# Cost-optimized, battery-powered motor drive using dual-channel power MOSFET

## About this document

### Scope and purpose

This user manual describes a cost-optimized solution including the board REF_18V_90W_SLFOC and its firmware from Infineon for a battery-powered motor drive application such as domestic robots or smaller power motor drives. This solution provides a complete hardware and firmware design for the PMSM motor, utilizing XMC™ 1300 Arm® Cortex®-M0 MCU, the highly integrated MOTIX™ 6ED2742S01Q gate driver, OptiMOS™ dual N-MOSFET for high efficiency, and single-shunt sensorless field-oriented control (FOC) methodology.

### Intended audience

This document is intended for users who would like to design a cost-optimized motor drive with a single-shunt sensorless FOC methodology.

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# 1 Introduction

Creating efficient and compact designs for battery-powered motor drives is crucial in today's competitive market. Infineon's dual-channel power MOSFETs offer a cost-optimized solution that ensures high performance and reliability, while delivering numerous customer benefits.

Infineon's solution provides the following advantages:

- **High price/performance ratio**: By integrating two MOSFETs in a single package, Infineon's dual-channel power MOSFETs deliver exceptional value, ensuring that customers get the most out of their investment
- **Lower BOM cost**: The use of sensorless field oriented control (FOC) eliminates the need for position sensors, reducing the BOM cost. This streamlined approach employs only one shunt and an integrated current sense amplifier (CSA)
- **High power efficiency**: Leveraging OptiMOS™ technology, the ISA250250N04LMDS dual N-MOSFET and the MOTIX™ 6ED2742S01Q highly integrated gate driver ensure high efficiency, contributing to longer battery life and improved performance

Infineon's cost-optimized motor drive solution, including the REF_18V_90W_SLFOC board and its firmware, provides a complete package for sensorless FOC. This approach contrasts with widely used market solutions based on trapezoidal control and Hall sensors, offering a superior alternative.

Key components of this solution include:

- **XMC™ XMC1300 Arm® Cortex®-M0 MCU:** 32-bit microcontrollers with Arm® Cortex®-M0, delivering an industry-leading price/performance ratio
- **MOTIX™ 6ED2742S01Q highly integrated gate driver:** Three-phase motor control gate driver IC, ensures robust control and protection features
- **OptiMOS™ ISA250250N04LMDS dual N-MOSFET:** Dual N-channel power MOSFET 40 V in SO-8 package, optimized with OptiMOS™ technology for high efficiency

The XMC1302-Q024F0064 32-bit microcontroller with Arm® Cortex®-M0 is specifically designed for low-cost embedded control applications. The XMC1000 series is the top choice for elevating traditional 32-bit designs, covering a wide range of applications from typical 32-bit tasks to digital power conversion and even field-oriented motor control. The XMC1300 family is capable of integrating all necessary control and analog interface functions required for sensorless FOC, brushless (BLDC), brushed DC, and PMSM motors.

The MOTIX™ 6ED2742S01Q is a 160 V SOI-based gate driver specifically designed for three-phase BLDC motor drive applications. It features integrated bootstrap diodes that supply the three external high sides with charging bootstrap capacitors, supporting 100% duty cycle operation through a trickle charge pump. Protection features include undervoltage lockout, overcurrent protection with configurable thresholds, fault communication, and automatic fault clearing. The output drivers include a high-pulse current buffer stage designed to minimize driver cross-conduction. Additionally, a current sense operational amplifier (CSA) with selectable gain is integrated between VSS and COM.

This driver offers a straightforward, scalable, robust, and cost-effective one-stop solution for a variety of battery-powered applications. It is ideal for power tools, robotics, and light electric vehicles (LEVs) across a wide range of battery voltages.

Infineon offers the OptiMOS™ dual 30 V and 40 V portfolio, housed in a compact SO-8 package featuring two MOSFETs within a single package. This design supports a smaller PCB footprint, enabling more compact and efficient solutions. The new OptiMOS™ dual MOSFETs, available in both 30 V and 40 V versions, deliver a high price-performance ratio in the SO-8 package category. Infineon's dual MOSFETs, offered in N and P, as well as N

and N-channel configurations, are ideal for applications such as lawn mower robots, vacuum cleaner robots, drones, and various other low power DC-DC applications. A notable example from this portfolio is ISA250250N04LMDS, which features a 40 V $V_{DS}$ and a maximum $R_{DS(on)}$ of 25 mΩ.

This solution is ideal for motor drives in domestic robots and smaller power motor drives, addressing a wide range of battery-powered applications with a focus on cost-effectiveness and performance.

# 2 System overview

## 2.1 System block diagram

Figure 1 shows a simplified system block diagram where OptiMOS™ 6 ISA250250N04LMDS dual N channel power MOSFET is used for a three-phase PMSM motor control system.

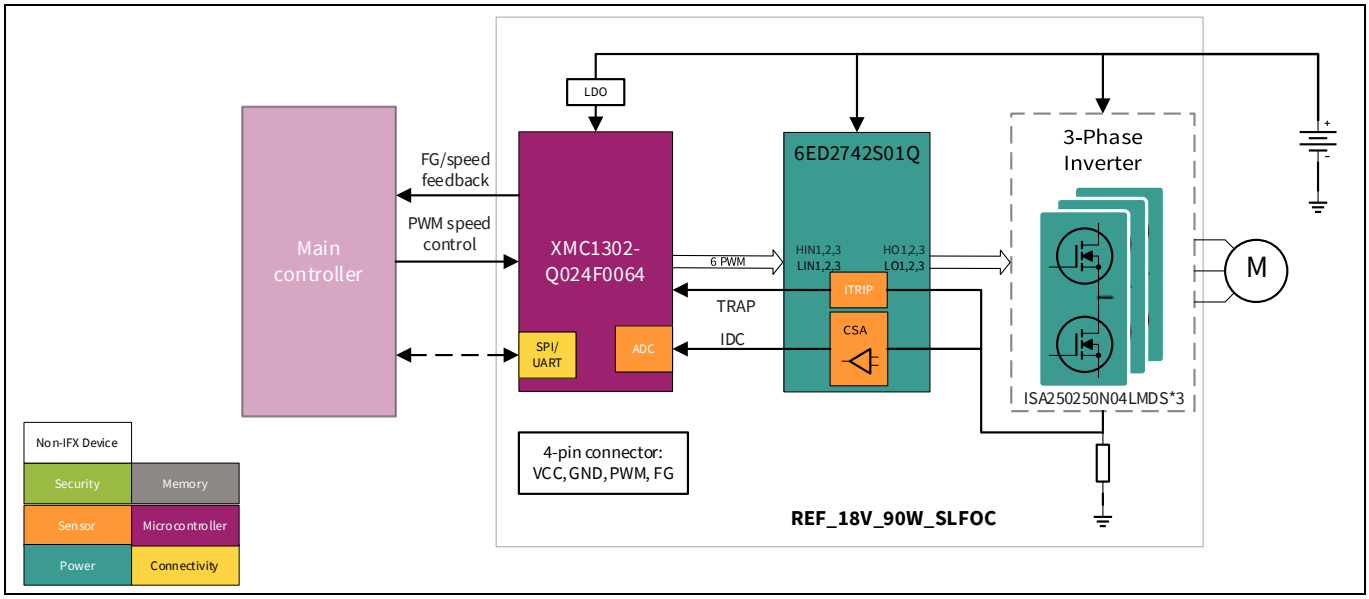


**Figure 1 System block diagram**

## 2.2 Board overview

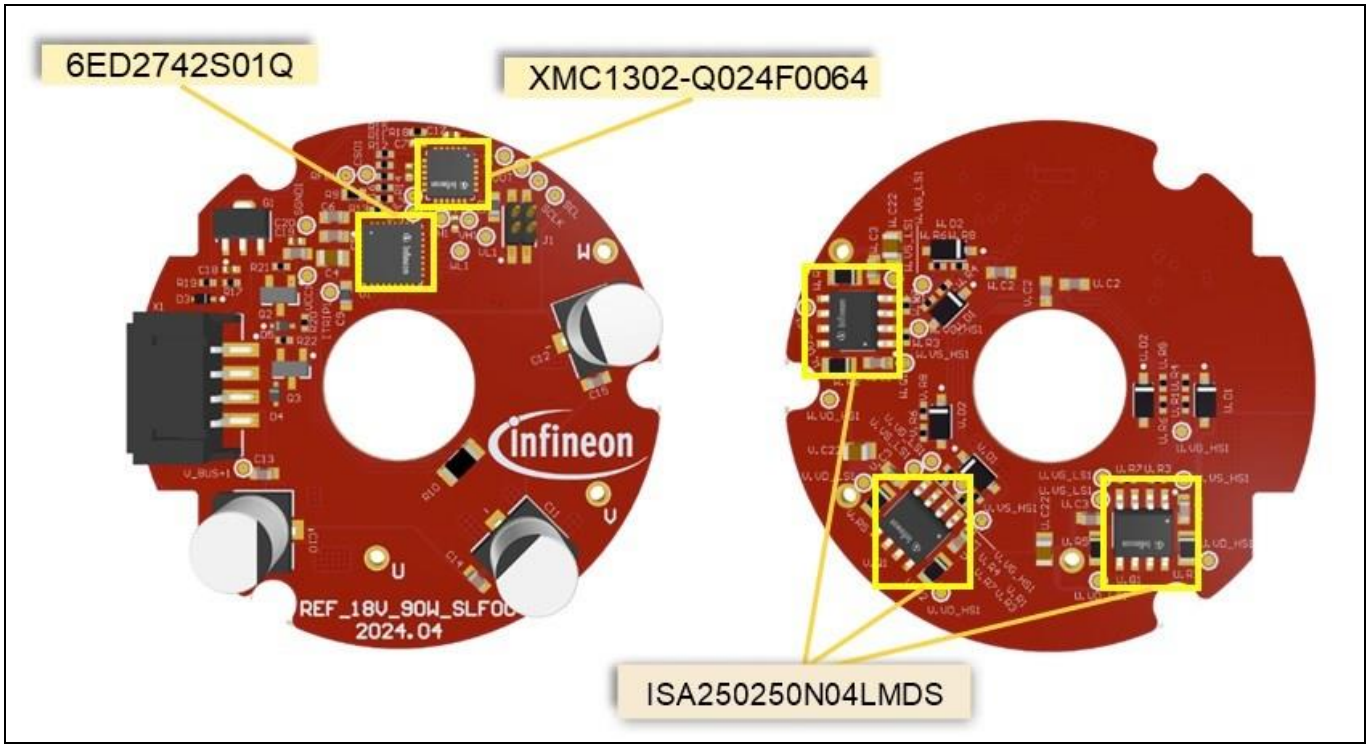


**Figure 2 Reference board REF_18V_90W_SLFOC**

## 2.3 Board connections

**Table 1 Board connections**

| Connector | Pin | Symbol | Function |
|---|---|---|---|
| X1 | 1 | FG | Speed feedback |
| | 2 | PWM | Speed input |
| | 3 | GND | Ground |
| | 4 | PVDD | Power supply input |
| J1 (Debugger) | 1 | DVDD | +3.3 V supply |
| | 2 | SWDIO | SWD data |
| | 3 | GND | GND |
| | 4 | SWDCLK | SWD clock |
| Inverter output | U | U | Motor terminal connection - U |
| | V | V | Motor terminal connection - V |
| | W | W | Motor terminal connection - W |

## 2.4 Specifications

**Table 2 Board specifications**

| Parameters | Symbol | Values | | | Unit | Notes |
|---|---|---|---|---|---|---|
| | | Min. | Nom. | Max. | | |
| Supply voltage | $V_{in}$ | 10 | 18 | 21 | V | – |
| Max output current | $I_{out\_max}$ | – | 5 | – | A | Ambient temperature: 25°C, 10 minutes, continuous, RMS |
| Max output power | $P_{out\_max}$ | – | 90 | – | W | Ambient temperature: 25°C, 10 minutes, continuous |
| Peak output current | $I_{out\_peak}$ | – | 10 | – | A | Ambient temperature: 25°C, 30 seconds, RMS |
| Peak output power | $P_{out\_peak}$ | – | 180 | – | W | Ambient temperature: 25°C, 30 seconds |
| Number of shunts | – | – | 1 | – | – | Current sensing shunt |
| Switching frequency | $F_{PWM}$ | – | 20 | – | kHz | – |
| Board outer diameter | $D_{outer}$ | – | 45 | – | mm | Circular board outer diameter |
| Board Inner hold diameter | $D_{inner}$ | – | 13 | – | mm | Circular board inner hold diameter |

# 3 Schematics and PCB layout

## 3.1 Schematics

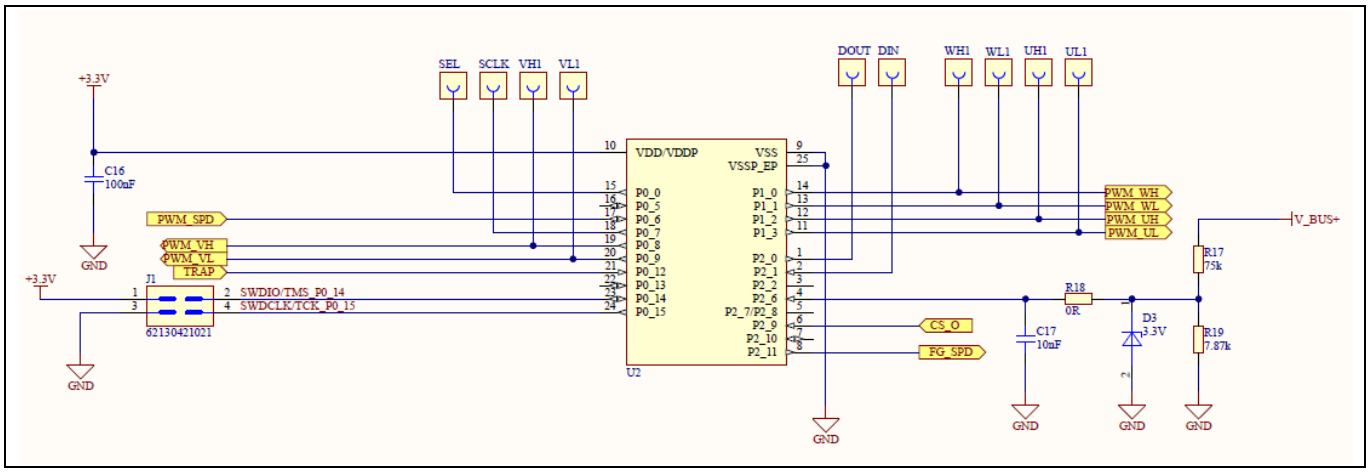


**Figure 3 MCU - XMC1302**

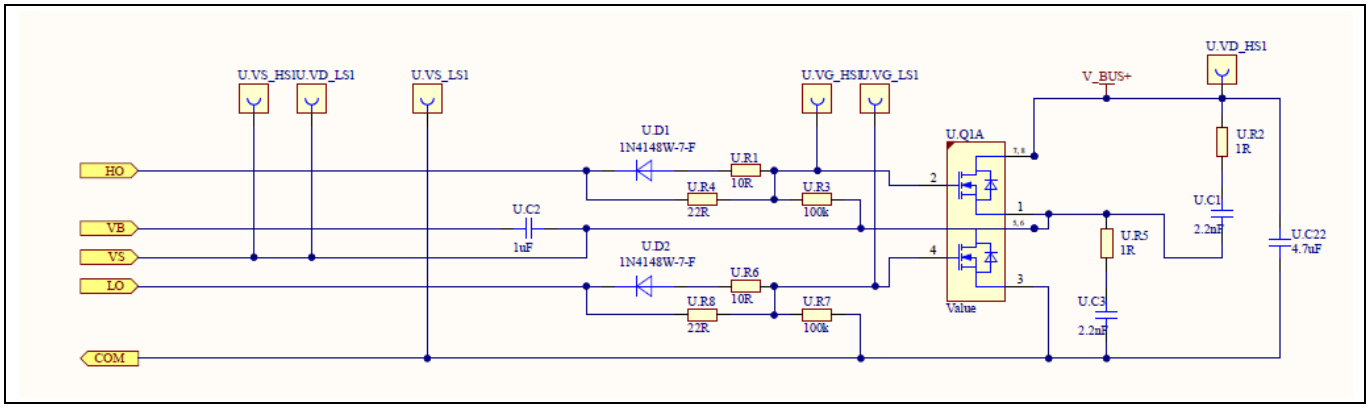


**Figure 4 Power stage - phase “U”**

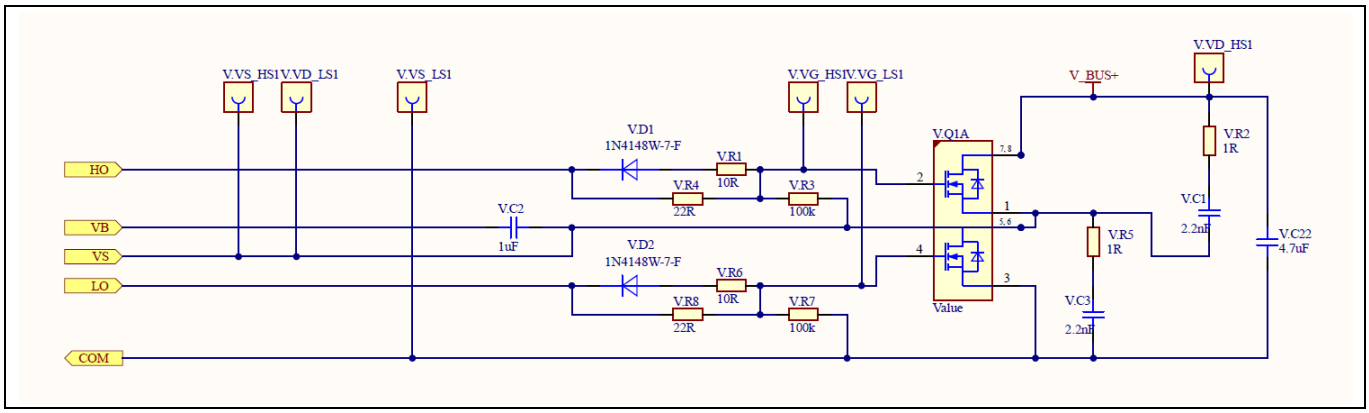


**Figure 5 Power stage - phase “V”**

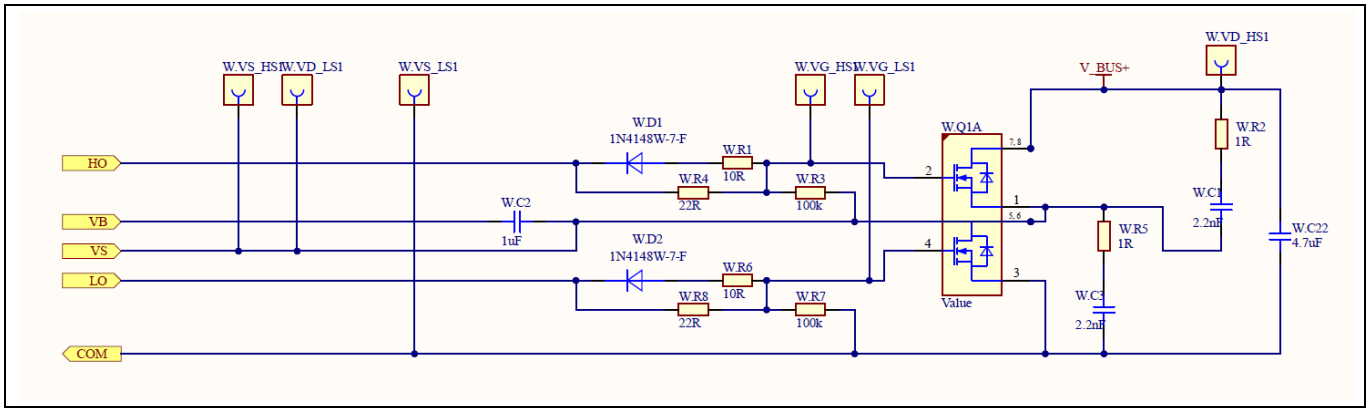


**Figure 6 Power stage - phase “W”**

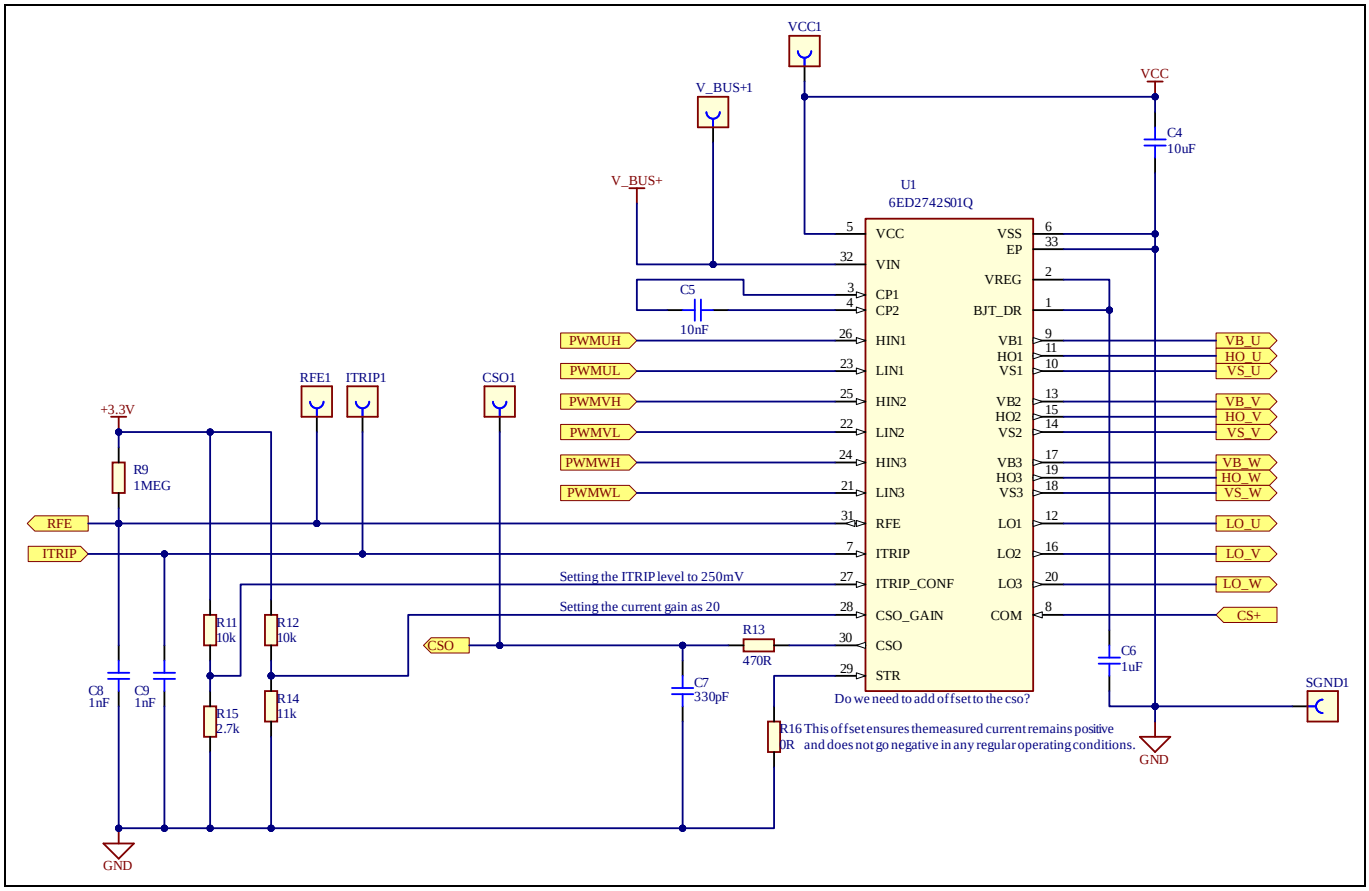


**Figure 7 Gate driver 6ED2742S01Q**

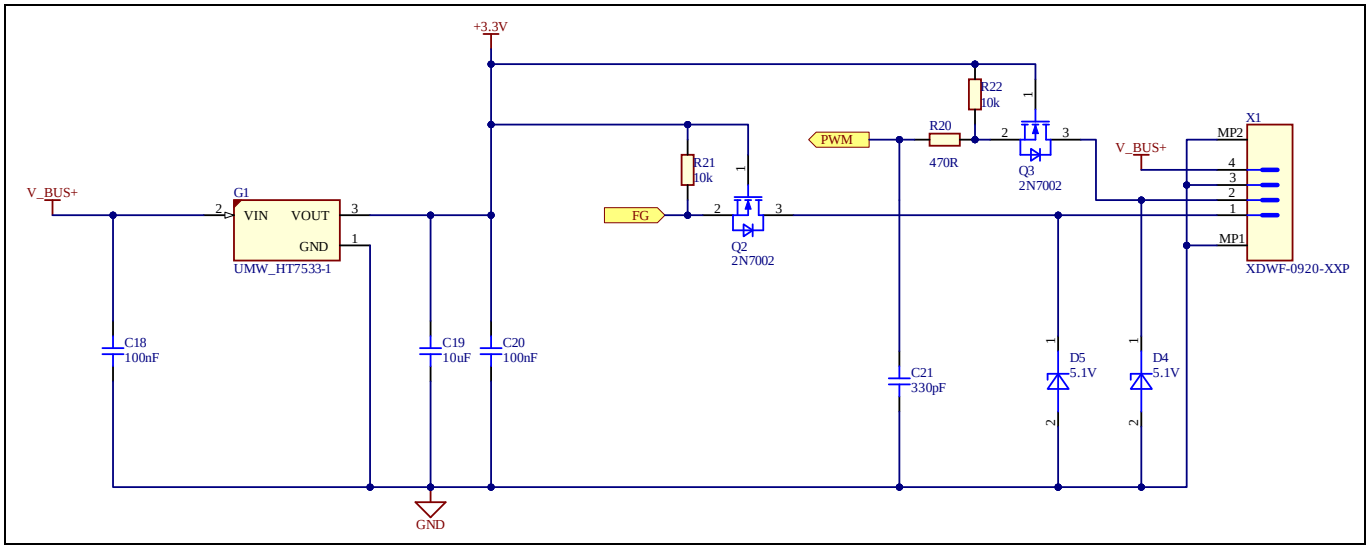


**Figure 8 Auxiliary power supply and connector**

## 3.2 PCB layout

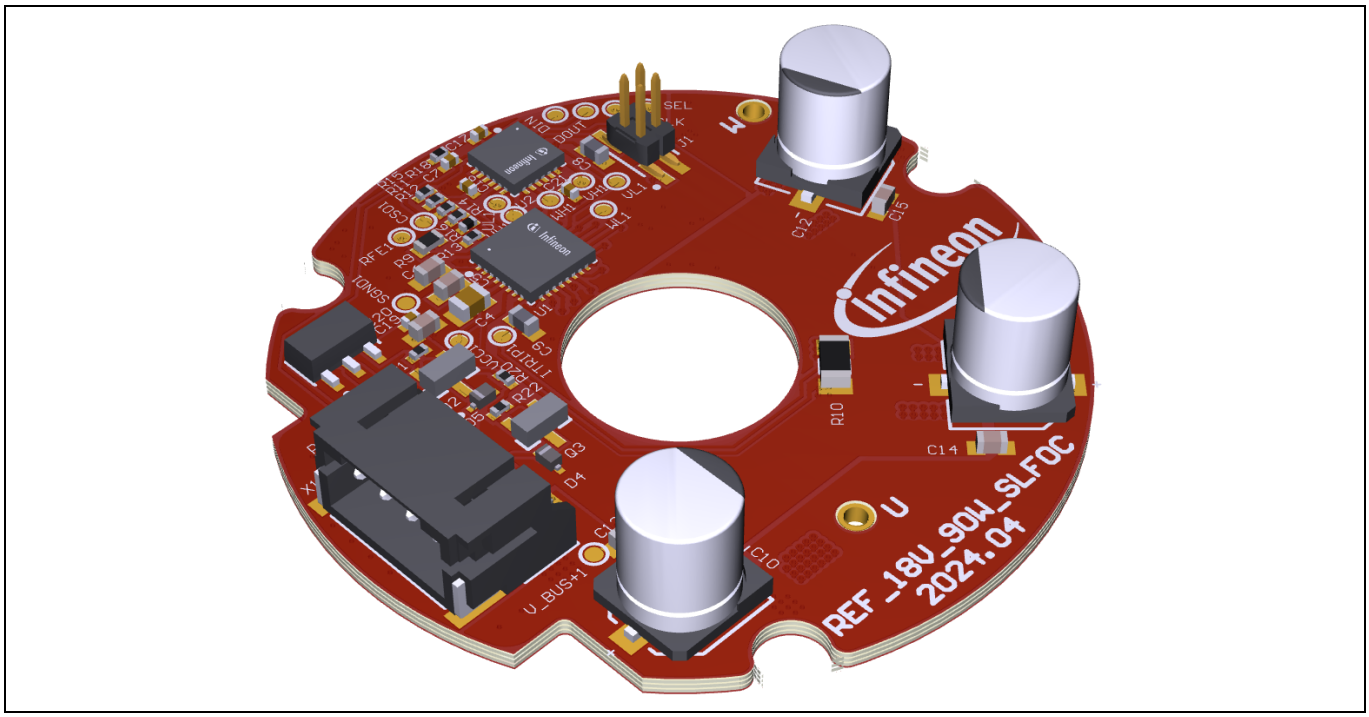


**Figure 9 Board 3D view**

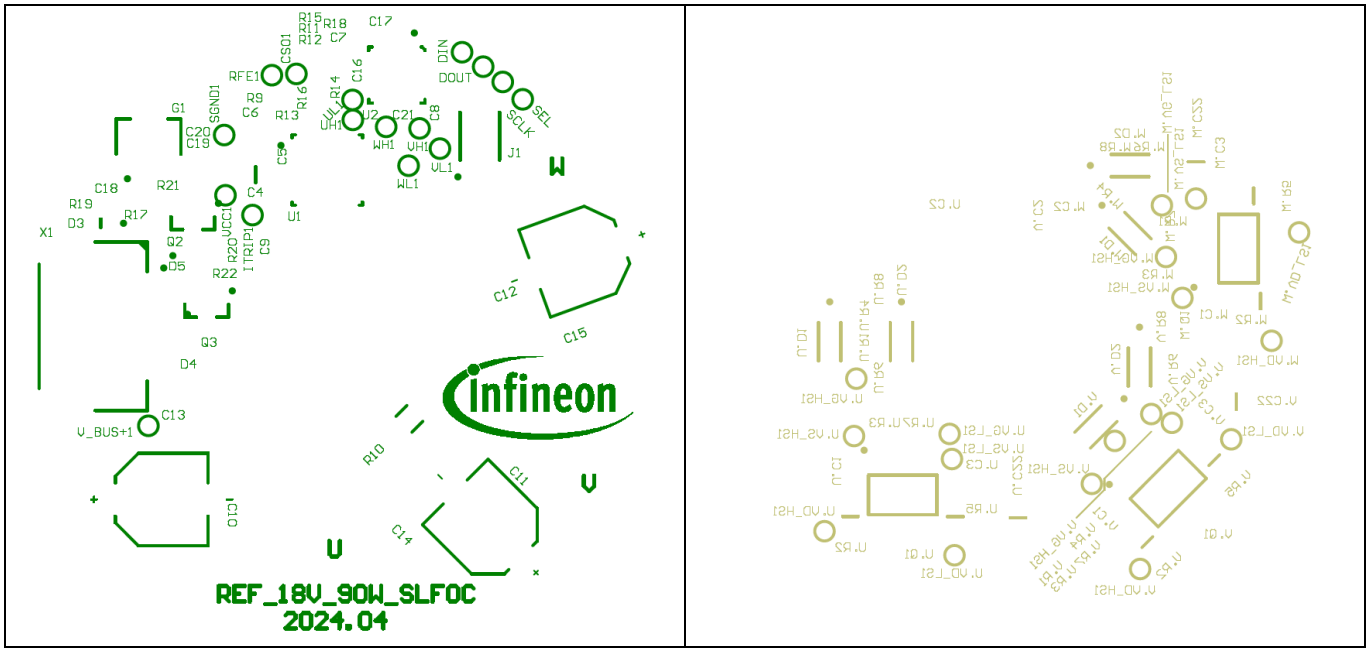


**Figure 10 Top overlay and bottom overlay**

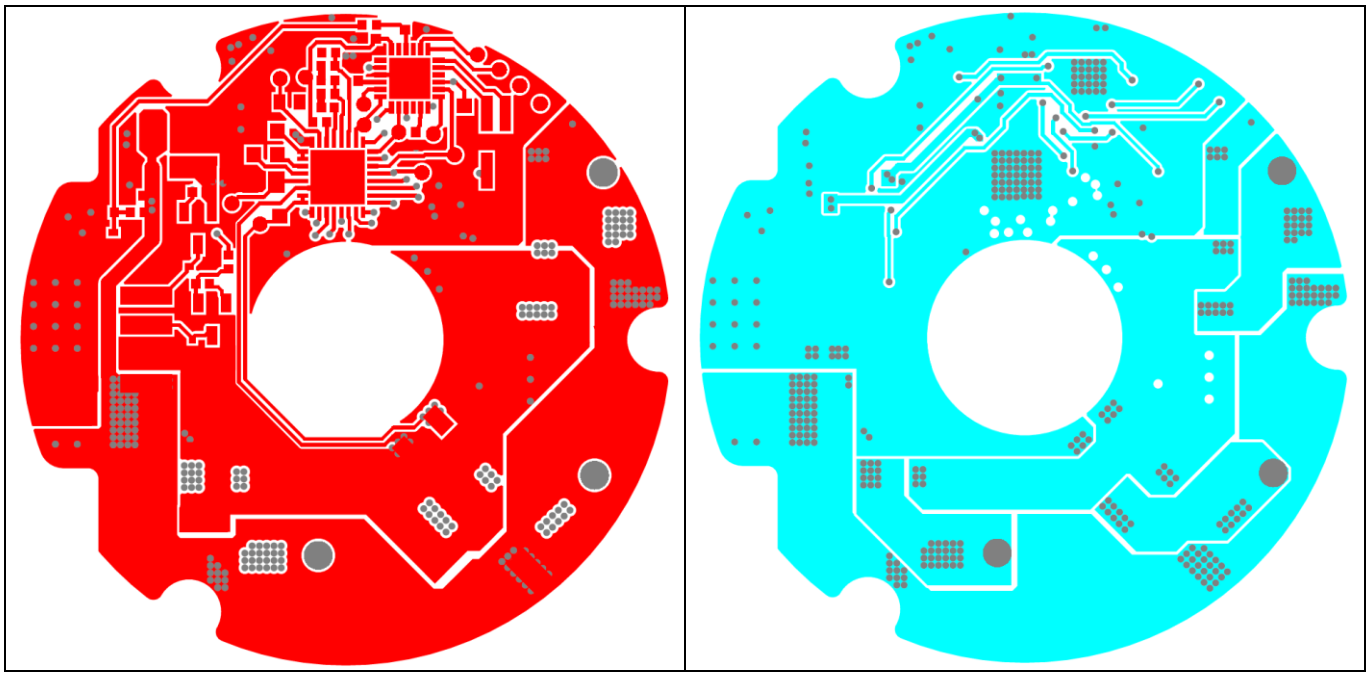

**Figure 11 Top layer and MID1 layer**

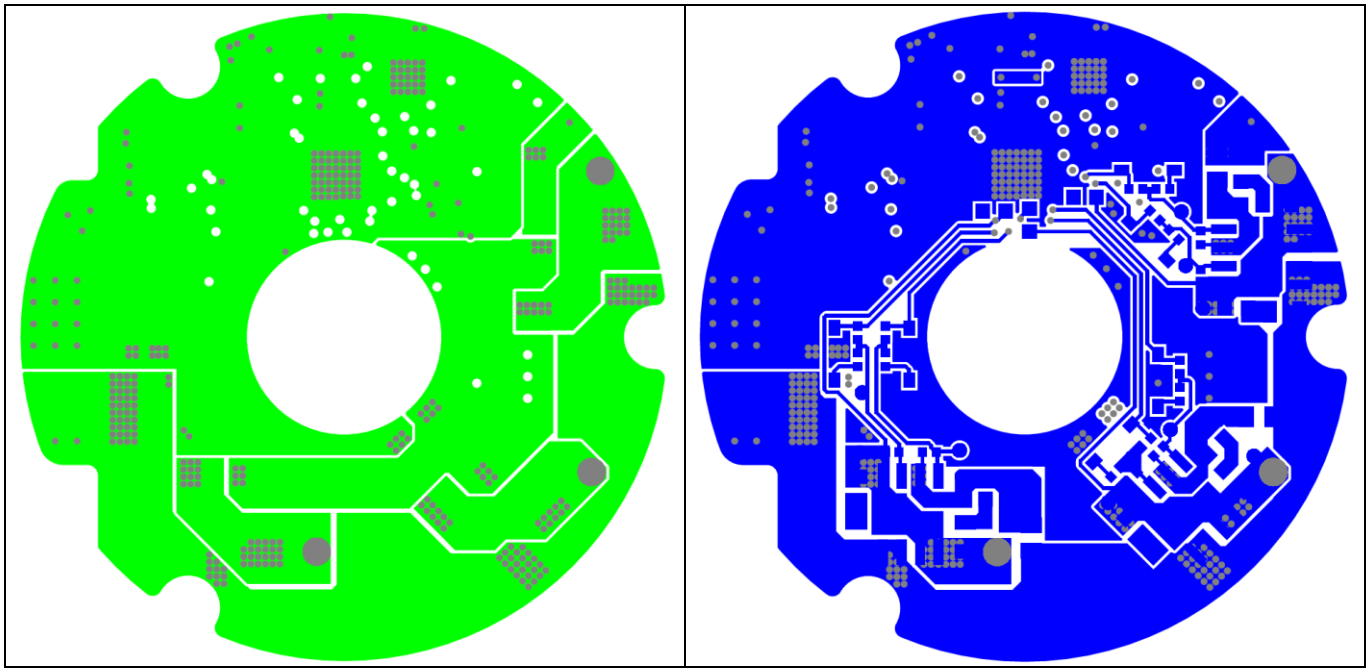

**Figure 12 MID2 layer and Bottom layer**

## 3.3 Bill of materials (BOM)

**Table 3 BOM**

| Reference | Qty | Value/rating | Manufacturer | Part number |
|---|---|---|---|---|
| C4 | 1 | 10uF / 25V / 0805 | Murata | GRM219R61E106MA12 |
| C5 | 1 | 10nF / 25V / 0603 | Murata | GRM188R71E103JA01 |
| C6, U.C2, V.C2, W.C2 | 4 | 1uF / 50V, 25V / 0603 | Murata | GRM188R61H105KAAL, GRM188R71E105KA12 |
| C7, C21 | 2 | 330pF / 25V / 0402 | Murata | GRM1555C1E331JA01 |
| C8, C9 | 2 | 1nF / 50V / 0603 | Kemet | C0603C102F5GAC |
| C10, C11, C12 | 3 | 47uF / 35V / | Nippon Chemi-Con | EMVE350ARA470MF80G |
| C13, C14, C15 | 3 | 2.2uF / 50V / 0603 | Murata | GRM188R61H225KE11 |
| C16, C18, C20 | 3 | 100nF / 16V, 50V / 0402 | Murata | GRM155R61C104JA88, GRM155R61H104KE14D |
| C17 | 1 | 10nF / 25V / 0402 | Murata | GRM155R71E103KA01 |
| C19 | 1 | 10uF / 16V / 0603 | Murata | GRM188R61C106KAAL |
| D3 | 1 | 3.3V | ON Semiconductor | SZMM5Z3V3T1G |
| D4, D5 | 2 | 5.1V | ON Semiconductor | MM5Z5V1T1G |
| G1 | 1 | UMW_HT7533-1 | - | UMW_HT7533-1 |
| J1 | 1 | 62130421021 | Wurth Elektronik | 62130421021 |
| Q2, Q3 | 2 | 2N7002 | ON Semiconductor | 2N7002 |

| Reference | Qty | Value/rating | Manufacturer | Part number |
|---|---|---|---|---|
| R9 | 1 | 1MEG / 75V | Vishay | CRCW06031M00FK |
| R10 | 1 | 10mR / 1206 | Vishay | WSLP1206R0100FEA |
| R11, R12, R21, R22 | 4 | 10k / 50V / 0402 | Vishay, Panasonic | CRCW040210K0FK, ERJ2GEJ103X |
| R13, R20 | 2 | 470R / 50V / 0402 | Vishay | CRCW0402470RFK |
| R14 | 1 | 11k / 50V / 0402 | Vishay | CRCW040211K0FK |
| R15 | 1 | 2.7k / 50V / 0402 | Vishay | CRCW04022K70FK |
| R16 | 1 | 0R / 50V / 0402 | Yageo | RC0402JR-070RL |
| R17 | 1 | 75k / 50V / 0402 | Vishay | CRCW040275K0FK |
| R18 | 1 | 0R / 50V / 0402 | ROHM Semiconductors | SFR01MZPJ000 |
| R19 | 1 | 7.87k / 50V / 0402 | Vishay | CRCW04027K87FK |
| U1 | 1 | 6ED2742S01M | Infineon Technologies | 6ED2742S01M |
| U2 | 1 | IFX_XMC1302-Q024F0064 | Infineon Technologies | XMC1302-Q024F0064 |
| U.C1, U.C3, V.C1, V.C3, W.C1, W.C3 | 6 | 2.2nF / 50V / 0603 | Murata | GRM188R71H222JA01 |
| U.C22, V.C22, W.C22 | 3 | 4.7uF / 50V / 0805 | Murata | GRM21BR61H475KE51 |
| U.D1, U.D2, V.D1, V.D2, W.D1, W.D2 | 6 | 1N4148W-7-F | Diodes Incorporated | 1N4148W-7-F |
| U.Q1, V.Q1, W.Q1 | 3 | | Infineon Technologies | ISA025025N04LMDS |
| U.R1, U.R6, V.R1, V.R6, W.R1, W.R6 | 6 | 10R / 50V / 0402 | Vishay | CRCW040210R0FK |
| U.R2, U.R5, V.R2, V.R5, W.R2, W.R5 | 6 | 1R / 150V / 0805 | Vishay | CRCW08051R00FK |
| U.R3, U.R7, V.R3, V.R7, W.R3, W.R7 | 6 | 100k / 50V / 0402 | Vishay | CRCW0402100KFK |
| U.R4, U.R8, V.R4, V.R8, W.R4, W.R8 | 6 | 22R / 50V / 0402 | Vishay | CRCW040222R0FK |
| X1 | 1 | XDWF-0920-XXP | - | XDWF-0920-XXP |

## Revision history

| Document revision | Date | Description of changes |
|---|---|---|
| V 1.0 | 2025-02-06 | Initial release |

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