient gate voltage to the IGBT. This could be dangerous, as it would drive the IGBT out of saturation and into the linear operation where the losses are very high and quickly overheat. This feature monitors all the positive supply voltages: the main 15 volt input voltage and the two secondary voltages. The PWM pulses are inhibited in the primary section of the drive as long as the input voltage is less than 12.5 volts. In case the high-frequency DC/DC converter fails, there is also a monitoring function on each of the two positive 15 volts of the secondary: if the voltage drops below 12.5 volts, then the pulses are turned OFF and the OC_ERROR signal is asserted.

TURN ON/TURN OFF RESISTORS

In order to optimize the turn on and turn off speed of a particular IGBT, the user must carefully choose the proper turn/off resistors. The values of these resistors determine the maximum amount of gate charging/discharging current and should ensure correct and safe commutation of the IGBT. When calculating the peak charging/discharging currents for a particular IGBT, the user must observe the following:

1. The maximum peak output current is 15 Amps/channel
2. The maximum output average current is 200ma/channel
3. For a particular application, the user must determine from the IGBT's data sheet (the gate charge characteristic Q_{GE} versus gate voltage V_{GE}) for a given DC link operation and at 15 volts gate. This is the maximum gate charge Q_{GATE}. For a given switching frequency f(Khz) the output average current can be calculated as follows:

   $I_{OUT\text{-}AVERAGE}$ (mA) = f (Khz) * Q_{GATE} (nC)

   This value must be less than 200mA for the drive to be able to correctly operate.

4. The equivalent input gate emitter capacitance of the IGBT is next calculated as

$$C_{in} \ ? \ \frac{Q_{GATE}}{? V_{GATE}} \qquad ? V_{GATE} \ ? \ V_{GATE(ON)} \ ? \ V_{GATE(OFF)} = 15 - (-10) = 25V$$

It is important to note that this is the true capacitance seen by the drive during the commutation process and it should not be confused with C_{ISS} specified on the IGBT data sheet because this is the input capacitance measured with a very small collector voltage (typically less than 30 Volts) and does not take into account the internal feedback effect that takes place during switching (the MILLER effect). Only if a resonant zero voltage switching topology is used can the C_{ISS} be used as equivalent input capacitance for calculating the required power to drive the IGBT.

1. The total power used to for driving the IGBT can now be calculated:

   P = f (KHz) * C_{IN} * $?V_{GATE}^2$ (W) where $?V_{GATE}$ = 25 Volts

2. The TURN-ON gate resistor must be selected: $R_{GATE(ON)} = V_{GATE(ON)}/ I_{PEAK}$

   We can therefore write $R_{GATE(ON)}$(MIN) = $V_{GATE(ON)}/I_{PEAK}$(MAX), where

   $V_{GATE(ON)}$ = 15 Volts and I_{PEAK}(MAX) = 15 Amps

3. The TURN-OFF gate resistor must be selected: $R_{GATE(OFF)} = V_{GATE(OFF)}/ I_{PEAK}$

   We can therefore write $R_{GATE(OFF)}$(MIN) = $V_{GATE(OFF)}/I_{PEAK}$(MAX), where

   $V_{GATE(OFF)}$ = -10 Volts and I_{PEAK}(MAX) = 15 Amps

Note that there is a provision for using different turn on /turn off resistors. The turn on resistors are R66 (TOP) and R75 (BOTTOM) respectively while the turn–off resistors are R67 (TOP) and R76 (BOTTOM). For correct operation, the turn on and the turn off resistors should limit the peak output current to 15A.

GUIDELINES FOR CHOOSING THE GATE RESISTORS

When selecting the gate turn on and turn off resistors, the user tries to charge/discharge the IGBT's gate as quickly as possible in order to reduce the switching losses. However, it is important to acknowledge that extremely fast turn on of the IGBT will cause a high overcurrent due to the turn-off behavior of the freewheeling diode of the other IGBT in the arm. The limited di/dt capability of the free-wheeling diode is usually the main factor that dictates the maximum turn-on speed of a given IGBT. Often in trying to speed up the IGBT switching time, the diode will fail in overvoltage or the losses will increase because the diode cannot turn off fast enough and a short circuit path will be developed between the IGBT that turns on and the free-wheeling diode that turns off. Another important aspect is to minimize the parasitic inductance in the DC link circuit in order to keep the turn off overvoltage of the IGBT within the maximum value specified in the data sheet of the IGBT. Low inductance snubber capacitors and low inductance distributed bus bar layout are mandatory at current levels above 50 Amps. Careful analysis and interpretation of both drive and IGBT's data sheets are required in order to correctly choose the gate resistor values. It is highly recommended to start a new design with higher values for the TURN-ON/ TURN-OFF resistors and observe the commutation process by means of an oscilloscope and then gradually reduce the values of the resistors.

PRELIMINARY ELECTRICAL CHARACTERISTICS (Ta = 25 C)

Input supply voltage: 15 Volts +/- 10%
Maximum input current: 850mA (for an output average current of 200 mA on each channel):
Output average current: 200 mA for each channel
Output peak current: 15 Amps
Minimum gate turn-on resistance: 1 ohm
Minimum gate turn-off resistance: 1 ohm
Collector-emitter voltage sense: 1200/1700 Volts
Reference for VCE monitoring: user selectable (3 to 12 Volts)

Input threshold voltage high (min):	8.25 Volts (for 15V input)
	2.75 Volts (for 5V)
Input threshold voltage low (max):	6.75 Volts (for 15V input)
	2.25 Volts (for 5V)

Common mode rejection: typical 100 Kvolts/? sec

Input–output momentary withstand voltage: 4000 volts rms (1min, RH<50%, T = 25C)
6000 volts rms (special order)
Dead-time range: 0 to 10 ? sec (higher values are also possible but not recommended)

Propagation delay time: typical 600 nsec

(NOTE: The above delay time is considered for the case with no dead time adjustment)

Operating temperature: -40 to 85 C

Storage temperature: -55 to 100 C
Turn on output voltage: 15 Volts
Turn off output voltage: -10 Volts

DRIVE CONNECTORS

1. INPUT CONNECTOR (MICROFIT JUNIOR P/N 43025-1200):

Pin 1	Second PWM pulse (BOTTOM)
Pin 2	First PWM pulse (TOP)
Pin 3	Reset
Pin 4	Open collector FAULT signal.
Pins 5,6,7,8	Input supply (+15V)
Pins 9,10	PWM pulse ground (DIGITAL GROUND)
Pins 11,12	Input supply return (POWER GROUND)

2. OUTPUT CONNECTORS (MICROFIT JUNIOR P/N 43645-0600)

Pin 1:	IGBT's COLLECTOR
Pins 2,3,4	Not connected
Pin 5:	IGBT's GATE
Pin 6:	IGBT's EMITTER

3. TERMINALS: Female-tin (MOLEX P/N 43030-0007)
   Female-gold (MOLEX P/N 43030-0009)

IMPORTANT NOTES:

1) By default, jumper J9 internally connects the two grounds: digital grounds from the PWM pulses (pins 9 and 10 from the input connector) and the power ground (pins 11 and 12 from the input connector). **DO NOT REMOVE THIS JUMPER.**
2) It is **NOT** recommended to use a dead time smaller than 2?sec.
3) It is **NOT** recommended to use a blanking-time smaller than 3?sec or a short-circuit threshold less than 7 volts.
4) In the event of a short circuit the drive will latch in the off position if jumpers J14, J11, J12, J17 and J18 are all ON. The user must use the OC_ERROR signal (pin 4 from P1) and disable any other drives in the circuit, for instance the other two drives of a three-phase converter, from the controller. The digital controller should then reset the corresponding drive by pulling the RESET line (pin 3 from P1) to ground and normal operation can resume.

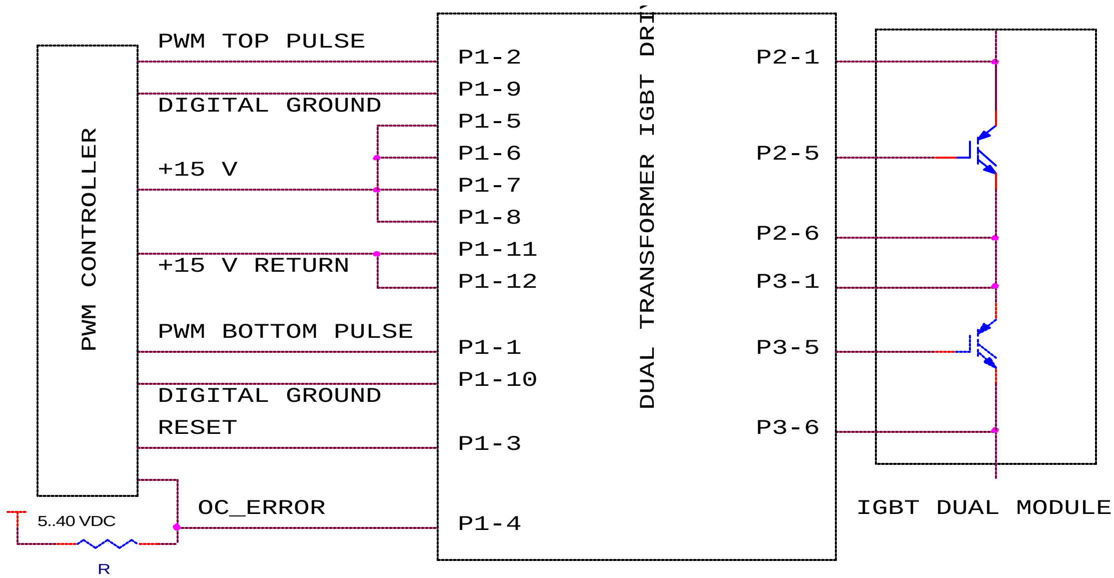

Fig. 1 Typical interconnection between the IGBT drive and a PWM controller

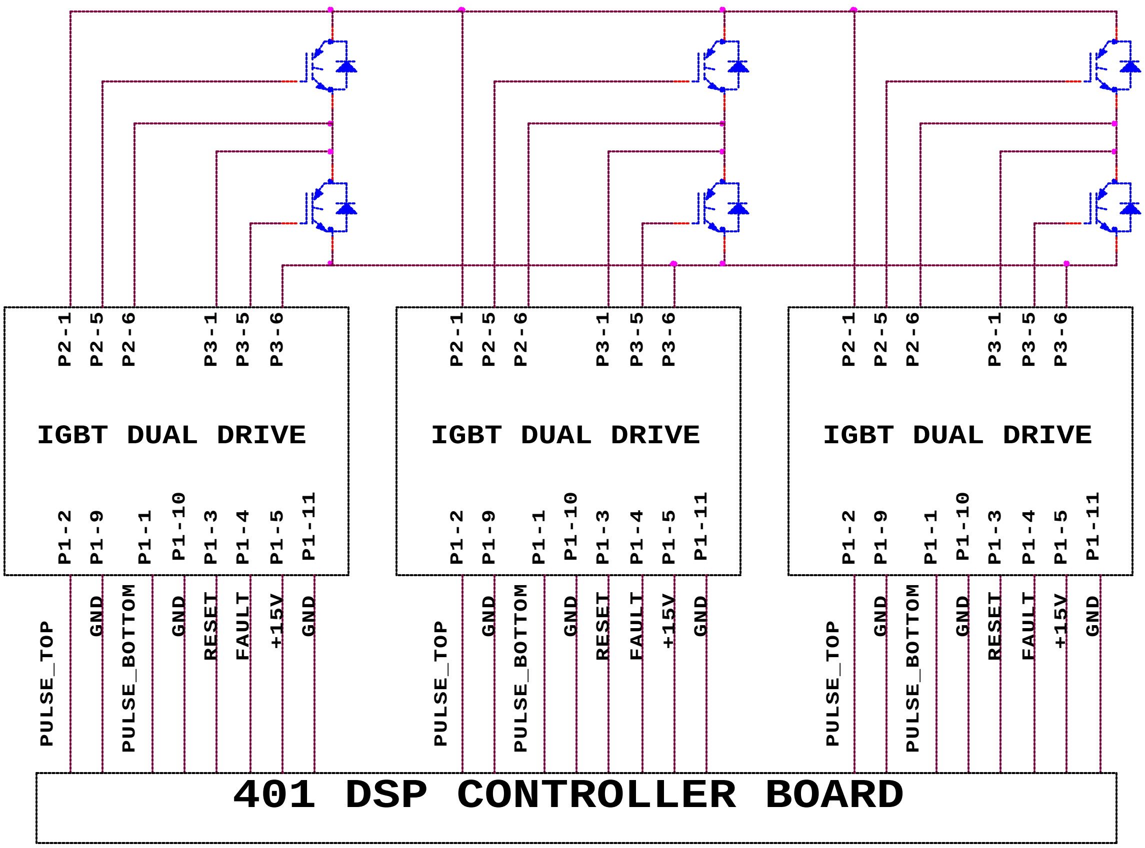

Fig. 2 Typical interconnection between IGBT drive and high performance digital DSP controller

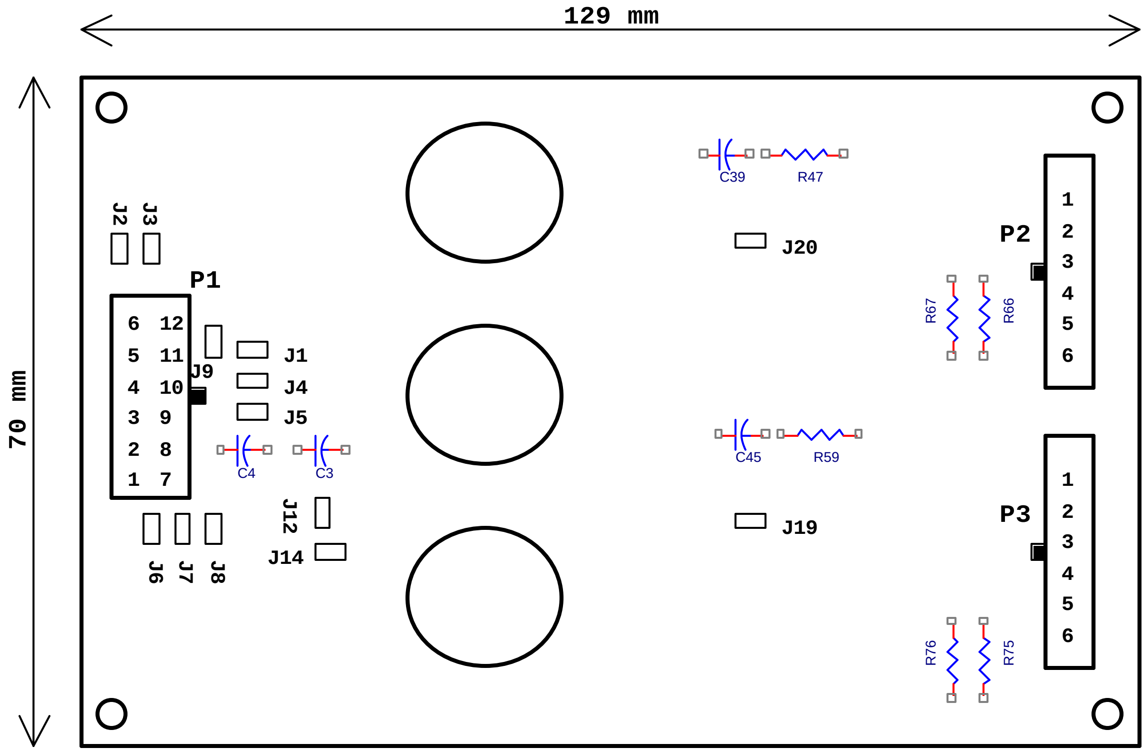

Fig. 3 Top assembly view

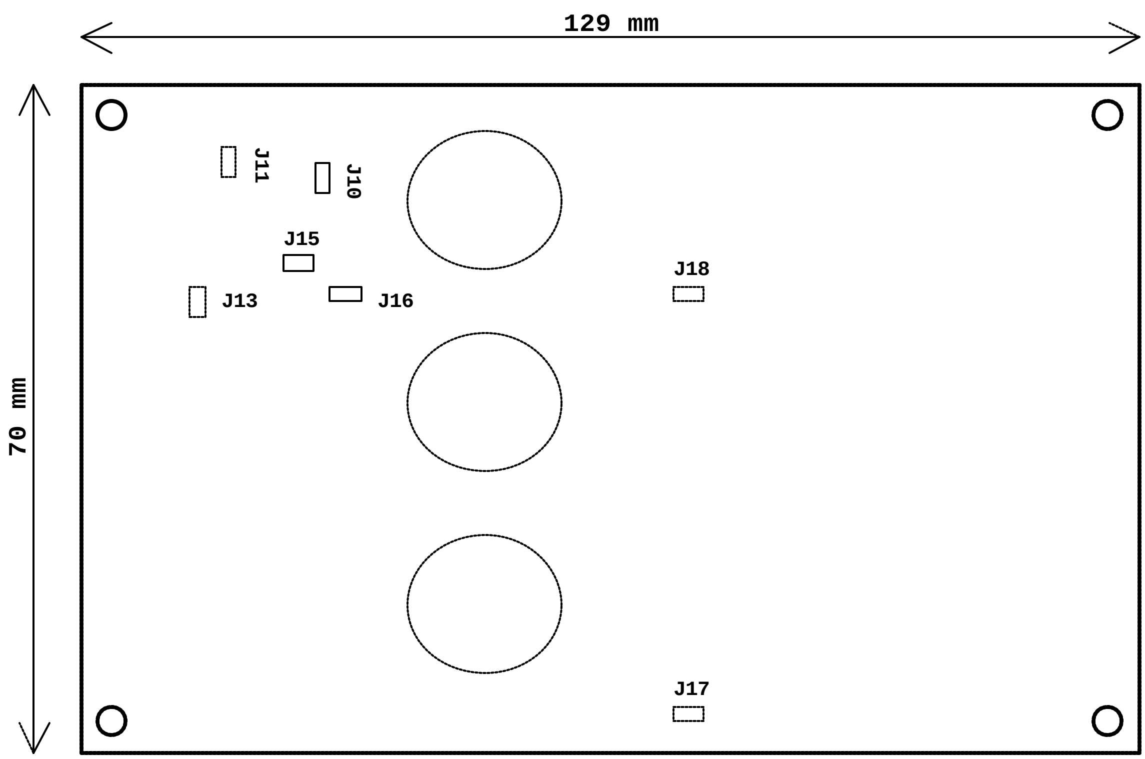

Fig. 4 Bottom assembly view