Solar optimizer using REF_OPTIMIZER_600 W Buck Reference Board

About this document

Scope and purpose

Solar optimizers are installed with solar panels to maximize the energy yield from each panel and overcome the shading issue. In the residential and commercial solar system, the output of the optimizers are connected in series to build the DC link for string inverters. Solar optimizers are also used in portable energy storage, solar lightening, EV solar roofs, and satellite power supply. The topology is typically buck or buck-boost.

This document introduces Infineon's REF_OPTIMIZER_600 W reference board intended for buck solar optimizer, including the hardware design, loss analysis, the maximum power point tracking (MPPT) software, and testing results. The newest OptiMOS™ 6 is used to yield in highest efficiency.

Intended audience

The intended audience for this document are design engineers, technicians, and developers of electronic systems.

Infineon components featured

- OptiMOS™ 6 ISC080N10NM6 power MOSFET 100 V, 8 mΩ
- EiceDRIVER™ 2EDL8034-F5B Dual-channel junction-isolated gate driver IC
- XMC™ XMC1302-Q040X0200 AB 32-bit Microcontroller Arm® Cortex®-M0
- OPTIREG™ linear voltage regulator TLS203B0EJ V33 with a fixed 3.3 V output

Reference Board/Kit

Product(s) embedded on a PCB with a focus on specific applications and defined use cases that may include software. PCB and auxiliary circuits are optimized for the requirements of the target application.

Note: Boards do not necessarily meet safety, EMI, quality standards (for example UL, CE) requirements.

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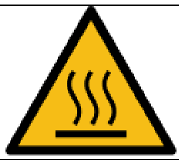
Note: *Please note the following warnings regarding the hazards associated with development systems*

Table 1 Safety precautions

	**Warning:** *The DC link potential of this board is up to 1000 VDC. When measuring voltage waveforms by oscilloscope, high voltage differential probes must be used. Failure to do so may result in personal injury or death.*
	**Warning**: *The evaluation or reference board contains DC bus capacitors which take time to discharge after removal of the main supply. Before working on the drive system, wait five minutes for capacitors to discharge to safe voltage levels. Failure to do so may result in personal injury or death. Darkened display LEDs are not an indication that capacitors have discharged to safe voltage levels.*
	**Warning:** *The evaluation or reference board is connected to the grid input during testing. Hence, high-voltage differential probes must be used when measuring voltage waveforms by oscilloscope. Failure to do so may result in personal injury or death. Darkened display LEDs are not an indication that capacitors have discharged to safe voltage levels.*
	**Warning:** *Remove or disconnect power from the drive before you disconnect or reconnect wires, or perform maintenance work. Wait five minutes after removing power to discharge the bus capacitors. Do not attempt to service the drive until the bus capacitors have discharged to zero. Failure to do so may result in personal injury or death.*
	**Caution:** *The heat sink and device surfaces of the evaluation or reference board may become hot during testing. Hence, necessary precautions are required while handling the board. Failure to comply may cause injury.*
	**Caution:** *Only personnel familiar with the drive, power electronics and associated machinery should plan, install, commission and subsequently service the system. Failure to comply may result in personal injury and/or equipment damage.*
	**Caution:** *The evaluation or reference board contains parts and assemblies sensitive to electrostatic discharge (ESD). Electrostatic control precautions are required when installing, testing, servicing or repairing the assembly. Component damage may result if ESD control procedures are not followed. If you are not familiar with electrostatic control procedures, refer to the applicable ESD protection handbooks and guidelines.*
	**Caution:** *A drive that is incorrectly applied or installed can lead to component damage or reduction in product lifetime. Wiring or application errors such as undersizing the motor, supplying an incorrect or inadequate AC supply, or excessive ambient temperatures may result in system malfunction.*
	**Caution:** *The evaluation or reference board is shipped with packing materials that need to be removed prior to installation. Failure to remove all packing materials that are unnecessary for system installation may result in overheating or abnormal operating conditions.*

1 Introduction

Solar optimizers are a significant element in the renewable energy sphere, particularly in the field of photovoltaic (PV) solar power systems. Their primary role is to enhance and optimize the performance of individual solar panels, thereby maximizing the overall energy production of the solar power system.

Solar optimizers, often referred to as power optimizers, are small electronic devices connected with each solar panel in a PV system. They are installed at the site of the solar panel, usually on the back of the panel or integrated into its frame. Their fundamental job is to regulate the DC electricity output from each solar panel, converting it into a more efficient form that can then be used or stored. The main aim of solar optimizers is to minimize the losses in energy output that can occur due to various factors such as shading, dust, or misalignment of solar panels. They achieve this by individually tuning the output from each solar panel to ensure that all panels in the system produce their maximum possible power.

Solar optimizers utilize maximum power point tracking (MPPT) technology. MPPT continuously adjusts the voltage and current levels to find the maximum power output under any given set of conditions. This enables each solar panel to operate at its highest efficiency, regardless of the performance of other panels in the system. This is particularly helpful in situations where some panels may be shaded or operating under different conditions than others.

By allowing each panel to perform at its best, solar optimizers can significantly increase the overall efficiency and output of a solar power system. They also enable more flexible system design, as panels can be installed in different orientations and angles without adversely affecting the system's overall performance. Moreover, solar optimizers can provide detailed monitoring of each panel's performance, helping to quickly identify and address any issues. Solar optimizers are sometimes compared to microinverters, another technology used to enhance solar system performance. While both serve to optimize power output, they operate differently.

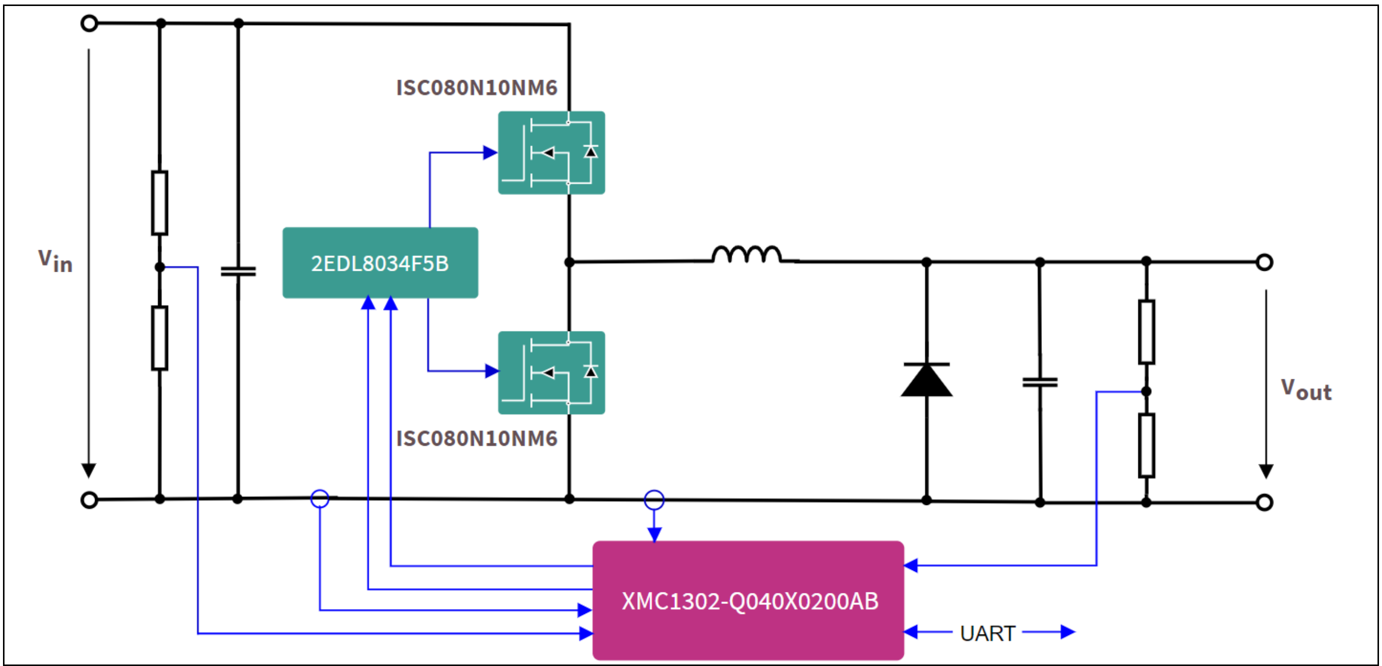


Figure 1 Block diagram of REF_OPTIMIZER_600 W buck solar optimizer reference board

Unlike microinverters, which convert DC power to AC at each panel, solar optimizers often employ a buck converter to step down the input voltage from the solar panel to a lower output voltage, which is then fed into a central inverter or other power conversion stages. The buck converter plays a crucial role in conditioning the DC power output from each solar panel, ensuring that it is optimized for maximum energy production. By stepping down the voltage, the buck converter helps to reduce energy losses and increase the overall efficiency of the solar power system [1].

Infineon's REF_OPTIMIZER_600W is a reference design for a buck optimizer that utilizes a buck converter to step down the input voltage from the solar panel to a lower output voltage. The main components of the REF_OPTIMIZER_600W reference board can be seen in the block diagram in Figure 1.

2 REF_OPTIMIZER_600 W reference board design

This section details the converter design for the buck optimizer. The specifications listed in Table 2 represents the design parameters, which are obtained with the proposed reference design.

Table 2 REF_OPTIMIZER_600 W reference board specifications

Maximum input power	600 W
Maximum input voltage	80 V
Maximum input current	18 A
MPPT voltage range	15-80 V
Switching frequency	200 kHz
Maximum efficiency	>98.5%
MPPT efficiency	>99%
Inductor current ripple	Ip-p 30%-40%
Output voltage ripple	1%

2.1 Buck converter

Depending on the input voltage and power level of the optimizer different MOSFETs should be used to optimize the efficiency accordingly. For the parameters stated in Table 2 the ISC080N10NM6 OptiMOS™ 6 100 V yielded the lowest losses. Depending on the EMI requirements the switching waveforms, need to be adapted, which can be done using either gate resistance, capacitance or utilizing the snubber network. The proposed design uses a 15 µH inductor (744361500) which limits the ripple current to the specifications stated in Table 2. If the slope compensation is required for the control, the shunt RL1 can used to measure the inductor current.

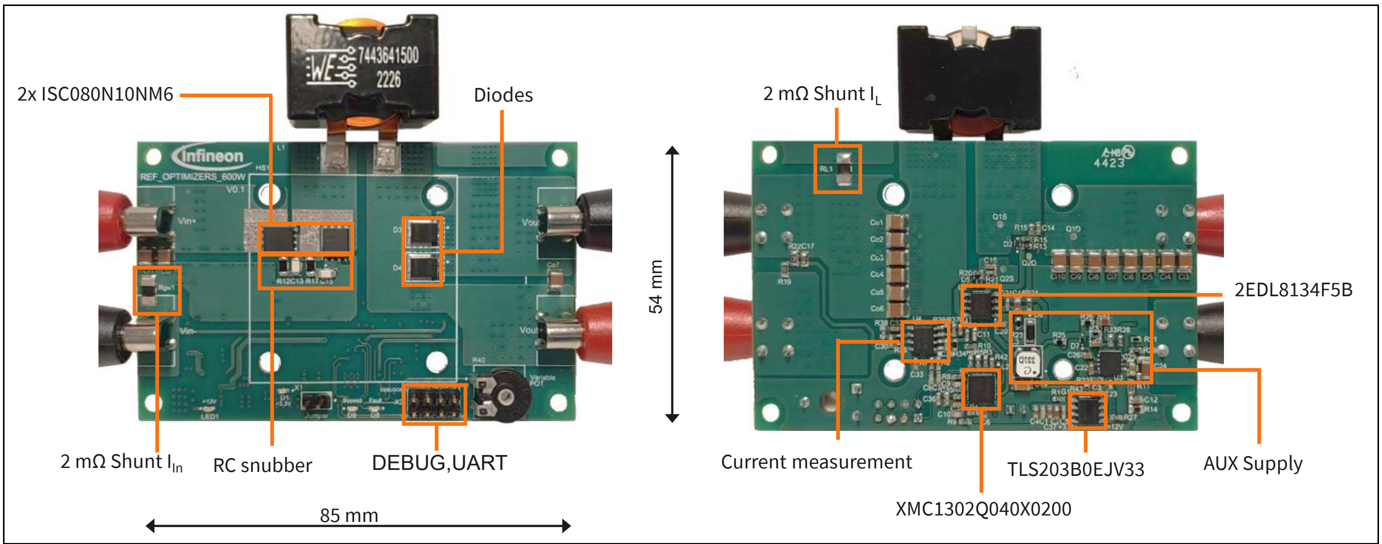


Figure 2 REF_OPTIMIZER_600W buck solar optimizer reference board

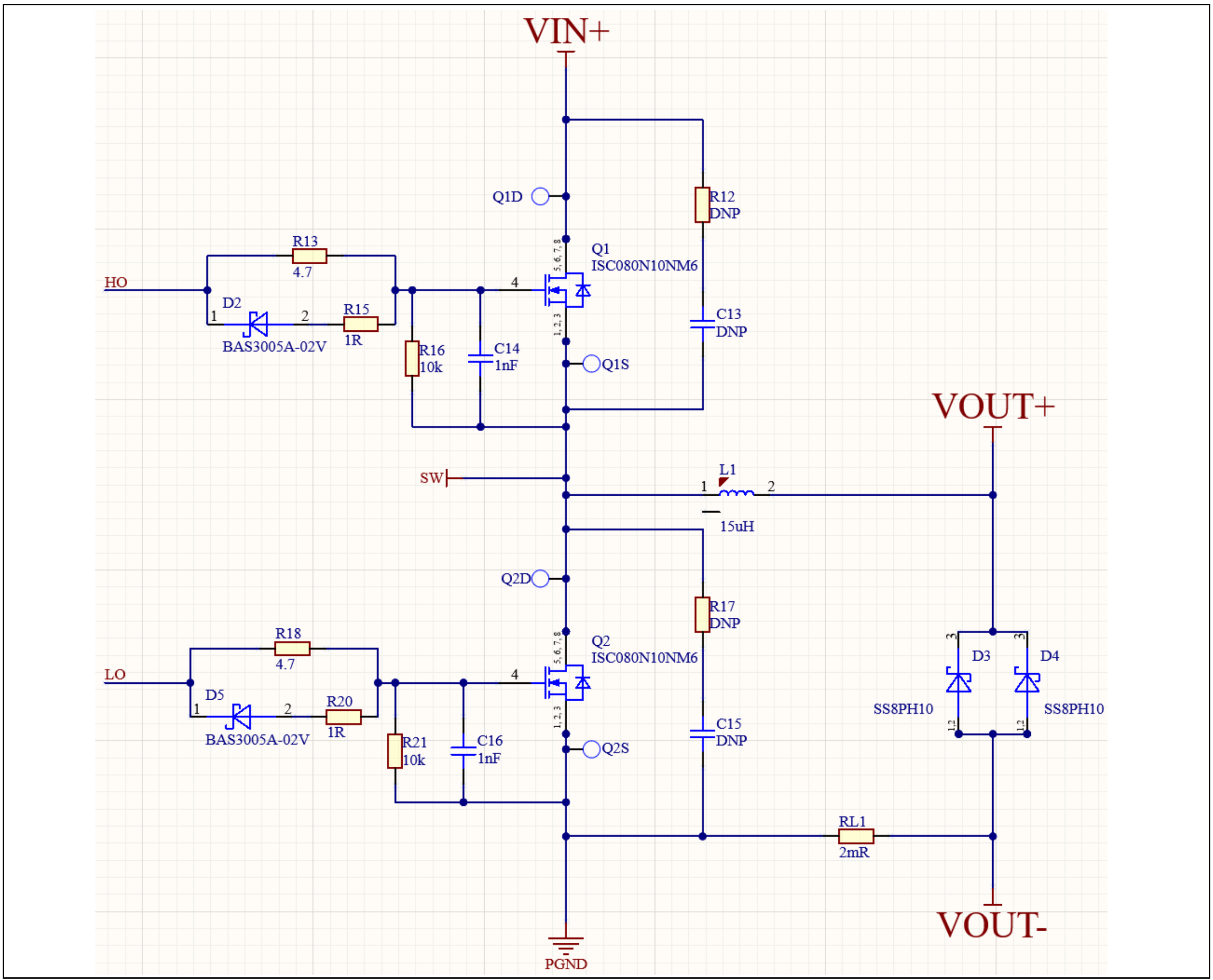


Figure 3 **Half-bridge including gate and snubber circuitry**

The used driver is the 2EDL8034-F5B which is designed to drive both high-side and low-side MOSFETs in a half-bridge configuration. The IC only needs a minimum number of external components and features a 120 V integrated bootstrap diode. The power supply for the high-side is done using a 1:1 transformer. The 12 V output is also used later to create the logic voltage for the microcontroller as well as the operational amplifier.

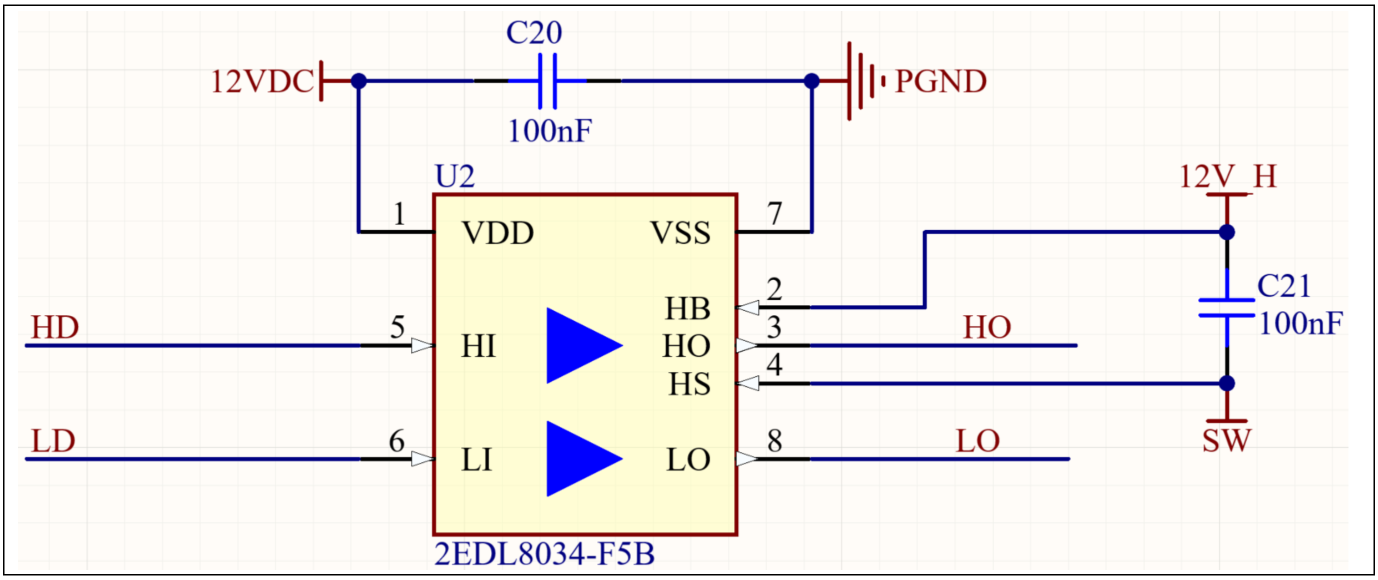


Figure 4 Dual gate driver with integrated bootstrap diode

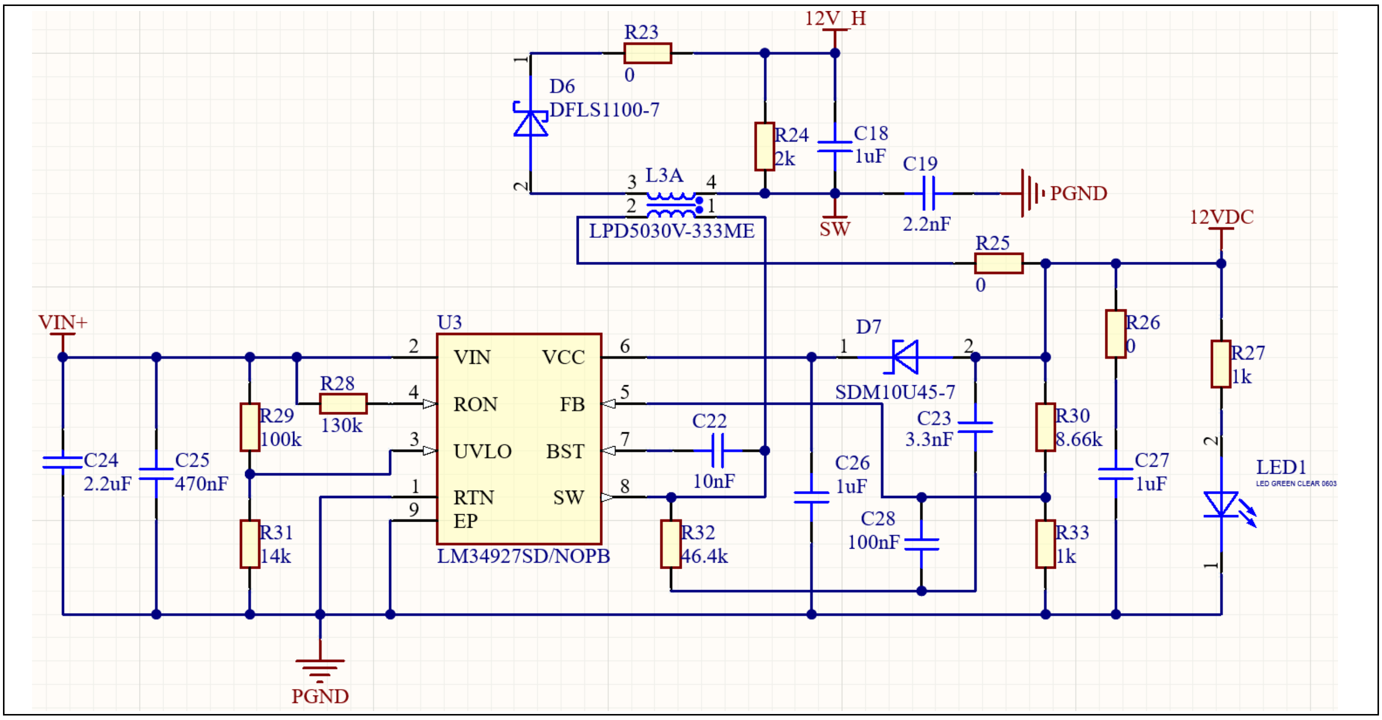


Figure 5 High side isolated gate drive supply with 1:1 transformer

2.2 Current and voltage measurement

To control the buck converter and implement the MPPT algorithm, it is necessary to monitor the input and output voltages, as well as the input and inductor currents. For this, the voltage is measured using the voltage dividers and a low-pass filter. The current measurement is done via a dual amplifier using an amplification factor of 83. The amplified signal is then routed to the MCU, XMC1302-Q040X0200. The MCU then feeds these signals into the control loop structure and operate with a capture compare unit 8 (CCU8) to control the buck converter. The 8-pin connector can be used to program the controller.

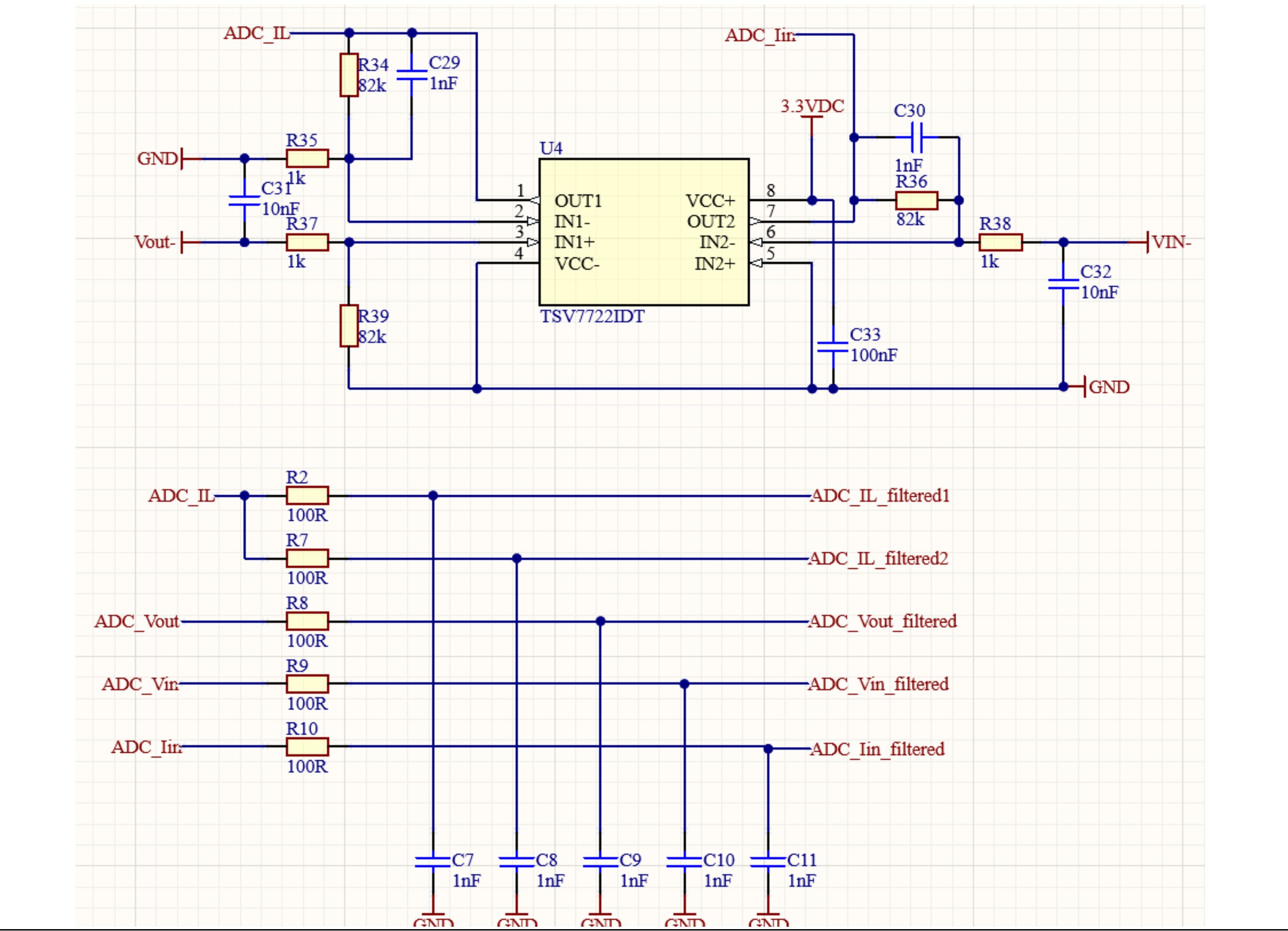


Figure 6 Voltage and current measurement filters and non-inverting amplifier circuit for the shunt current measurement

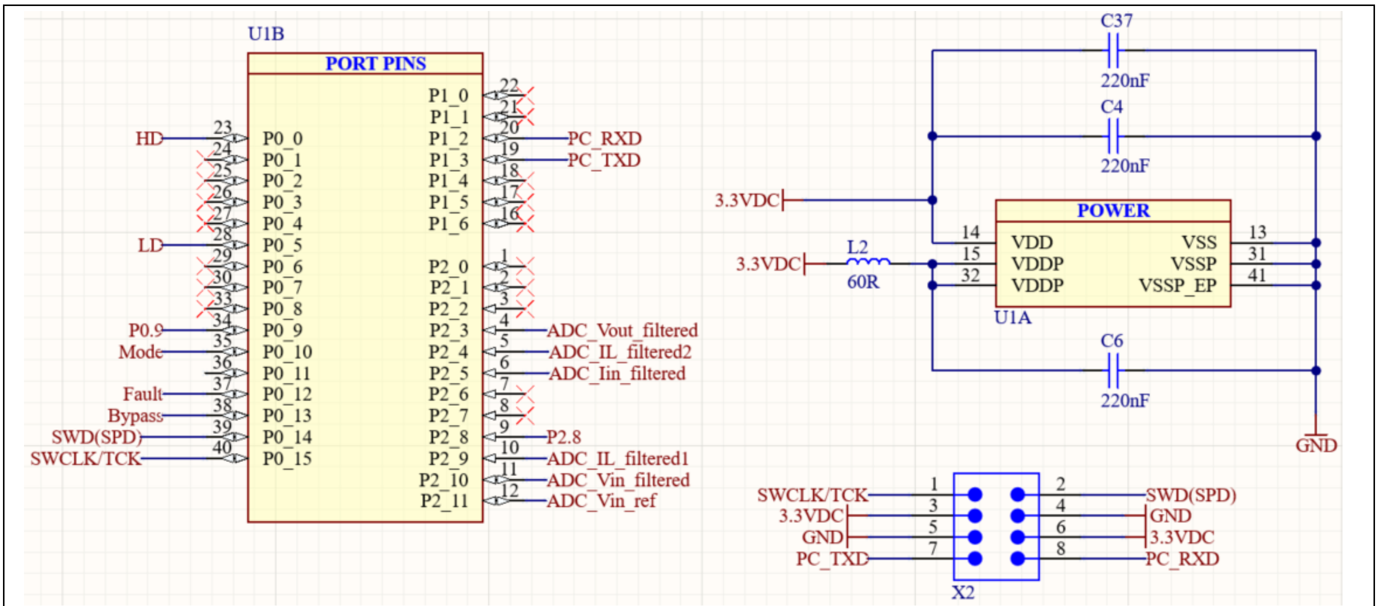


Figure 7 Microcontroller with 8-pin debug interface

3 Measurements

Depending on the connected PV panel, its orientation, and angle, the input characteristic changes, which can lead to different results on efficiency. In this chapter, the term ‘efficiency’ refers to the efficiency of the power electronics, including auxiliaries. However, one needs to distinguish it from the MPPT efficiency, which is depending on the measurement accuracy as well as the implemented algorithm. This combination yields the system efficiency.

3.1 Power electronics efficiency

The devices for the measurement setup are described Table 3. One limitation of the setup is the multimeter (Fluke 175), which can measure the input current only upto 10 A.

Table 3 Measurement device description

Device	Part number	Description
Power Supply	62150H-1000S	80 V/18 A 650 W rating as minimum
Load	EA-ELR 9250-70	At least 650 W power dissipation
Multimeter	Input: Fluke 175; Output: Keysight 34461A + YN01-07751BS000000	Input current and voltage measured with Fluke 175 (Limiting input current to 10 A), output current and voltage measured with Keysight 34461A utilizing 3 mΩ shunt

As only the power electronics efficiency is required, the duty cycle is set constant to 75% and the input voltage is stepped up from 40 V to 80 V in 10 V increments. The measurement points are taken from 1 A output current interval, up to either reaching the 10 A input current limit or the 600 W output power limit, whichever is reached first.

Depending on the input voltage, the efficiency curve follows a different trajectory (see Figure 8). At low input voltages, the efficiency is higher due to the lower switching losses as well as the more efficient auxiliary power supply. For an output current of 5 A and higher, the efficiency is nearly independent from the input voltage. Furthermore, the higher the output power, the higher the measured efficiency.

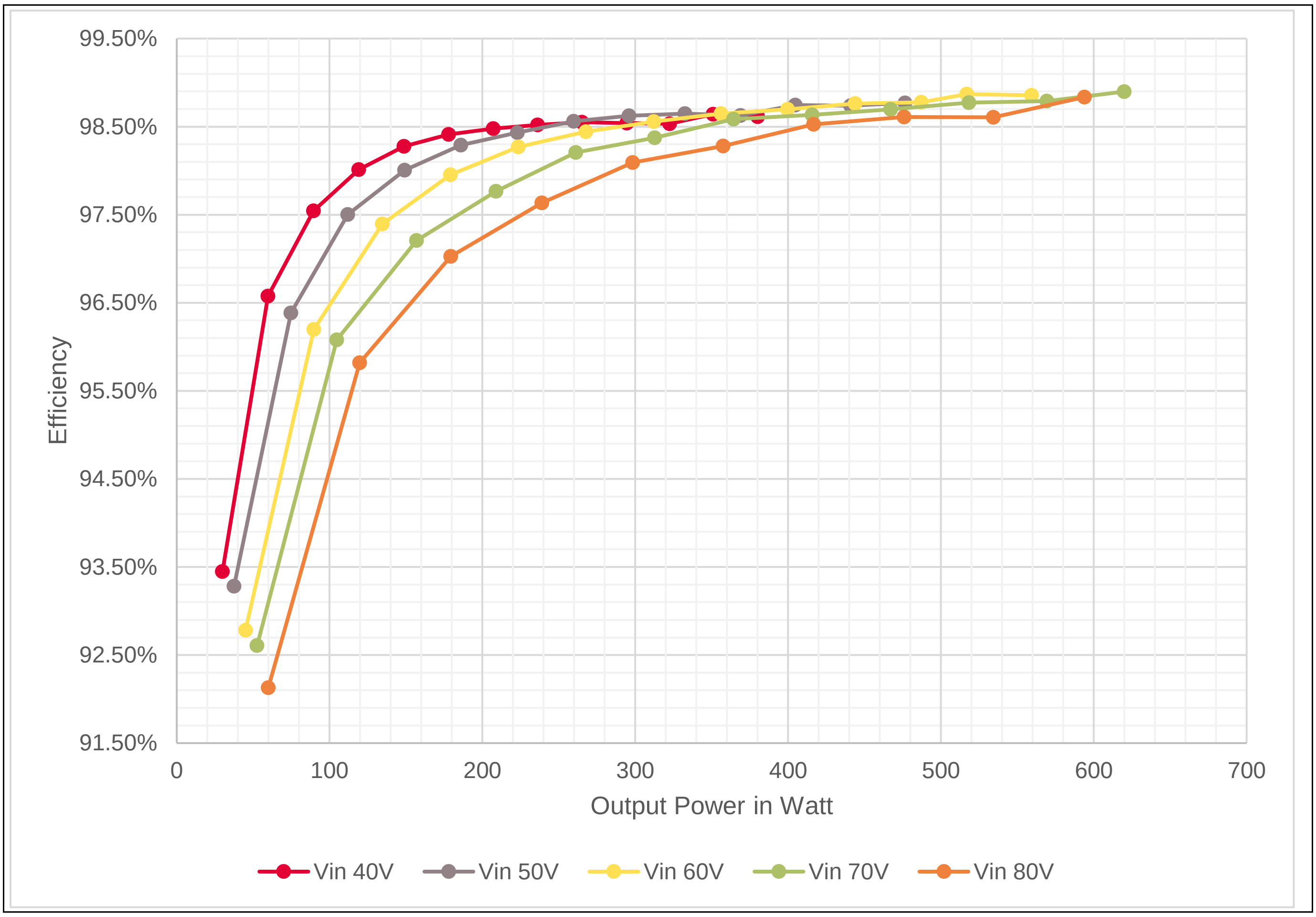


Figure 8 **Efficiency measurement at different input voltages**

Comparing the efficiency results with the calculation according to reference [2], yields similar results. For V_{in} = 80 V and I_{out} = 10 A, the losses were calculated to be 6.54 W, while 7 W was observed in the measurement. The calculated losses include losses due to switching, conduction, shunt, inductance, and auxiliary losses. From Figure 9, one can see that the switching losses dominate, followed by inductance and conduction losses. If higher efficiency is required, the auxiliaries and shunt section of the board should be revisited as the used switches are best in class. Furthermore, this approach would yield in high efficiency increases at low voltage levels.

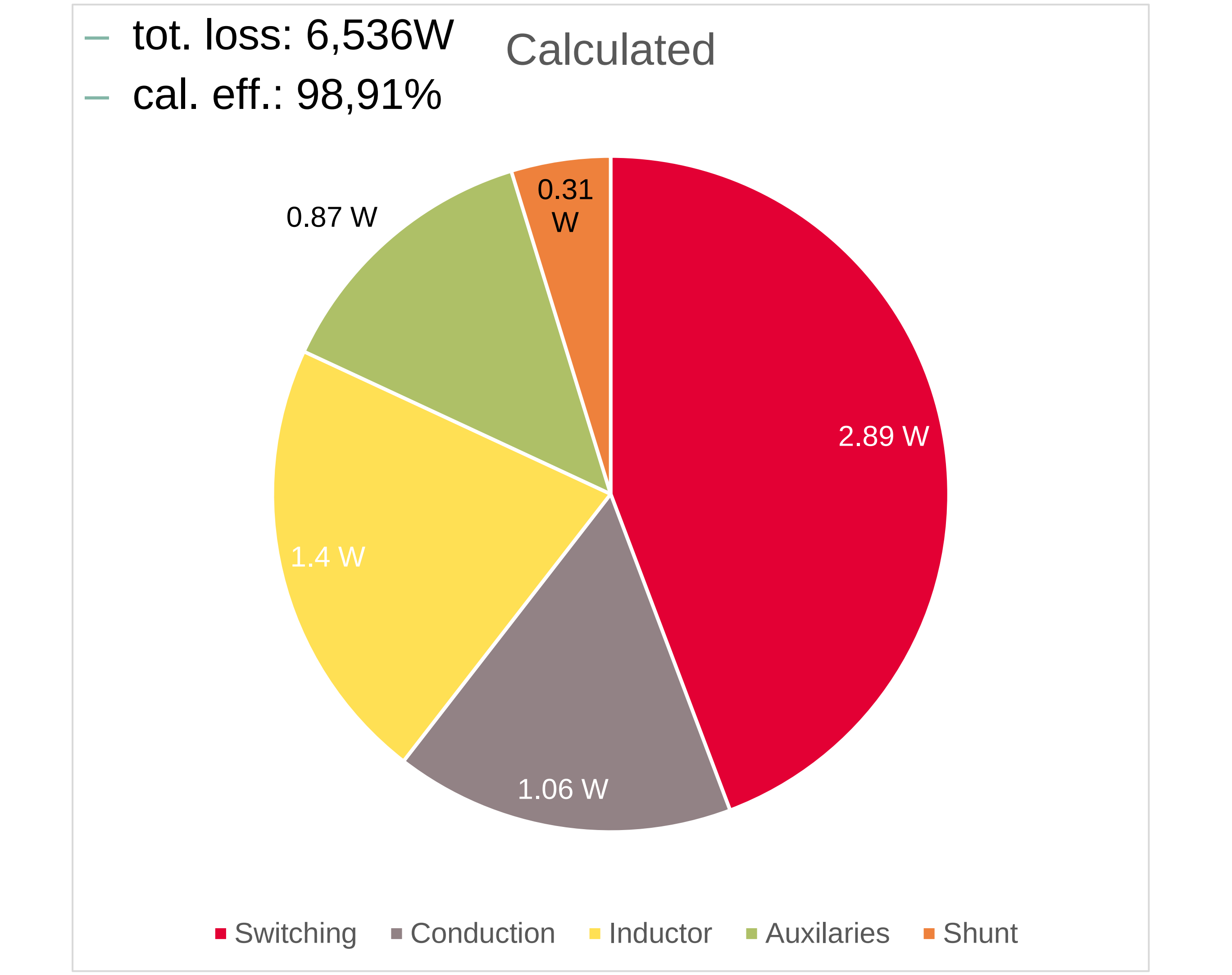


Figure 9 **Calculated losses of the power stage at V_{IN}= 80 V and I_{Out} = 10 A with 75% duty cycle**

3.2 Transient voltage measurement

To achieve high switching performance, the drain source voltages were measured. For the high side VDS measurements, an optically isolated probe, the PMK FireFly®, was used. The low side VDS measurement is measured with a 1:10 passive probe head with spring. The dead-time has been set to 32 ns. From Figure 11, the high-side turn on can be seen for the case of $V_{IN} = 80$ V and $I_{IN} = 10$ A. The highest observed voltage is 94.4 V resulting out of a high and low frequent ringing. The higher frequency component originated out of the charging and discharging of the output capacitances, and the low frequent part is dependent on the distance to the input capacitances. As the overshoot is still well inside the limits, the switching speed of 13 V/ns could still be increased. In case a snubber is put in place, the transients could be increased even further.

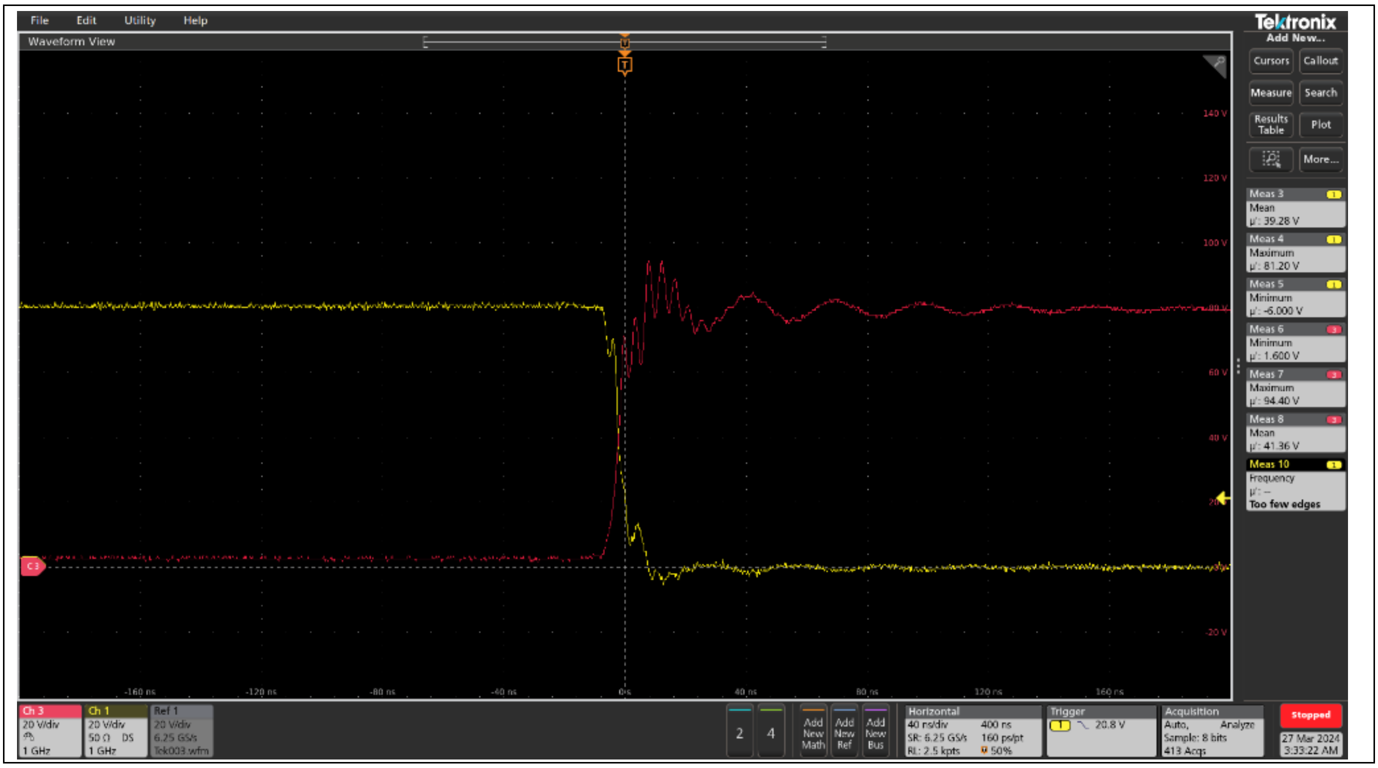


Figure 10 Drain source voltages at low side turn on

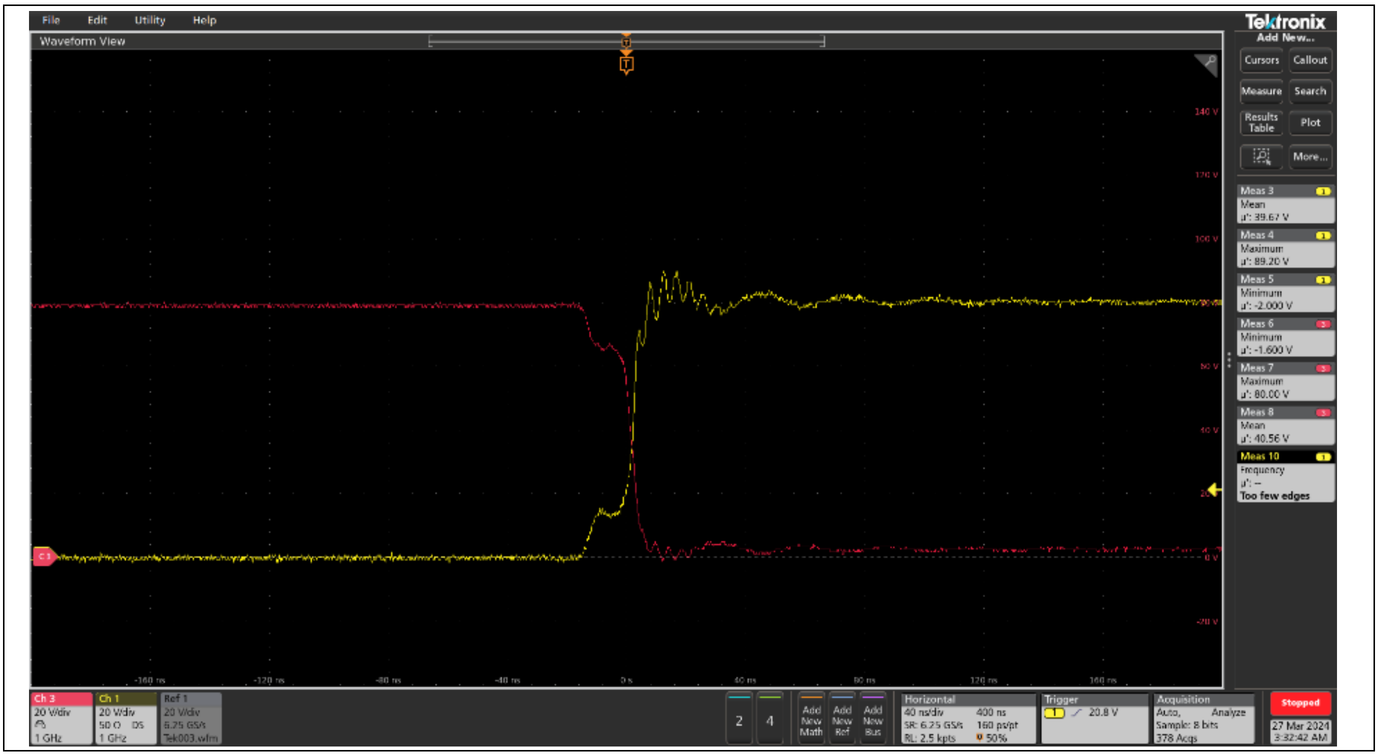


Figure 11 Drain source voltages at high side turn on

3.3 MPPT efficiency

In order to test the MPPT tracking efficiency, a PV module or an emulator needs to be connected. For this measurement, the following devices listed in Table 4 is used.

Table 4 Measurement device description

Device	Part Number	Description
Power Supply	62150H-1000S	80V/18A 650W rating as minimum
Load	EA-ELR 9250-70	At least 650W power dissipation

In the PV emulator, various modes can be set to modify its output characteristics over time. For this measurement, a Sandia Model has been chosen with the parameters as seen in Figure 12. The test results have shown an average MPPT efficiency of 99.15%, peaking at 99.44%. When the output power is higher, the tracking performance improves as small changes in the duty cycle result in a more significant change in power level. As a result, the influence of noise in the measurement is reduced.

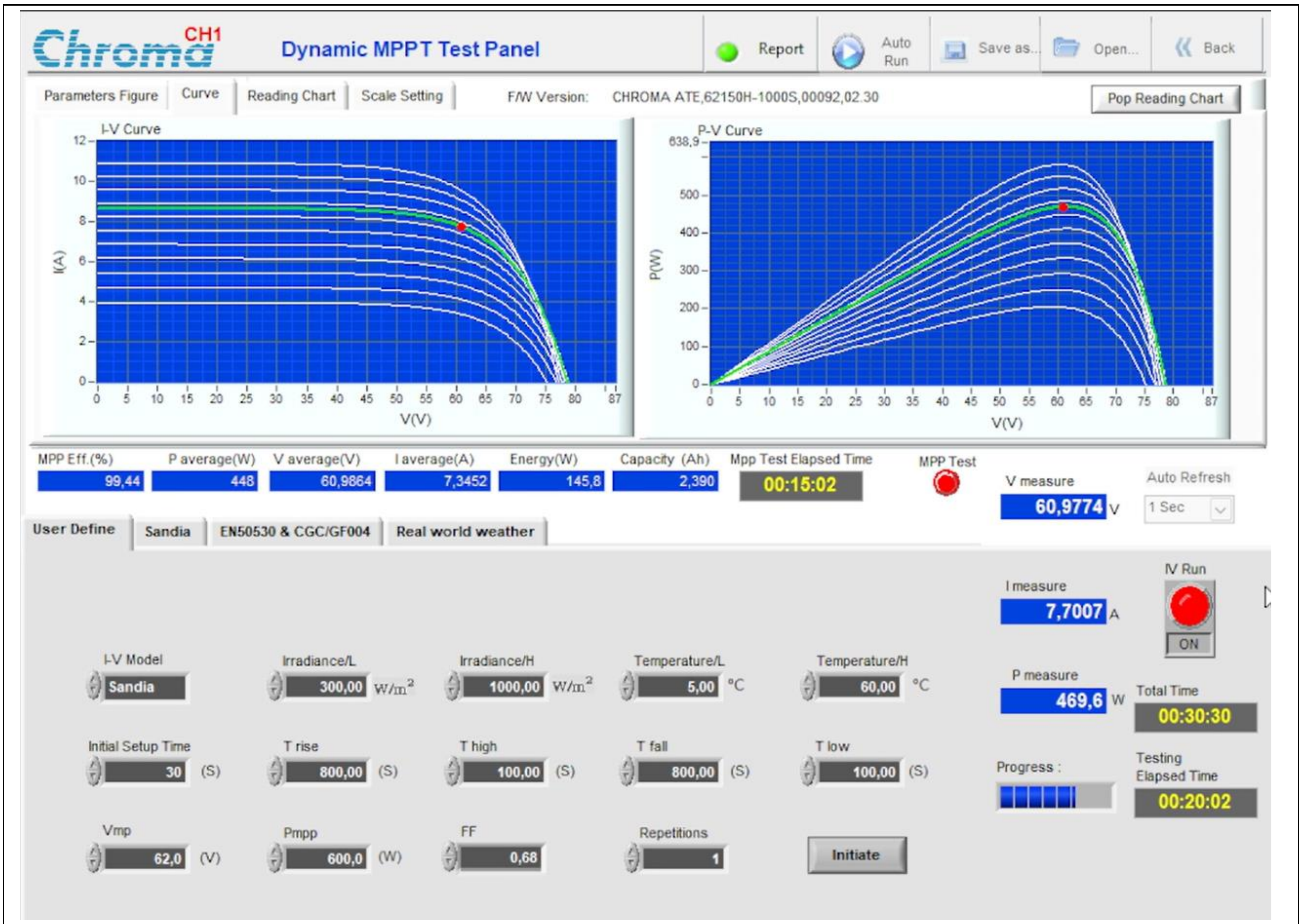


Figure 12 Solar emulator GUI during MPPT testing

3.4 Thermal measurement

The reference board is utilizing a top-side-cooled heatsink with convective heat transfer. The MOSFETs used are bottom-side-cooled devices; hence, the thermal performance can be easily increased by swapping these for their topside-cooled counterparts. For the parameters stated in Table 2, the used switches are yielding a low thermal stress level on the board. Figure 13 shows the thermal performance at the maximum power of 600 V at 80 V V_{in} and 7.5 A I_{in}. The hottest section of the board is close to the input terminals, where the copper trace is heating up due to the high-side losses. There is still enough thermal headroom to either shrink the thermal conductivity or increase the power level of the board.

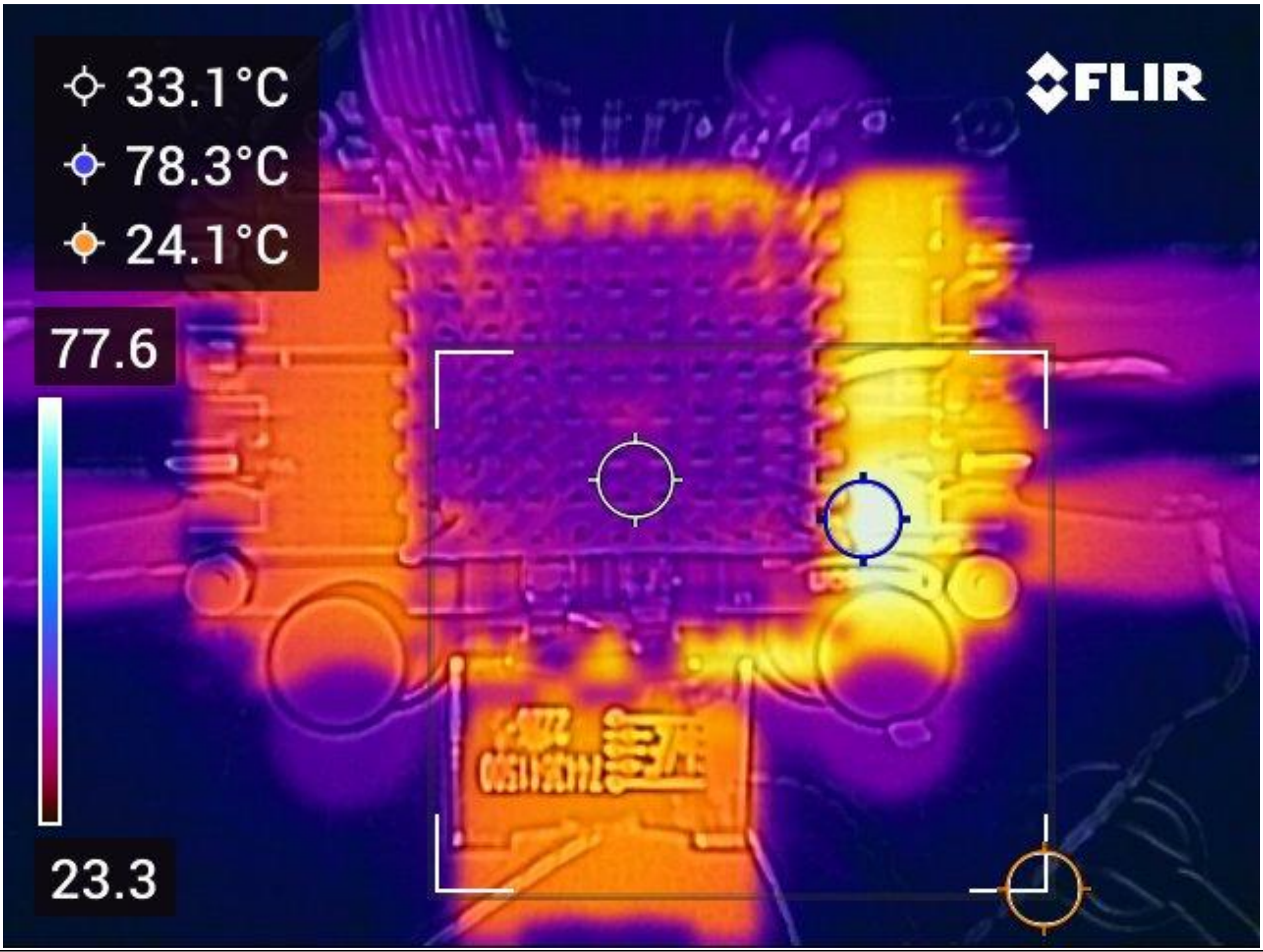


Figure 13 Thermal image of the board at 80 V V_{in} / 7.5 A I_{in} and 70 V V_{out} / 8.5 A I_{out}

4 Software

Unlike conventional buck converter, in an optimizer, the input voltage is controlled to maximize the power output from the PV cell. This is possible due to the non-linear behavior of a PV cell. By increasing the duty cycle, the output current of the optimizer increases, which in turn increases the input current drawn from the PV cell. As a result, the input voltage of the optimizer decreases. By measuring the input power, a working point with the highest possible input power can be found by the optimizer.

In this optimizer, a cascaded control loop with inner current control and output voltage control is used. The controllers themselves are 2P2Z controllers. The current loop is called at a frequency of 50 kHz, whereas the voltage loop is called every 25 kHz. This leads to a very quick response time in case the load or input power changes.

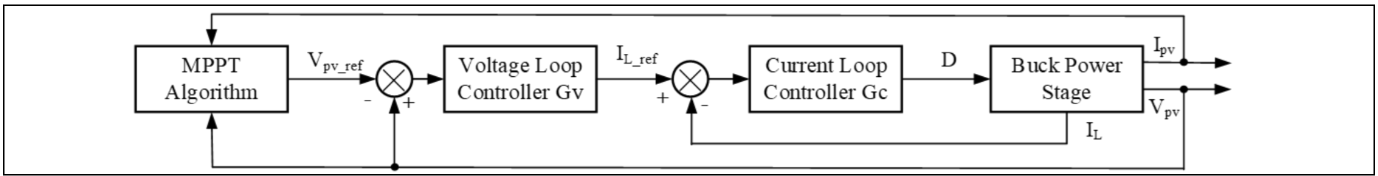


Figure 14 Control structure of the optimizer

The MPPT algorithm is called every 2 seconds and checks if the power has increased or decreased compared to the last function call. It will then set the reference voltage accordingly. In case the input power changed only marginally, the reference is kept constant, as then the maximum power point has already been reached close enough. The step size of the reference voltage is set to ~0.8 V, allowing the algorithm to quickly track the target voltage in case of shadowing, while still accurately reaching the maximum power point. The firmware itself can be adapted to fit for other voltage and current ranges as well. If the input voltage is too low, the power stage will remain inactive as the high side gate drive supply needs to have a minimum of 7.5 V plus some margin to function properly. Furthermore, the software will not start switching until a minimum of 15 V is reached.

The board should come pre-flashed and ready to be used. However, in case changes to the software need to be made, the following instruction should guide you through this process.

4.1 Software deployment and debugging

Prerequisites:

- Download and install DAVE™ IDE from Infineon Developer Center.
- Register the board with the attached serial number on the Infineon website. Download the firmware that is already pre-flashed on the board.

Programming and debugging are carried out via the XMC™ Link isolated debug probe as shown in Figure 15.

Figure 15 XMC™ Link isolated debugger probe

Note: An additional external power supply is required when using an isolated debugging probe.

4.1.1 Open the firmware project in DAVE™

Perform the following steps to set up and debug the firmware project.

1. Connect the optimizer board to the debug probe using the larger 2.54 mm pitch ribbon cable and the 8-pin box header (X2).
   An additional external power supply is required when using an isolated debugging probe.
2. Import the downloaded firmware project in DAVE™ by navigating to **File** > **Import** > **Infineon** > **DAVE Project**.
   This firmware project was created within DAVE™ IDE containing the device definition, settings, and source files required to compile and build the executable code, which can be downloaded into the Flash program memory of the XMC™ controller.

Note: For the firmware, register the board with the attached serial number on the Infineon website. This enables you to access to the pre-flashed firmware on the board.

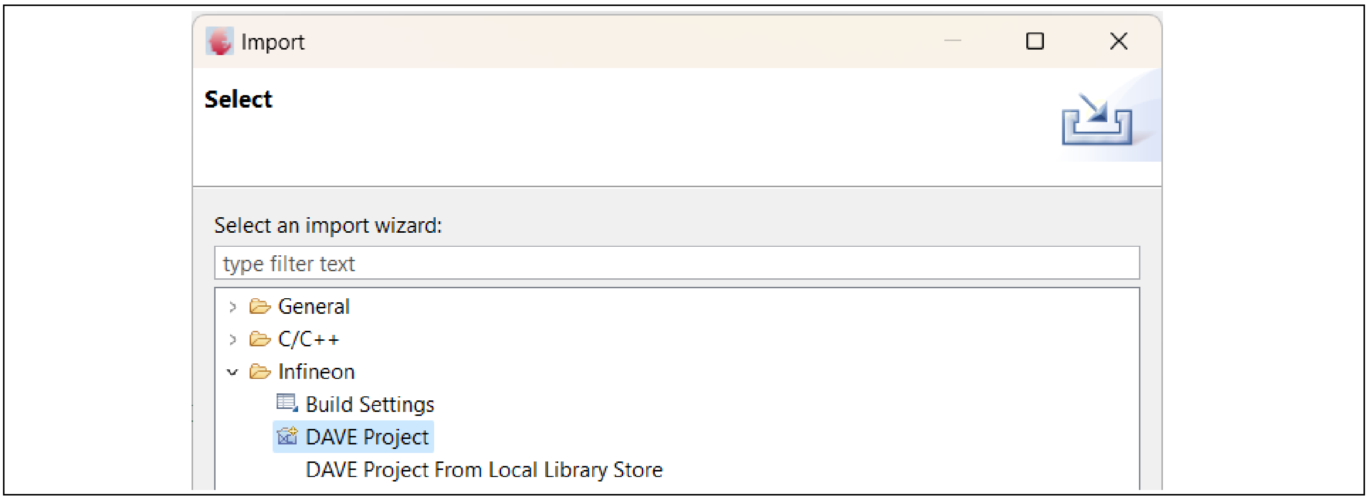


Figure 16 DAVE™ IDE import window

3. Open the **C/C++ Projects** tab.

The *main.c* file contains the main body of the source code, *mppt_pno.h* contains the main struct describing the MPPT algorithm, and the *xmc_2p2z_filter_fixed.h* contains all the necessary function calls for the current and voltage loops.

The apps are listed in the app dependency tree window in the DAVE™ CE screen and displayed graphically in the app dependency window.

4. To configure the app, double-click on any app.
   A menu appears with options for configuration.
   The manual pin allocator is used to select which I/O pins are mapped to each of the app inputs and outputs.
5. Once the configuration is complete, generate the corresponding ".c" and ".h" source code files by clicking the **Generate Code** button (See Figure 17,highlighted in blue).

Note: For more complex functionality, download the necessary functions from the DAVE™ library.

4.1.2 Setting the BMI in DAVE™

In case the board is used for the first time, the BMI (Boot Mode Index) needs to be set. The BMI value determines the start-up mode and debug configuration of the XMC1000. Bootstrap modes via UART or SPI as well as single pin debug or SWD are supported.

To set the BMI, perform the following steps.

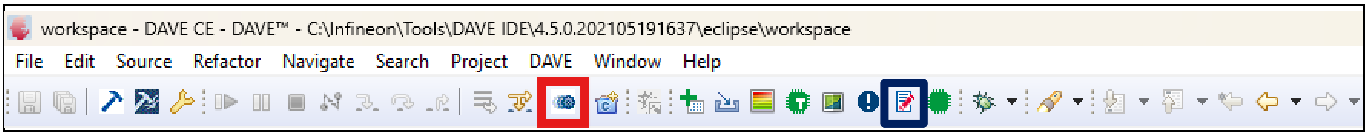


Figure 17 DAVE™ IDE with Generate Code button highlighted in blue and BMI Set and Get button in red

1. Click the **BMI Get Set** button (See Figure 17, highlighted in blue).

2. Press the **Get BMI** button to acquire the current set BMI value on the MCU.
3. Click **Select** under the **BMI Selection** tab.
   By default, the detected BMI Value is **ASC Bootstrap Load Mode (ASC_BSL), no debug**. In this mode the board cannot be debugged. In case User Mode (DEBUG) SWD0 is shown, jump to point 10.
4. Change the BMI to **User Mode (Debug) SWD0 (SWDIO_P0.14, SWDCLK=P0.15)** by choosing it out of the drop-down menu and press the **Set BMI** button as shown in Figure 18.

Note: *For a different design, instead of SWD0, it is possible to use SWD1 interface located at different pins. Hence, it is recommended to refer the schematic before setting the BMI value.*

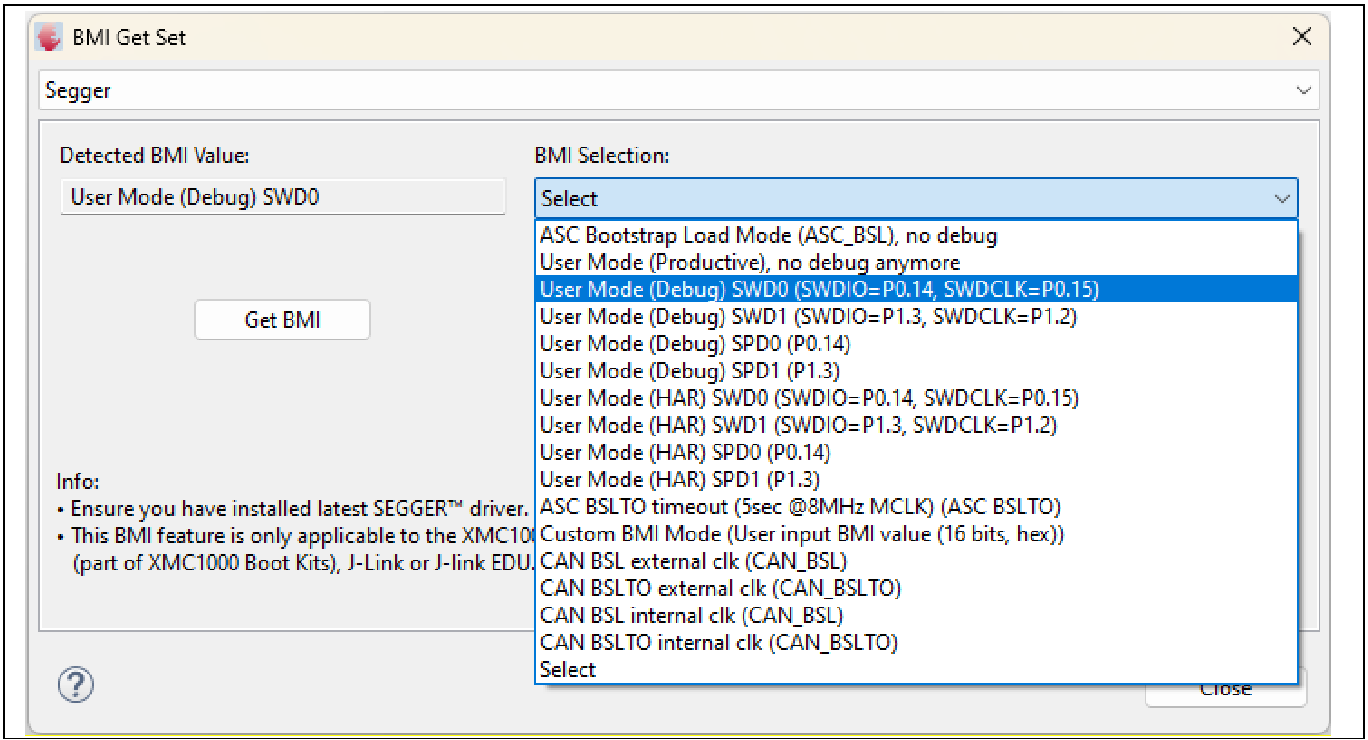


Figure 18 BMI Set and Get window

5. To apply the imported project to the board , built the firmware project by clicking the **Build Active Project** button, see Figure 19.
6. Click the **Debug** button to program the board.
   The debug screen appears, where the program can be launched. In case the board is tested without any modifications, the firmware just needs to be built and flashed.
7. Supply the board with power, as the debugger itself is isolated.

Note: *Supply the board with smaller than 12 V to prevent the MPPT's operation.*

8. Launch the program via the debug screen.

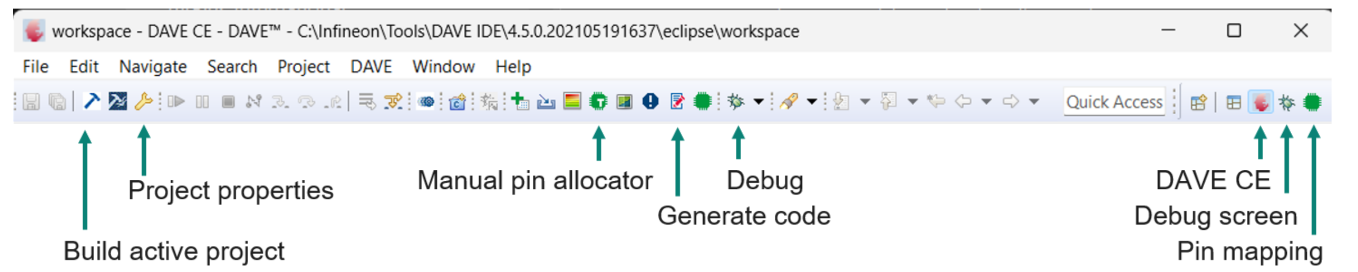


Figure 19 DAVE™ IDE main commands

4.2 Firmware settings

There are several parameters which can be changed in the firmware depending on the used PV module or the populated switches. One part which can be changed depending on the requirements on the control are the A and B parameters of voltage and current loop.

Code listing 1 2P2Z parameters

```
/*V loop parameter*/
#define V_B0 (+0.101)
#define V_B1 (-0.099)
#define V_B2 (-0.00)
#define V_A1 (+1.0)
#define V_A2 (+0.0)
#define V_K  (+0.1)

...

/*I loop parameter*/
#define I_B0 (+0.1413)
#define I_B1 (-0.1253)
#define I_B2 (+0.00)
#define I_A1 (+1.0)
#define I_A2 (+0.0)
#define I_K  (+0.005)
```

The controller itself is simplified to a PI compensator, by defining the parameters as below:

- B2 = 0
- B1 = (Ki – KP)/K
- B0 = (Ki + KP)/K
- A2 = 0
- A1 = 1

Where, K is the gain. So, in a Z domain, the KP, and Ki are:

- KP = 1/2×(B0-B1)×K
- Ki = 1/2×(B0+B1)×K

The control parameters are tuned for high stability over the whole operating range and quick responsiveness.

Depending on the used switches and gate driver as well as the corresponding gate and snubber settings, the dead-time needs to be adjusted. As the switching frequency is 200kHz and the clock frequency 64MHz, the time of timer tick results in 32 ns. Hence the smallest dead-time setting despite '0' is 1 tick. This is set for both the rising and falling edge. If more dead-time is needed due to a slower gate setting, the number of ticks can be increased.

Code listing 2 Dead-time settings

```
PWM_CCU8_SetDeadTime(&PWM_CCU8_0,XMC_CCU8_SLICE_COMPARE_CHANNEL_1,1U,1U);
```

Depending on the used PV module and its characteristics, the MPPT controller settings can be fine-tuned to achieve the highest performance. The following parameters in Code listing 3 can be changed:

- DeltaPmin, minimum change in measured power in mW needed for change in operating point (50 equals 1.59 V)
- MaxVolt, maximum reference voltage for voltage loop (2700 equals 85.7 V)
- MinVolt, minimum voltage required at input for switches to start operation (378 equals 12 V)
- Stepsize, change in reference voltage value for voltage control loop (25 equals 0.79 V)

All other parameters in the struct are status variables changing during runtime of the program

Code listing 3 Dead-time settings

```
typedef struct {
      int32_t  Ipv;
      int32_t  Vpv;
      int32_t  DeltaPmin;
      int32_t  MaxVolt;
      int32_t  MinVolt;
      int32_t  Stepsize;
      int32_t  VmppOut;
      int32_t  DeltaP;
      uint32_t  PanelPower;
      uint32_t  PanelPower_Prev;
      uint16_t mppt_enable;
      uint16_t mppt_first;
}mppt_pno;

typedef mppt_pno *mppt_pno_handle;

#define mppt_pno_DEFAULTS {
      0,     \
      0,     \
      50,    \
      2700,  \
      378,   \
      25,    \
      0,     \
      0,     \
      0,     \
      0,     \
      0,     \
      1,     \

}
```

5 Startup

The board is delivered with the heatsink not attached so that measurements close to the MOSFETs can be done. Depending on the used thermal interface material, the correct distance holders as well as the correct screw length needs to be organized. However, the board can be used even without the heatsink if temperatures are externally monitored and therefore a full power of 600 W is not needed.

The board comes pre-flashed out of the box hence it can be operated as it is. If a non-factory new board is obtained, follow all steps outlined in Chapter 4. The board will have as initial input voltage reference point set to 60 V. If the input voltage is lower than 60 V, adapt the VmppOut parameter in the firmware. Otherwise, the MPPT algorithm may take a long time to adjust.

It is important to note that the optimizer is controlling the input voltage, not the output voltage. Therefore, when testing the board, one should not use a PV panel or PV emulator as source and a different test setup must be arranged. A regular power supply can be used if a resistor is placed in series to the positive input terminal of the optimizer board. In this case, the maximum power point would correspond to half the input voltage. The resistor will generate heat according to half the output power, so it has to be large enough to withstand the burnt energy. As reference, the PV emulator used for testing was the 62150H-1000S manufactured by Chroma and the used electronic load was the EA-EL 9080-170 B HP from EA Elektro-Automatik.

If further tests are conducted in terms of changing the switching frequency, the gate voltages need to be observed and changed accordingly, either by adjustment of the dead-time in the software, exchanging the gate resistances, or by making use of the possibility to place a snubber network. Depending on the target frequency and target power in a custom design, select the most efficient MOSFET and driver combination.

Note: *For the assistance involving the selection of a suitable MOSFET and driver combination, reach out to a local Infineon representative.*

6 Schematics

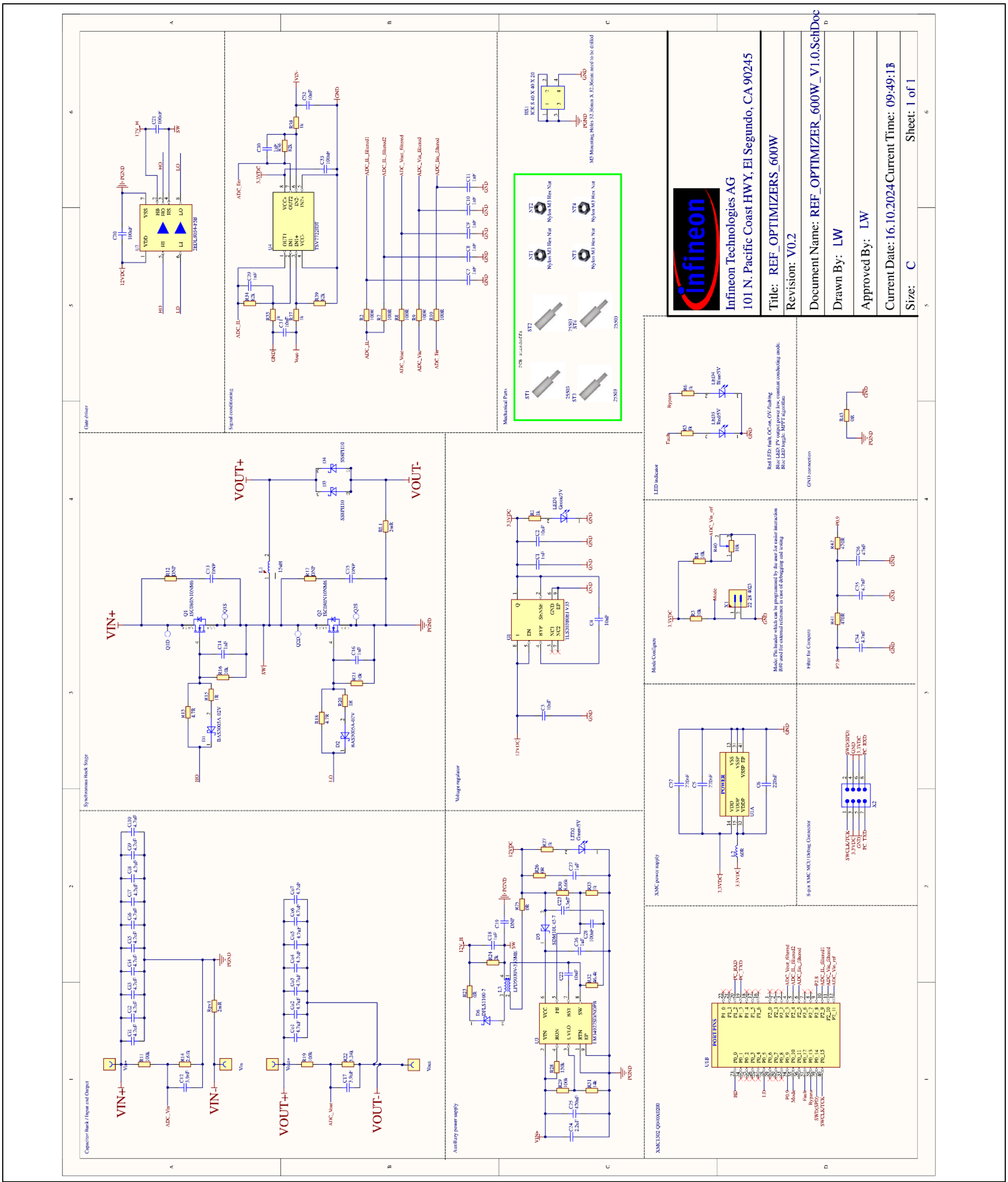


Figure 20 REF_OPTIMIZER_600 W schematics

7 PCB layout

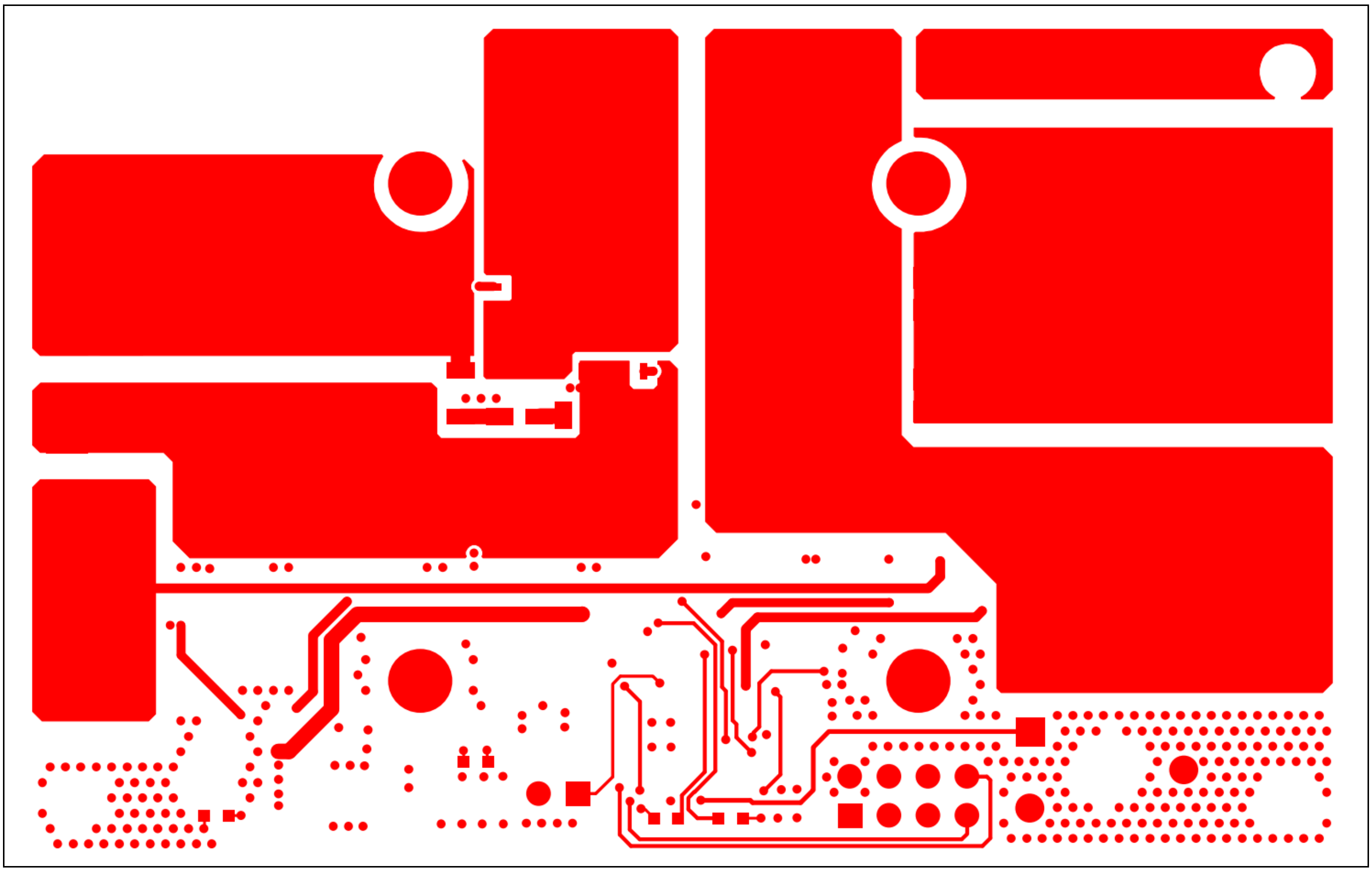


Figure 21 **REF_OPTIMIZER_600 W top layer**

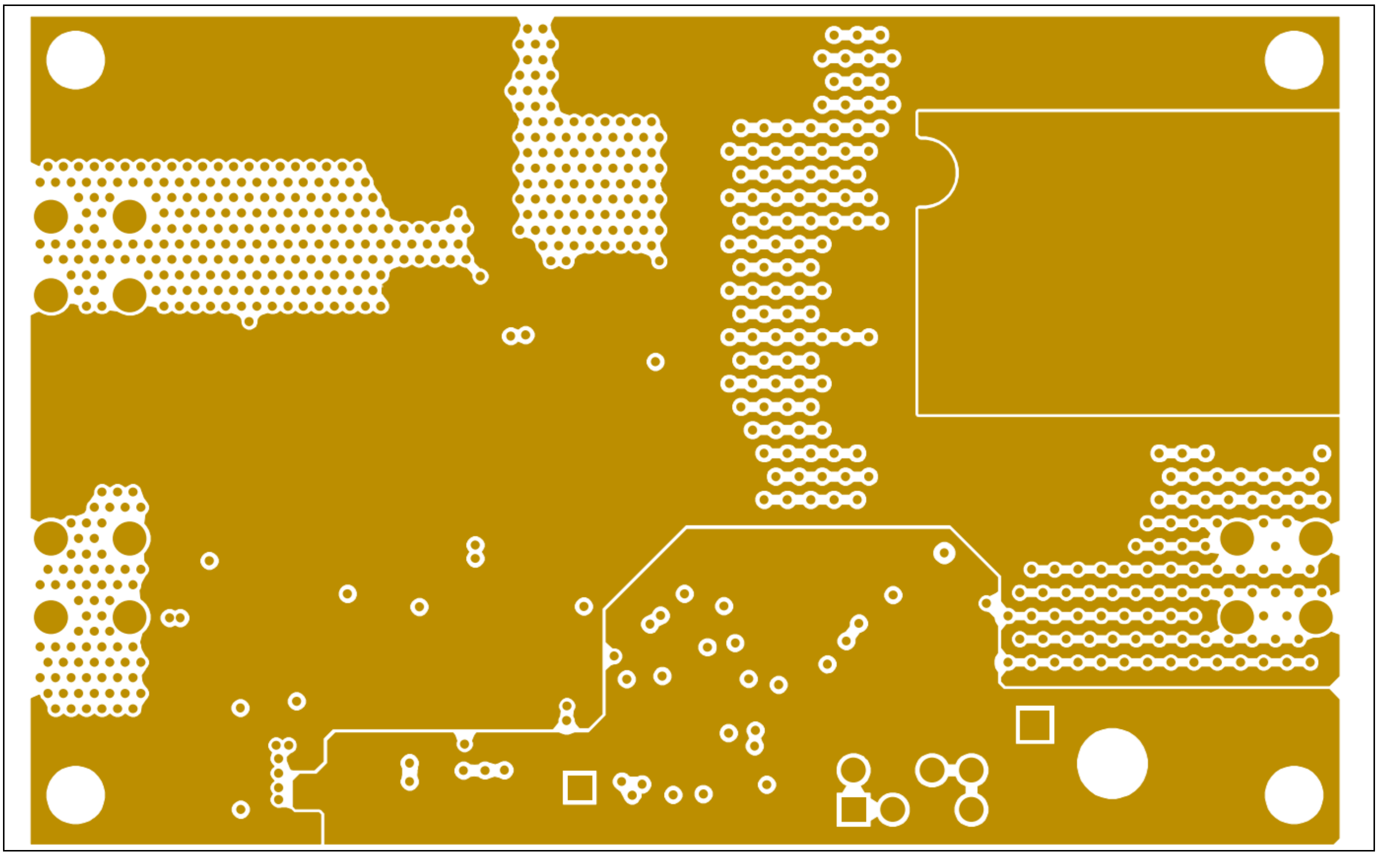


Figure 22 REF_OPTIMIZER_600 W first inner layer

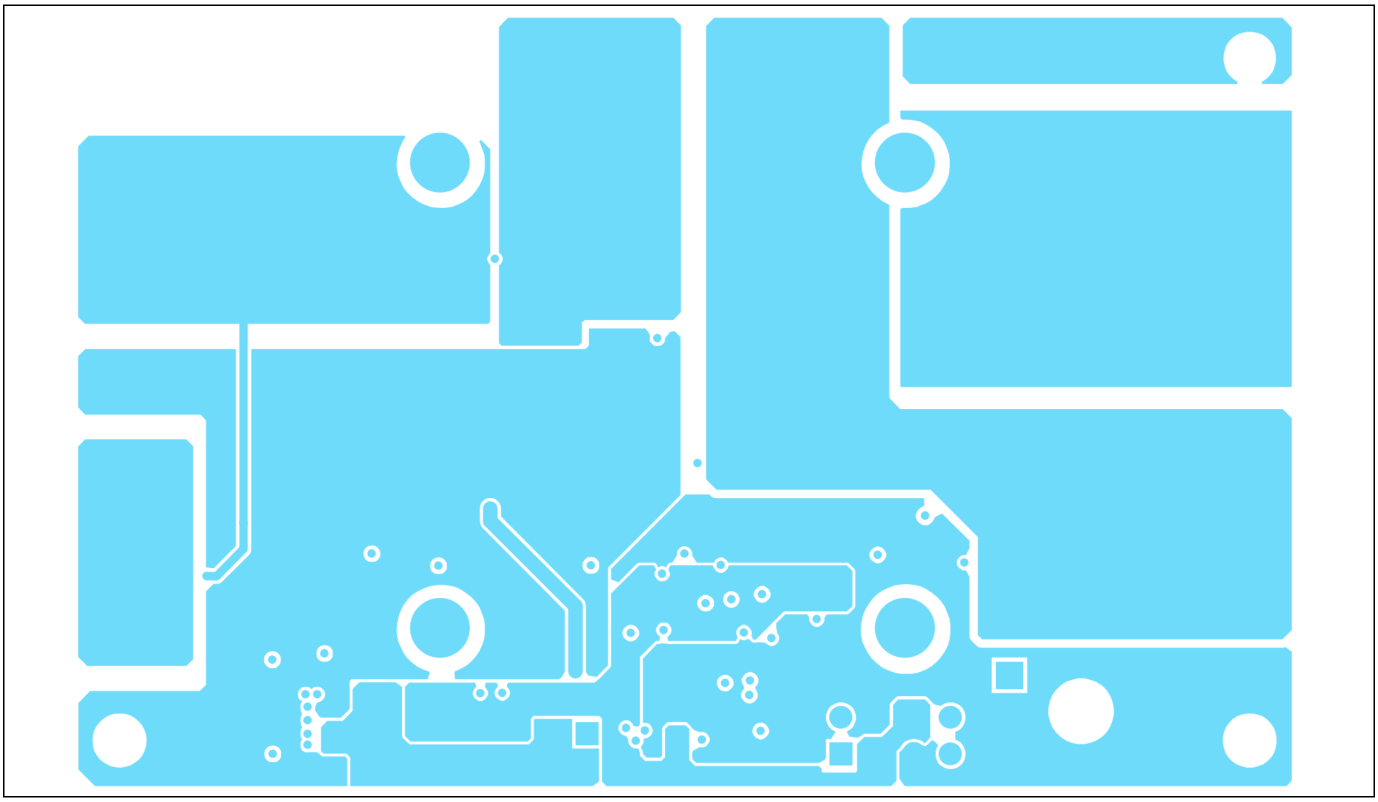


Figure 23 REF_OPTIMIZER_600 W second inner layer

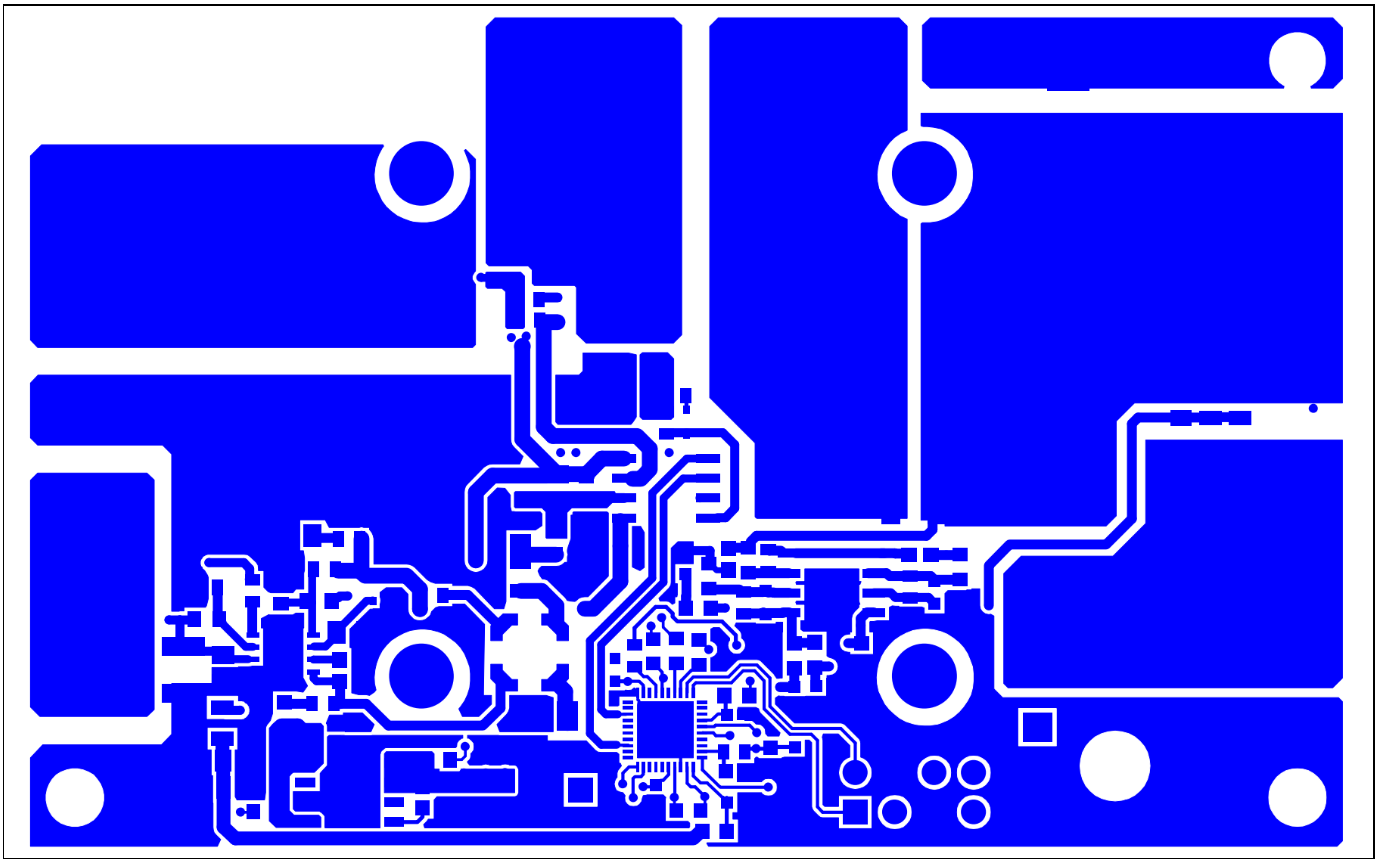


Figure 24 REF_OPTIMIZER_600 W bottom layer

8 BOM

Table 5 REF_OPTIMIZER_600 W bill of materials

Reference	Qty	Type	Value/Rating	Manufacturer	Part number
C1, C7, C8, C9, C10, C11	6	Capacitor	1 nF, 25 V, 0603, C0G	Würth Elektronik	885012006044
C2, C3	2	Capacitor	10 µF, 25 V, 0603, X5R	Würth Elektronik	885012106031
C4, C6, C37	3	Capacitor	220 nF, 25V, 0603, X7R	Würth Elektronik	885012206073
C5	1	Capacitor	10 nF, 25 V, 0603, X7R	Würth Elektronik	885012206065
C12, C17	2	Capacitor	3.9 nF, 50 V, 0805, X7R	MuRata	GRM2165C1H392JA01D
C13, C15	2	Capacitor	1 nF, 200 V, 1206, C0G	Kemet	C1206C102J2GACTU
C14, C16	2	Capacitor	1 nF, 50 V, 0603	Würth Elektronik	885012006063
C18, C27	2	Capacitor	1 µF, 25 V, 0805, X7R	TDK Corporation	C2012X7R1E105K
C19	1	Capacitor	DNP	–	
C20, C21, C28, C33	4	Capacitor	100 nF, 50 V, 0603, X7R	KYOCERA	06035C104KAT2A
C22, C31, C32	3	Capacitor	10 nF, 16 V, 0603, X7R	TDK Corporation	CGJ3E2X7R1C103K080AA
C23	1	Capacitor	10 nF, 16 V, 0603, X7R	TDK Corporation	CGJ3E2X7R1C103K080AA
C24	1	Capacitor	2.2 µF, 100V, 1210, X7R	TDK Corporation	C3225X7R2A225K230AM
C25	1	Capacitor	470 nF, 100V, 0805, X7S	TDK Corporation	CGA4J3X7S2A474K125AB
C26	1	Capacitor	1 µF, 16V, 0603, X7R	TDK Corporation	C1608X7R1C105K080AC
C29, C30	2	Capacitor	1 nF, 16V, 0603, X7R	Kemet	C0603C102K4RACTU
C34, C35	2	Capacitor	4.7 nF, 25V, 0603, X7R	Würth Elektronik	885012206063
C36	1	Capacitor	47 nF, 25V, 0603, X7R	Würth Elektronik	885012206069
Ci1, Ci2, Ci3, Ci4, Ci5, Ci6, Ci7, Ci8, Ci9, Ci10, Co1, Co2, Co3, Co4, Co5, Co6, Co7	17	Capacitor	4.7 µF, 100V, 1210, X7R	TDK Corporation	CNA6P1X7R2A475K250AE
D1	6	Diode	Green LED, 0603	Würth Elektronik	150060GS75000
D2, D5	1	Diode	Schottky diode, 30 V, 0.5 A, SC79	Infineon	BAS3005A-02V

Reference	Qty	Type	Value/Rating	Manufacturer	Part number
D3, D4	4	Diode	Schottky diode, 80 V, 5 A, TO-277B	Littelfuse	DST580S-A
D6	8	Diode	Schottky diode, 100 V, 1 A, PWRDI123	Diodes Inc.	DFLS1100-7
D7	3	Diode	Schottky diode, 40 V, 100 mA, SOD523	Diodes Inc.	SDM10U45-7
D8	1	Diode	Red LED, 0603	Lite-On Inc.	LTST-C190EKT
D9	1	Diode	Blue LED, 0603	Lite-On Inc.	LTST-C191TBKT
G1	1	LDO	Linear voltage regulator, 3.3 Vout	Infineon	TLS203B0EJ V33
HS1	4	Heatsink	Modified 40x40x20 mm heatsink 3.5K/W	Fischer Elektronik	ICK S 40 X 40 X 20
L1	1	Inductor	15 µH, SMD	Würth Elektronik	7443641500
L2	1	Inductor	60 Ω, Ferrite Bead, 0603	Würth Elektronik	74279267
L3	1	Inductor	22 µH, Coupled, SMD	Coilcraft	LPD5030V-333ME
LED1	1	Diode	Green LED, 0603	Lite-On Inc.	LTST-C190KGKT
NT1, NT2, NT3, NT4	1	Mechnical	Nylon M3 Hex Nuts	–	–
Q1, Q2	2	MOSFET	OptiMOS™ 6 power MOSFET 100 V 8 mΩ	Infineon	ISC080N10NM6
Q1D, Q1S, Q2D, Q2S	4	Test Point	Measurement testpoint	–	–
R1, R5, R6, R33, R35, R37, R38	7	Resistor	1 kΩ, 0603	KOA corporation	RK73H1JTTD1001F
R2, R7, R8, R9, R10	5	Resistor	100 Ω, 0603	KOA corporation	RK73H1JTTD1000F
R3, R4	2	Resistor	10 kΩ, 0603	ROHM semiconductor	MCR03EZPFX1002
R11, R19	2	Resistor	100 kΩ, 0805	Vishay	CRCW0805100KFKEA
R12, R17	2	Resistor	DNP	–	–
R13, R18	2	Resistor	4.7 Ω, 0603	Vishay	CRCW06034R70FKEA
R14	1	Resistor	2.61 kΩ, 0805	Vishay	CRCW08052K61FKEA
R15, R20	2	Resistor	1 Ω, 0603	Vishay	CRCW06031R00FKEA HP
R16, R21	2	Resistor	10 kΩ, 0603	Vishay	CRCW060310K0FKEA
R22	1	Resistor	3.24 kΩ, 0805	Vishay	CRCW08053K24FKEA
R23, R25, R26	3	Resistor	0 Ω, 0603	KOA S. E. Inc.	RK73Z1JTTD
R24	1	Resistor	2 kΩ, 0603	KOA S. E. Inc.	RN73H1JTTD2001B25
R27	1	Resistor	1 kΩ, 0603	ROHM semiconductor	MCR03EZPFX1001
R28	1	Resistor	130 kΩ, 0603	Vishay	CRCW0603130KFKEAC

Reference	Qty	Type	Value/Rating	Manufacturer	Part number
R29	1	Resistor	100 kΩ, 0603	Panasonic	ERJ-3EKF1003V
R30	1	Resistor	8.66 kΩ, 0603	KOA corporation	RK73H1JTTD8661F
R31	1	Resistor	14 kΩ, 0603	Vishay	CRCW060314K0FKEA
R32	1	Resistor	46.4 kΩ, 0603	KOA corporation	RK73H1JTTD4642F
R34, R36, R39	3	Resistor	82 kΩ, 0603	Vishay	CRCW060382K0FKEAC
R40	1	Potentio-meter	10 kΩ, THT	Amphenol	PT10MV10103A2020IPMS
R41, R42	2	Resistor	470 Ω, 0603	Vishay	CRCW0603470RFKEAC
R43	1	Resistor	0 Ω, 0603	Vishay	CRCW06030000ZSTA
RL1, Rpv1	2	Resistor	2 mΩ, 2010	KOA corporation	TLR2HWDTE2L00F50
ST1, ST2, ST3, ST4	4	Mechanical	NylonM3 HEX standoff	Keystone	599926
U1A	1	µC	32-bit Microcontroller ARM® Cortex®-M0	Infineon	XMC1302-Q040X0200AB
U2	1	Driver	Dual-channel junction-isolated gate driver IC	Infineon	2EDL8034-F5B
U3	1	Power Supply	Switched regulator for iso DC-DC	Texas Instruments	LM34927SD/NOPB
U4	1	IC	Dual high bandwidth OpAmp	STMicroelectronics	TSV7722IDT
Vin-, Vout-	2	Connector	Safety jack 25 A connector	Cal Test Electronics	CT3151SP-0
Vin+, Vout+	2	Connector	Safety jack 25 A connector	Cal Test Electronics	CT3151SP-2
X1	1	Connector	Vertical 1x2 pin header 2.54 mm	Würth Elektronik	61300211121
X2	1	Connector	Vertical 2x4 pin header 2,54 mm	Würth Elektronik	61300821121

References

[1] Damijan Zupancic: *Power optimizers for residential solar with MPPT tracking, Power Systems Design,2024 Aug*; Available online

[2] Jauregui D, Wang B, Chen R.: *Power loss calculation with common source inductance consideration for synchronous buck converters. Application Report (SLPA009A), Texas Instruments. 2011 Jun*; Available online

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