Phase Leg IGBT with an Integrated Driver Module

Reference Design

Overview

This design integrates IXYS Corporation's MIXA225PF1200TSF Phase Leg IGBT Module and IXIDM1403_1505_M High Voltage Isolated Driver Module into a functional high power device operated directly from a microcontroller unit (MCU) through a 4 kV isolation barrier. Powered from a single polarity 15V power supply, this design shows the operation of two 1200V IGBT devices with a maximum collector current of 360 A. Utilizing this design will allow for MCU alerts regarding fault signals about under – or overvoltage conditions on the primary and secondary sides, and overload conditions when IGBTs go into desaturation mode. The MCU can be powered from this module and does not require a separate power source. If a user prefers to drive the MCU via an external power source, this can be accomplished with internal IXIDM1403 logic powered from the same source, minimizing power consumption from the 15V power supply.

Features

The Phase Leg IGBT with Integrated Driver Module design includes the following features:

- Integrated gate drivers, IGBTs, and freewheeling diodes
- IGBT desaturation mode current sensing
- Extreme light punch through IGBT for 20–60 kHz switching frequency
- Square RBS operating area
- Low VCE saturation voltage
- Short circuit capability
- Under– and Overvoltage Lockout (UVLO/OVLO) for primary and secondary sides
- Input logic with Schmitt triggers for better noise immunity
- 4 kV fully isolated package
- Built-in NTC resistor for package temperature monitoring
- Operating ambient temperature : – 40 ^{0}C ∼ + 105 °C
- Environmentally friendly; EU RoHS compliant, Pb free

Potential Applications

This design provides a basis for developing a variety of power management applications such as:

- Microcontroller operated motors in various appliances
- High power converters

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Description

This design consists of a Base Power Board (Power Board) with the IXIDM1403_1505_M module affixed to it and the MIXA225PF1200TSF module as shown in Figure 1 (the module is located on the board's underside).

Figure 1. Design Assembly

The Power Board is a two-layer surface mount board that provides connections between the MIXA225PF1200TSF and IXIDM1403 modules and contains resistive dividers that limit IGBTs' de-saturation voltage, at which point overload protection is triggered.

A MIXA225PF1200TSF built-in temperature sensor and multiple protection functions prevent the device from encountering unconditional operations. The short-circuit-rated IGBTs with low saturation voltage and square RBS operating area guarantee fail-safe operation. Logic compatibility with +3.3V microcontrollers and high voltage isolation between both high and low side IGBTs simplifies the design and reduces cost of assembly.

A 12-wire flat flexible cable (FFC) with 1 mm pitch allows the IXIDM1403 module to communicate with the MCU. The FFC also provides power to drive the MCU with +3.3 V derived from the IXIDM1403 module that utilizes single +15 V source. If an external +3.3 V power supply is used to power the MCU, the same source can be used to drive the IXIDM1403 module's internal logic. In this case, the internal IXIDM1403 +3.3V power supply should be disabled by connecting the MODE pin to the +3.3 V source. Such a process will avoid competition between power sources and the IXIDM1403 module's internal logic will be powered from an external source. The IXIDM1403 module is able to provide up to 100 mA current at MCU initialization and up to 50 mA current to drive the MCU at a steady state.

The dimensions of the Power Board are 3.9” (L) x 2.45" (W) x 0.1" (H) without the IXIDM1403 module attached. The dimensions of the design assembly with all modules included are 6” (L) x 2.45” (W) x 1.88” (H).

Typical applications for this design are shown in Figures 2 and 3.

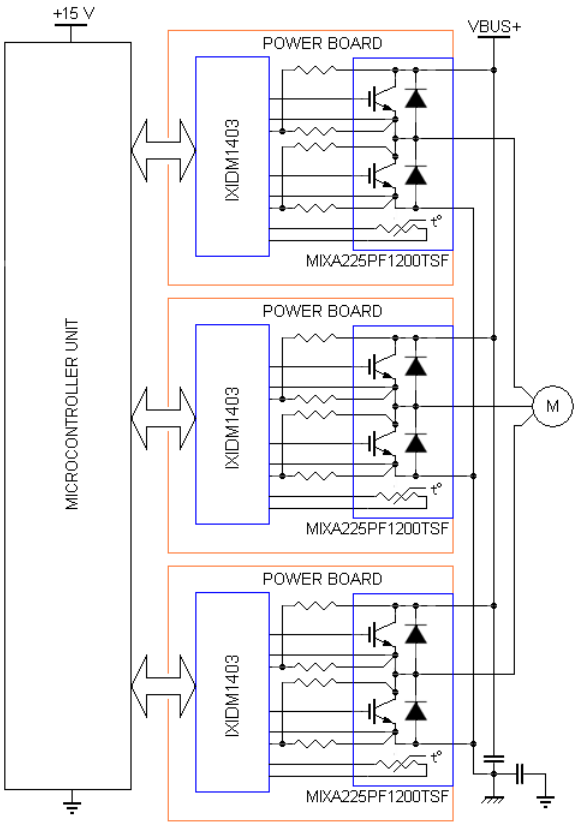

Figure 2: Typical Application Circuit of a Three-phase Motor Driver

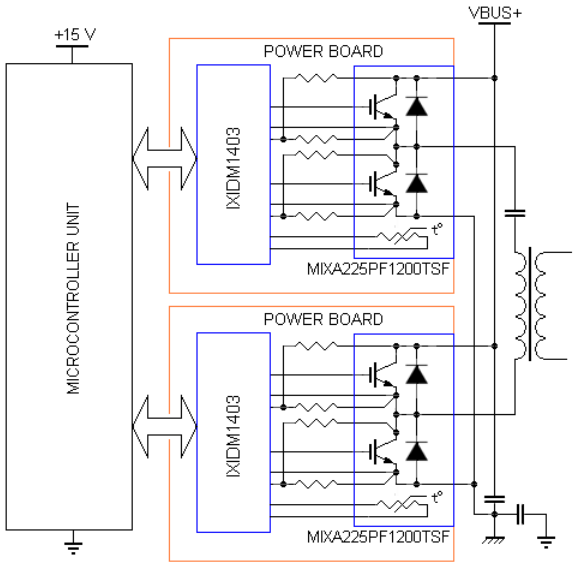

Figure 3: Typical Application Circuit of a Full-bridge Inverter

The Power Board electrical schematic diagram is shown in Figure 4.

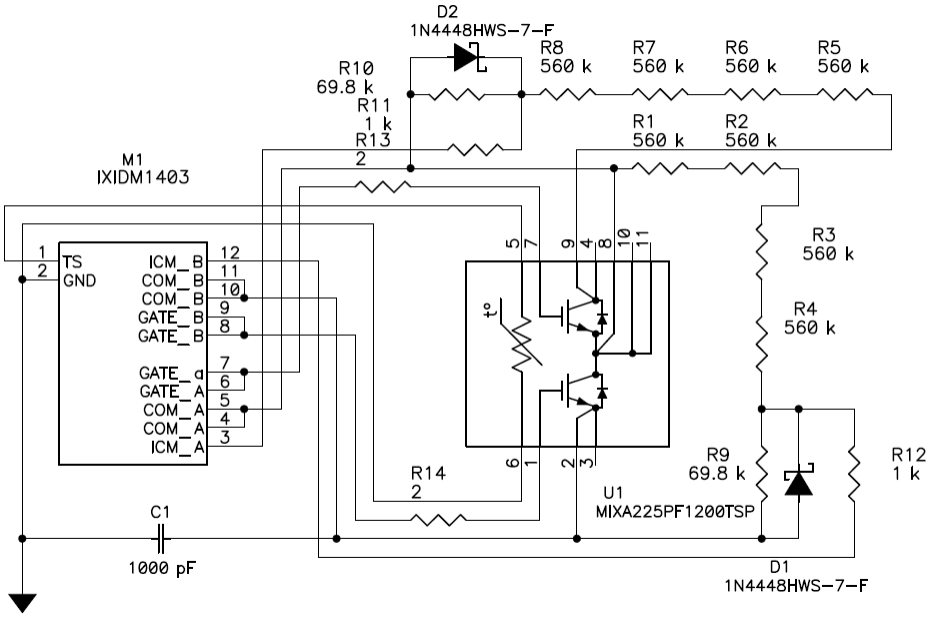

Figure 4: Power Board Electrical Schematic Diagram

Absolute Maximum Ratings and Electrical Operating Characteristics

Absolute maximum ratings and electrical operating characteristics are determined by the components used in assembly. For more information, refer to the IXIDM1403_1505_M and MIXA225PF1200TSF data sheets.

Pin Configuration

The pin configuration is shown in Figure 5.

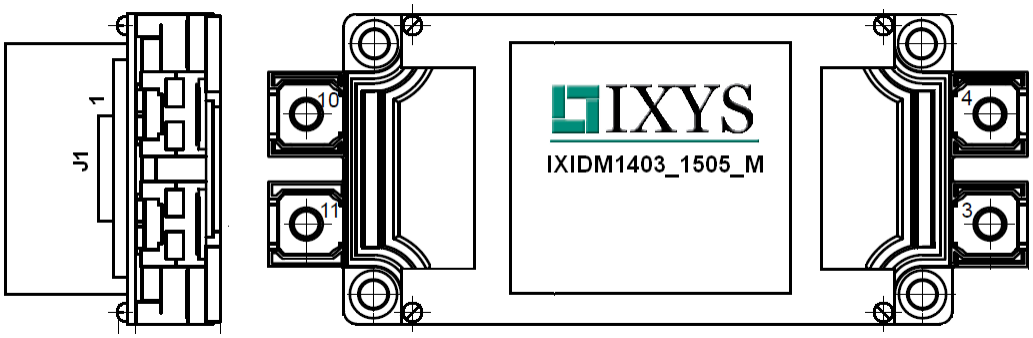

Figure 5: Pin Configuration

Pin Assignment

Table 1 lists the pins and their assignments.

Table 1. Pin Assignments

Module IXIDM1403, Connector J1		
Pin Number	**Pin Name**	**Functions**
1	+15 V	Supply voltage. Connect the positive terminal of the +15V supply source
2	+3.3 V	Output voltage to drive the external MCU. It should be disabled by the MODE pin set at logic high level if the MCU is powered from a source other than the module. In this case, the same external source should be used to drive the internal logic of the IXIDM1403 module.
3	MODE	MODE = 0 V or left open activates the internal +3.3V source. The MODE pin set above +2.5V disables the +3.3V source and an external source should be connected to +3.3V to operate the internal logic.

4	FLT_RESET	Positive logic pulse at this pin resets FAULT1 and FAULT2 conditions.
5	RESTART	Positive logic pulse at this input restarts the module.
6	CLK	Logic input to provide external clock in case synchronization between internal power supplies of different modules is required. If no external clock is applied, the internal clock will be used.
7	FAULT1	FAULT1 signal logic output
8	FAULT2	FAULT2 signal logic output
9	GROUND	Ground terminal for all power supplies and logic signals
10	INB	Channel B gate driver logic input
11	INA	Channel A gate driver logic input
12	TS	Terminal to translate thermo sensor information from the IGBT module to the MCU. It is a direct connection to pin #1 of the connector J4
Module MIXA225PF1200TSF		
3	VBUS-	Low side IGBT emitter power output
4	VBUS+	High side IGBT collector power input
10, 11	PHASE	High side IGBT emitter/low side IGBT collector power input/output

Operation

Before the start of operation, this design should be assembled on a heat sink with adequate dissipation power capability using the MIXA225PF1200TSF mounting holes. High power lines should be connected with respect to the MIXA225PF1200TSF pin assignments shown in Table 1. If the VBUS line is isolated from the signal ground line, these high power lines should be connected together by a ceramic capacitor with a value of ~220 pF–470 pF and rated to the required isolation voltage to prevent electrostatic damage (see Figures 2 and 3). Signals to/from the IXIDM1403 module and power should be provided by a 12-conductor flex cable with 1 mm pitch inserted into connector J1 of the IXIDM1403 module with the open conducting surface facing up. The recommended cable type is 98267 from Molex. In case of long cable and very noisy environment, it is recommended to use ferrite bids 28R0614-100 from Laird-Signal Integrity Products or identical located close to the IXIDM1403 module connector to improve noise immunity.

The power to drive the IXIDM1403 module should be applied between pin numbers 1 and 9 of connector J1. To drive the external MCU, power from the IXIDM1403 module in the form of a +3.3V source should be collected between pin numbers 2 and 9 (see Table 1. Pin Assignments). If an external +3.3V source is used to drive the MCU, use the same source to drive the IXIDM1403 module's internal logic blocks. In this case, the internal voltage source of the module should be disabled by connecting pin number 3 (MODE) to pin number 2 (+3.3V) to avoid competition between regulators. If more than one design is used with the same MCU, either an external +3.3V source or the +3.3V source should be derived from only one design. Other designs utilizing the +3.3V output(s) should be either left open or connected using diode O-ring connections to prevent competition between regulators.

Connector J1 pin number 3 (MODE) has a pull-down resistor, so if this pin is left open or grounded, the IXIDM1403 module uses an internal +3.3V power supply to drive logic blocks. If this pin is connected to the +3.3V output (pin number 2), the internal supply is disabled and an external +3.3V source should be applied to pin number 2 to drive the IXIDM1403 logic blocks.

The voltage applied to pin number 1 of connector J1 should be in the operating range specified in the IXIDM1403 data sheet. If under– or overvoltage occurs, gate drivers are disabled and respective fault signals are generated. These fault signals cannot be reset by the FLT_RESET signal from the MCU as long as the fault condition exists. Refer to the IXIDM1403 data sheet for more information about fault signals.

IXYS recommends that the MCU firmware monitors the existence of fault signals at all stages of the design before attempting to start the gate drivers. Such monitoring is necessary due to variations in over– and under-voltage thresholds from one part to another, which may block gate driver signals in certain designs. In such instances, non-standard operating conditions for a load may occur.

It is also recommended that short test pulses be emitted into channels A and B to verify the existence of normal operating voltages at the secondary side before the start of normal operations. If an over– or undervoltage condition exists on the secondary side, test pulses will be echoed into the respective fault outputs. These signals can be reset by the FLT_RESET signal from the MCU, but will be generated again at the next attempt to drive the gate in the fault channel.

The IXIDM1403 primary-to-secondary internal power converter operates by default from an internal 100 kHz clock with a ~50% duty cycle. If two or more designs are used, it may be useful to synchronize these clocks to minimize system noise. In this situation, an external 200 kHz clock should be applied to pin number 6 of connector J1. The IXIDM1403 switches from an internal clock to an external clock after eight consecutive clocks from an external source are recognized. If the external clock disappears for more than 40 µs, the internal clock will be used instead.

The external clock can also be used to correct the secondary side voltage by adjusting the duty cycle. The IXIDM1403 module copies the duty cycle of the external clock, which may vary from 10% to 50%.

Pin number 12 of Connector J1 is a direct connect to the temperature sensor of the MIXA225PF1200TSF module and can be used to monitor the MIXA225PF1200TSF package temperature by applying a steady low current and monitoring voltage drop between pin numbers 12 and 9. See the MIXA225PF1200TSF data sheet for temperature sensor resistance versus temperature dependence.

Typical Performance Characteristics

Figures 6–9 display IXIDM1403 performance with the 10 nF gate load capacitance, while Figures 10–16 display IXIDM1403 performance with the MIXA225PF1200TSF module as a load.

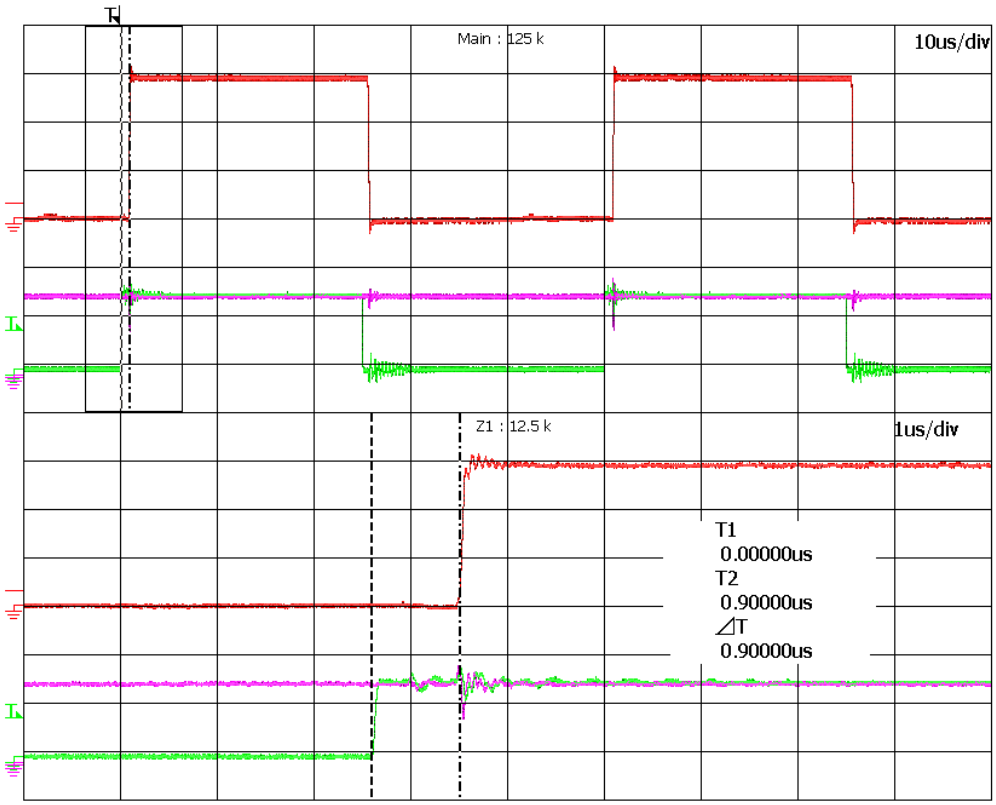

Figure 6: MIXA225PF1200TSF Operating in Complimentary mode with a Single Signal Source at IXIDM1403 Channel A and Channel B Permanently Enabled

Input to Output Propagation Delay at Rising Edge

Channel 1 – red – IGBT Module pin #3, 4 voltage, Channel 2 – green – IXIDM1403 channel A input signal, Channel 3 – magenta – IXIDM1403 channel B input signal.

Bottom portion of the Figure 6 is 10x magnified portion of the upper portion.

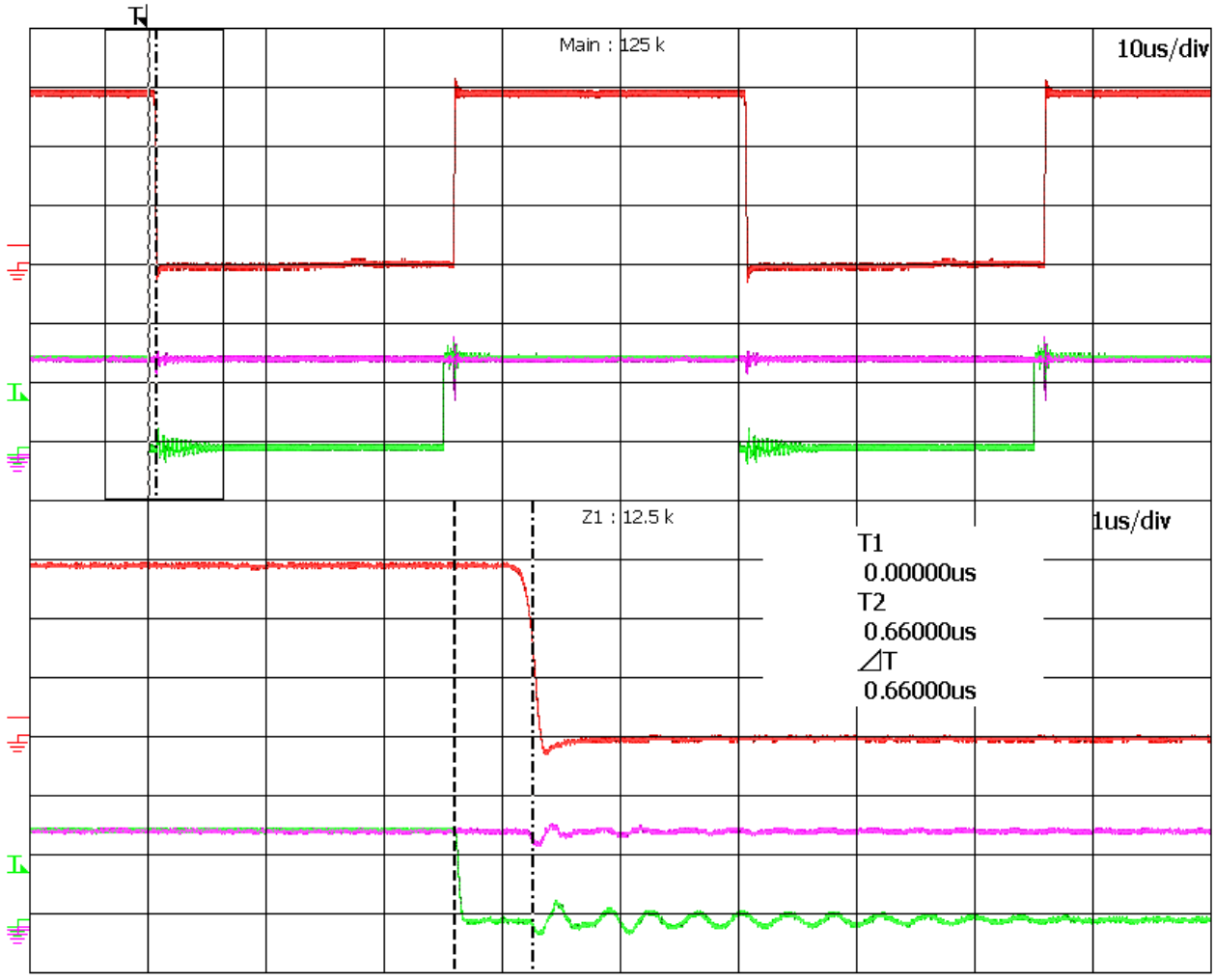

Figure 7: MIXA225PF1200TSF Operating in Complimentary mode with a Single Signal Source at IXIDM1403 Channel A and Channel B Permanently Enabled

Input to Output Propagation Delay at Falling Edge

Channel 1 – red – IGBT Module pin #3, 4 voltage, Channel 2 – green – IXIDM1403 channel A input signal, Channel 3 – magenta – IXIDM1403 channel B input signal.

Bottom portion of the Figure 7 is 10x magnified portion of the upper portion.

Package Drawing and Dimensions

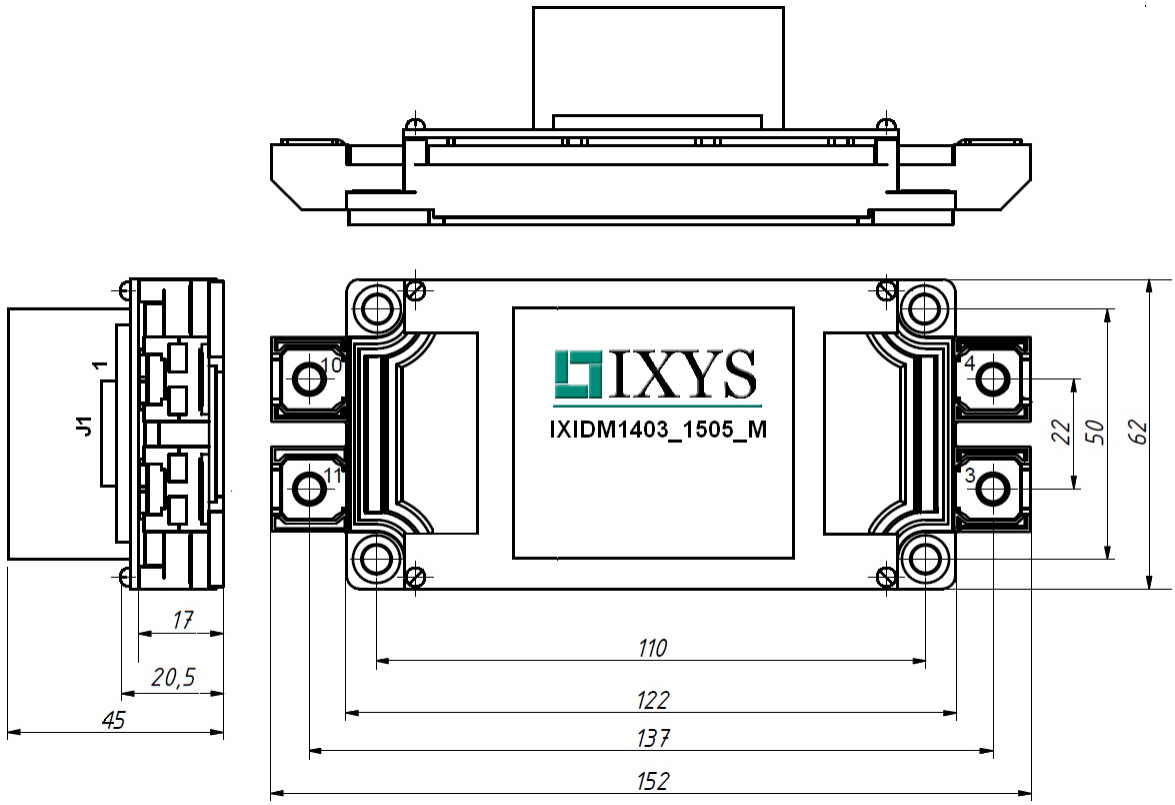

Figure 8. Package Drawing (Units: mm)

Marking

IXIDM1403_1505_Marking

Phase-leg IGBT Module Marking

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