350 W AC/DC HV LED driver reference design based on ICL5102HV

Targeted for street light and horticulture applications

About this document

Scope and purpose

This document details all aspects of a highly efficient, dimmable 350 W AC/DC LED driver reference board. The board was developed to demonstrate the performance of the ICL5102HV, an advanced 980 V resonant half-bridge controller IC with an integrated PFC stage. It is designed for LED driver applications such as horticulture and fishing lighting, street lighting, and parking space lighting where high AC input voltage systems are commonly used.

The document also describes the process of designing a tank with Infineon's LCC Design Tool. It also explains how a wide output voltage range is achieved due to the selected resonant LCC topology using the tool.

CoolMOS™ PFD7 950 V high-voltage MOSFET with best-in-class hard commutation ruggedness is used in the half-bridge as well as in the PFC stage ensuring safe operation across the whole load range.

Intended audience

This document is intended for design engineers, technicians, and developers of AC/DC LED drivers.

V 1.0
2024-12-12

Table of contents

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Safety precautions

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 V DC. 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 heatsink 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 ESD 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 Board specifications

Figure 1 describes the components of the reference board architecture and Table 2 highlights Infineon components used in the board.

- EMI filter, protection, and rectification
- Boost PFC stage operating in critical-conduction mode (CrCM) for the high- and medium-load cases and in discontinuous mode (DCM) for light-load cases
- Half-bridge resonant tank forming the LCC topology for a wide output voltage range
- Synchronous rectification ensuring high efficiency and low losses on the secondary side
- Analog dimming interface (0–10 V) going down to 1 percent load
- Single-sided PCB (70 µm/2 oz copper thickness) for cost saving

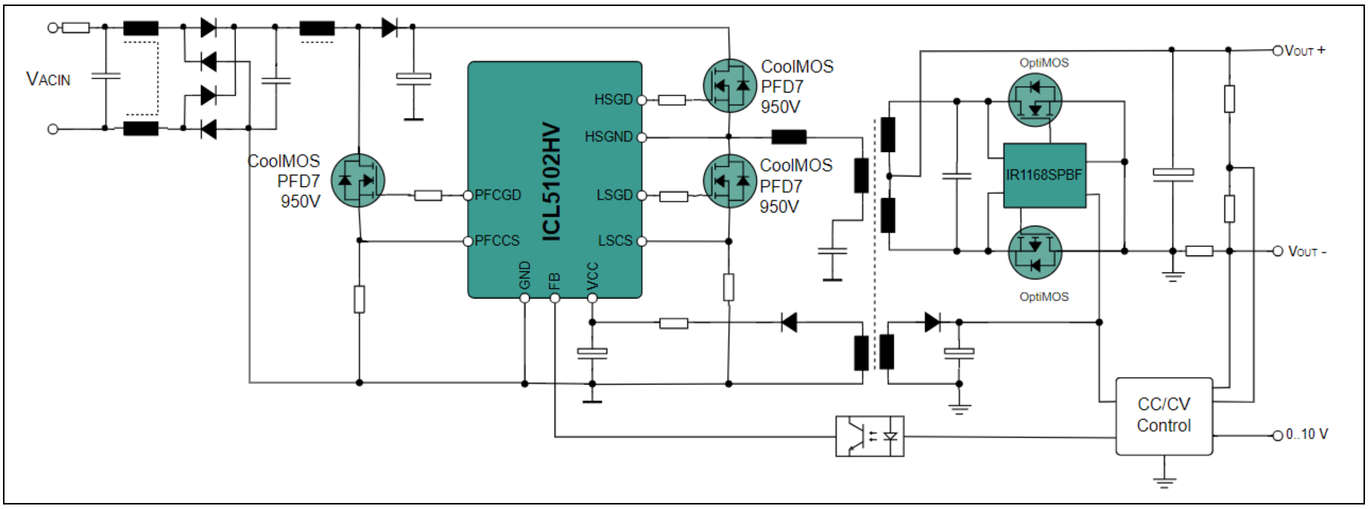


Figure 1 Block diagram

Table 2 Infineon key components

Description	Type	Package
980 V PFC+ resonant combo controller	ICL5102HV	PG-DSO-19
950 V PFC MOSFET	IPA95R450PFD7	PG-TO220-3
950 V half-bridge MOSFET (2x)	IPA95R310PFD7	PG-TO220-3
SR controller	IR1168STRPBF	PG-DSO-8
150 V SR MOSFET (2x)	BSC074N15NS5	PG-TSON-8

1.1 Electrical specifications

Table 3 provides the electrical specifications of the LED reference board.

Table 3 Electrical specifications

Description	Symbol	Value	Unit	Remarks
Input characteristics				
AC input voltage range Input frequency	V_{in} f_{in}	249 to 528 47 to 63	V_{RMS} Hz	$V_{in,nom}$ = 347 V_{RMS}
Analog dimming voltage	V_{LED}	0 to 10	V_{DC}	
Total harmonic distortion	THD	below 10 below 12 below 15	% % %	50% load at 277 V_{RMS} 50% load at 347 V_{RMS} 50% load at 480 V_{RMS}
Power factor	PF	0.99 0.91	–	100% load at 277 V_{RMS} 50% load at 480 V_{RMS}
EMI	acc. to EN 55015			100% load at 347 V_{RMS}/56 V_{DC}
Harmonics	acc. to IEC61000-3-2 Class-C, edition 5.1			–
Output characteristics				
Output voltage range Output current range	V_{OUT} I_{OUT}	35 to 56 0.0625 to 6.25	V_{DC} A	 1% to 100%
Rated output power Peak efficiency	P_{max} η_{peak}	350 95.7	W %	 Tested at 347 V_{RMS}/56 V_{DC}
Time to light	$T_{Start\text{-}up}$	413	ms	Tested at 347 V_{RMS} 100% load
Standby power consumption	P_{STDBY}	915	mW	Tested at 480 V_{RMS}
Line regulation	$\Delta V_{OUT,Line}$ $\Delta I_{OUT,Line}$	max. ±1 max. ±1	% %	Voltage regulation mode Current regulation mode
Load regulation	$\Delta V_{OUT,Load}$	max. ±1	%	$I_{OUT:}$ 1 to 100%

Analog dimming interface

The 350 W HV LED Driver has an analog dimming interface that enables the user to drive the load in a certain operating window, characterized in Figure 2. The output current can be adjusted in the range of 1–100 percent.

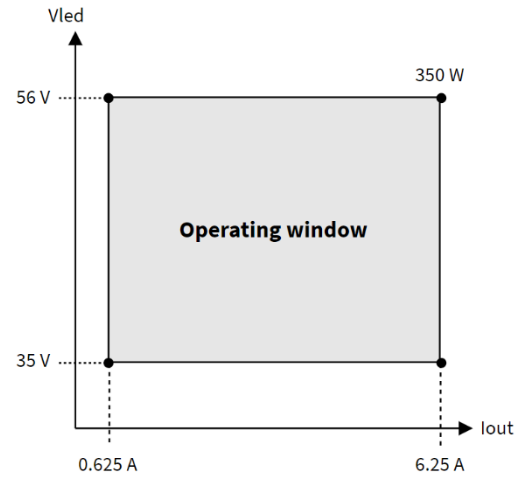


Figure 2 Operating window

1.2 Mechanical specifications

Table 4 provides the mechanical specifications of the LED reference board.

Table 4 Mechanical specifications

Description	Symbol	Value	Unit	Remarks
Board dimensions	L x W x H	275 x 70 x 41	mm	length x width x height
Weight	m	440	g	Fully assembled
PCB				
PCB copper thickness	–	70	µm	–
PCB thickness	–	1.6	mm	–

1.3 Test setup

Figure 3 shows the board's test setup used to evaluate the system performance. All measurements listed in this engineering report have been performed with the following test setup.

Equipment needed:

- High-voltage AC source (249 to 528 V_{RMS}/50 to 60 Hz)
- DC load (CV/CR/LED mode)
- DC power supply (0–10 V_{DC})

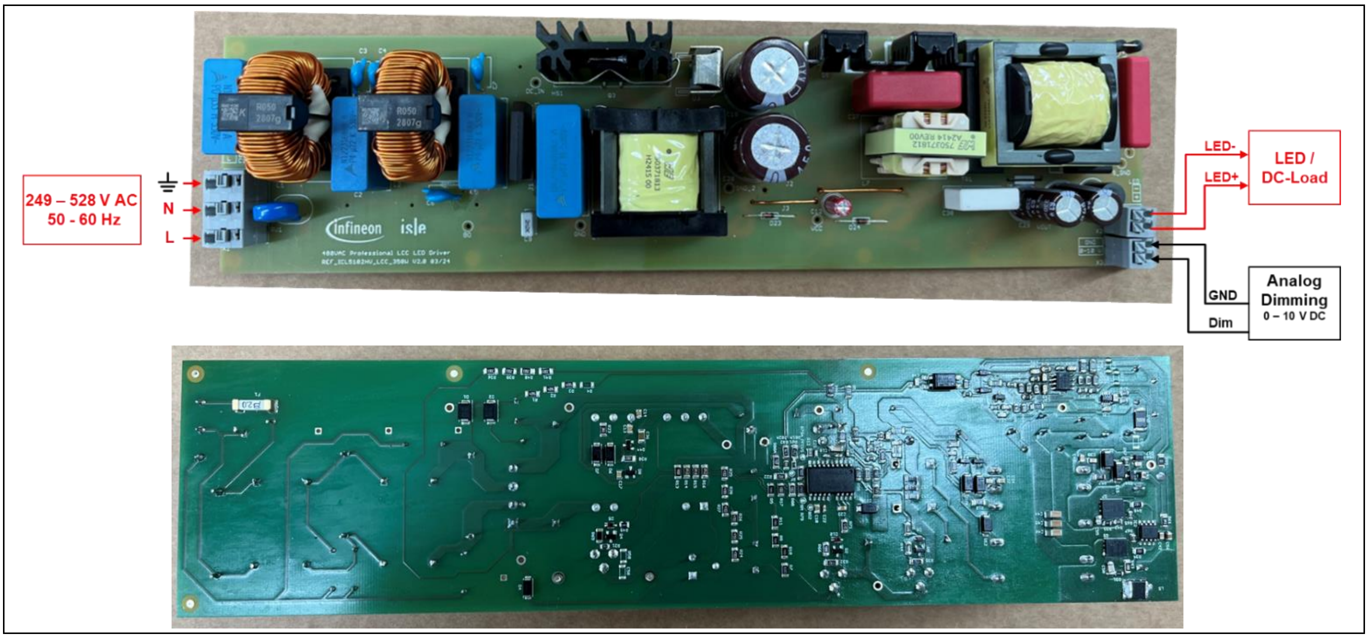


Figure 3 Board test setup

Attention: ***Lethal voltages are used in this reference design. Do not operate the board unless you are trained to handle high-voltage circuits. Do not leave this board unattended when it is powered up.***

2 Performance data

2.1 System efficiency

The overall system efficiency evaluated at several input conditions and over a wide dimming range are illustrated in Figure 4. A peak efficiency of 95.7 percent was achieved at full-load.

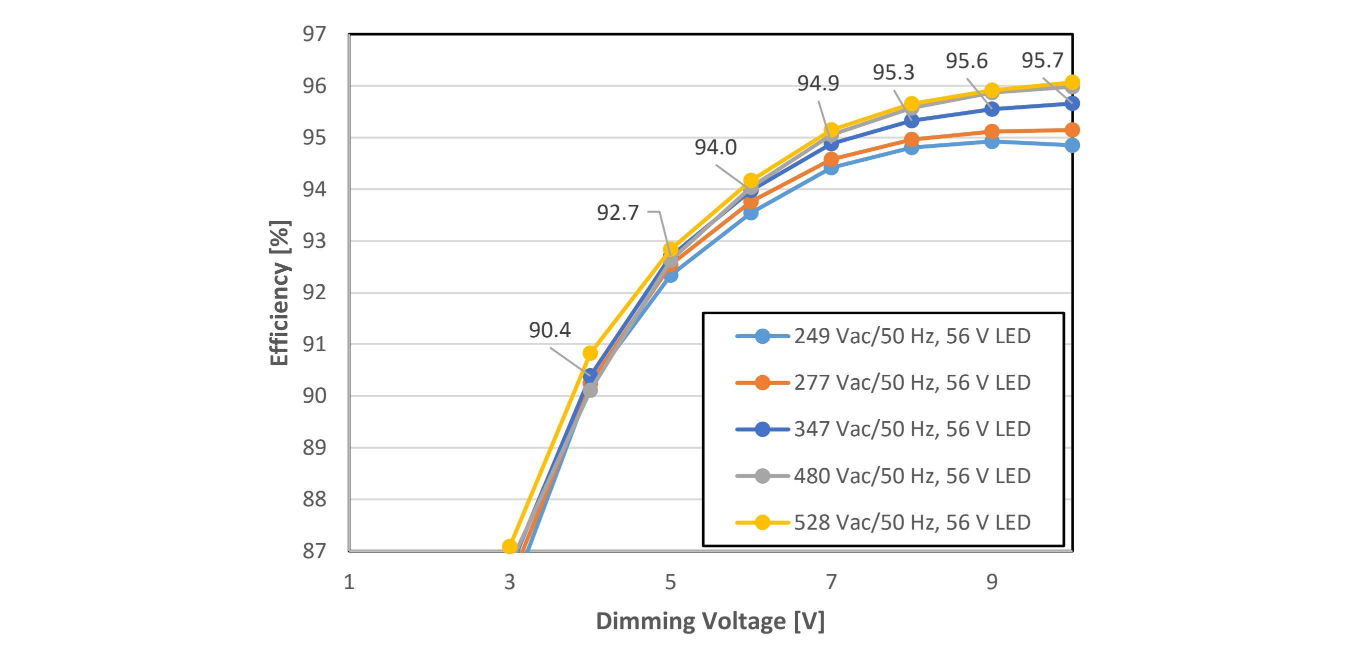


Figure 4 System efficiency over a wide dimming range

The system efficiency remains high over a wide output voltage range, as shown in Figure 5.

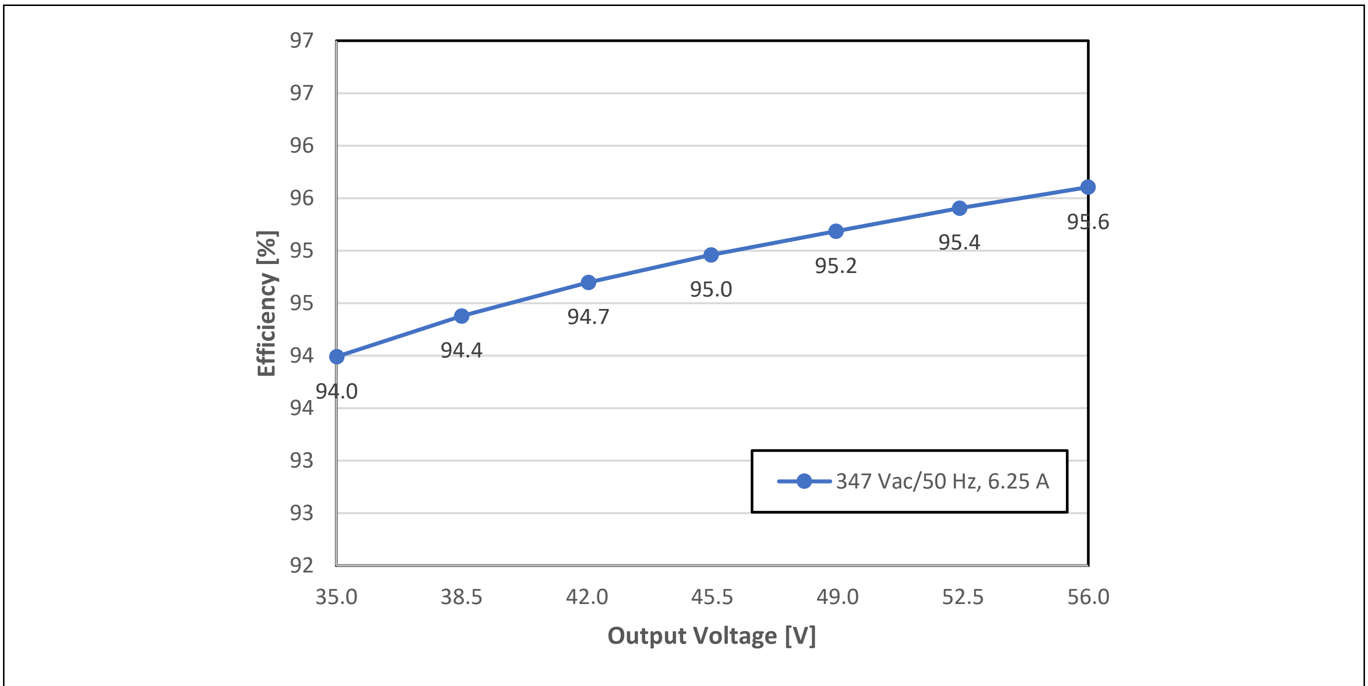


Figure 5 System efficiency over a wide output voltage range

2.2 Power factor

For a nominal input voltage, the power factor remains high over the entire dimming range (Figure 6).

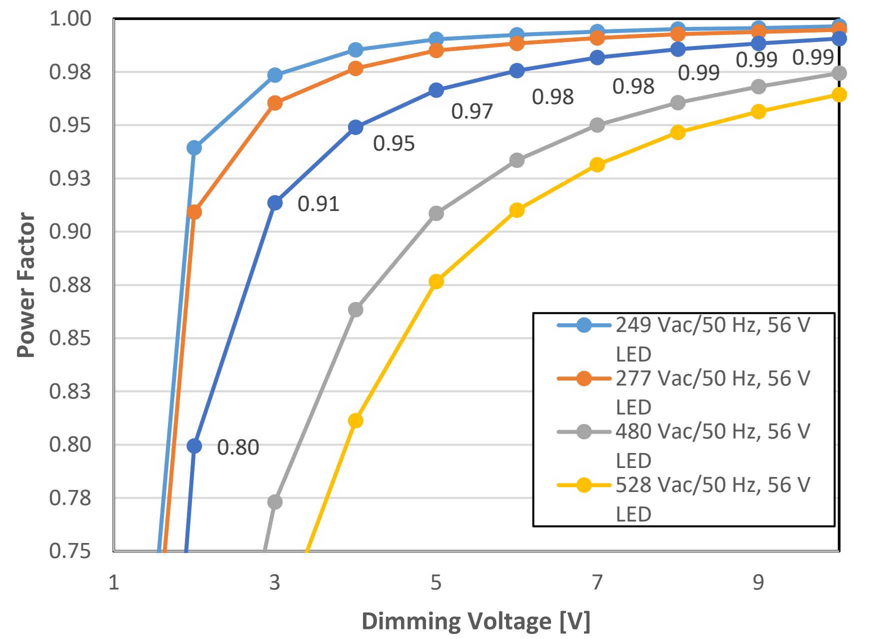


Figure 6 **Power factor across the entire dimming range**

Figure 7 shows the power factor results across the load range for the nominal input voltage.

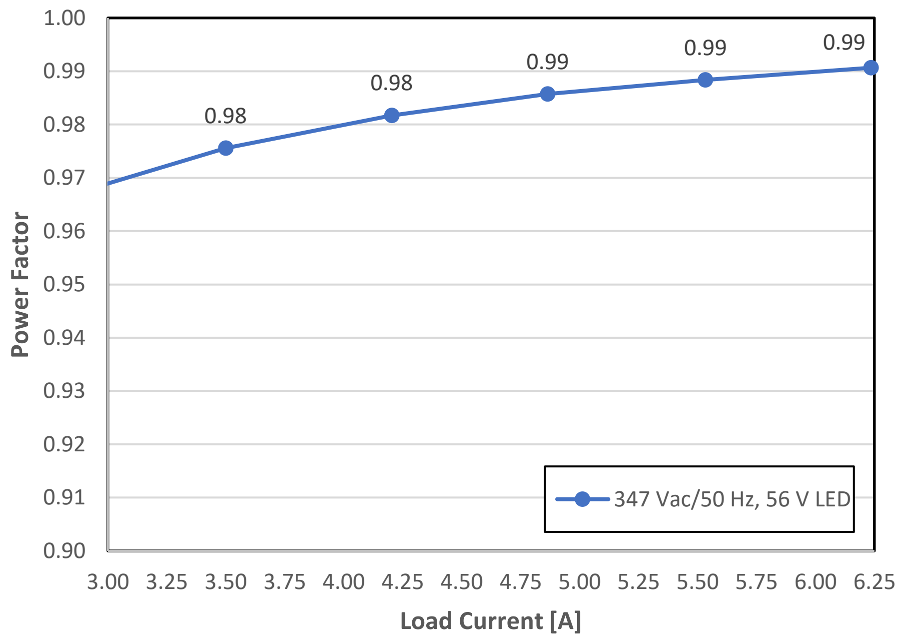


Figure 7 **Power factor across the load range at $V_{in,nom}$**

2.3 Total harmonic distortion (THD)

Best-in-class THD is achieved thanks to the controlled on-time of the PFC MOSFET in order to minimize THD and harmonics, as shown in Figure 8.

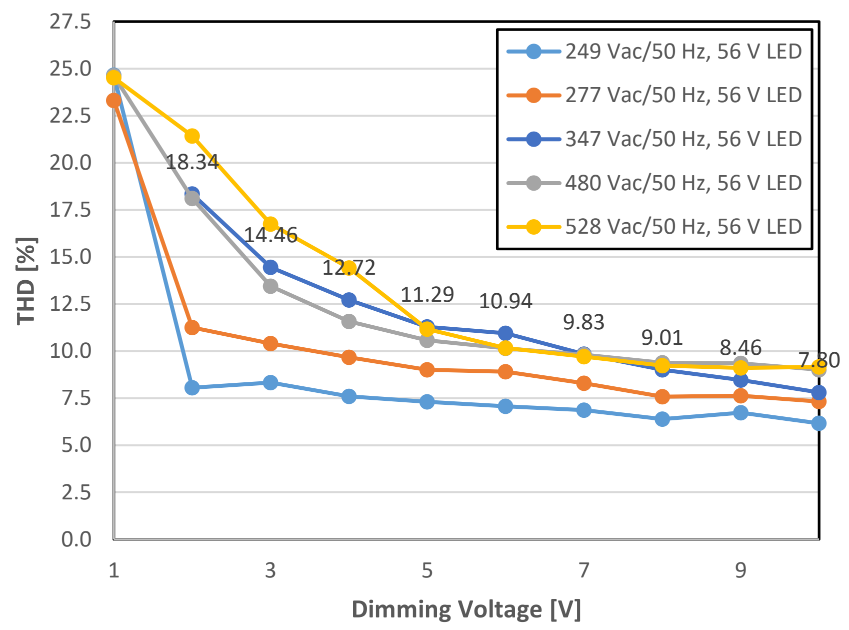


Figure 8 Total harmonic distortion (THD) across the dimming range

Figure 9 shows the THD results across the load range for the nominal input voltage.

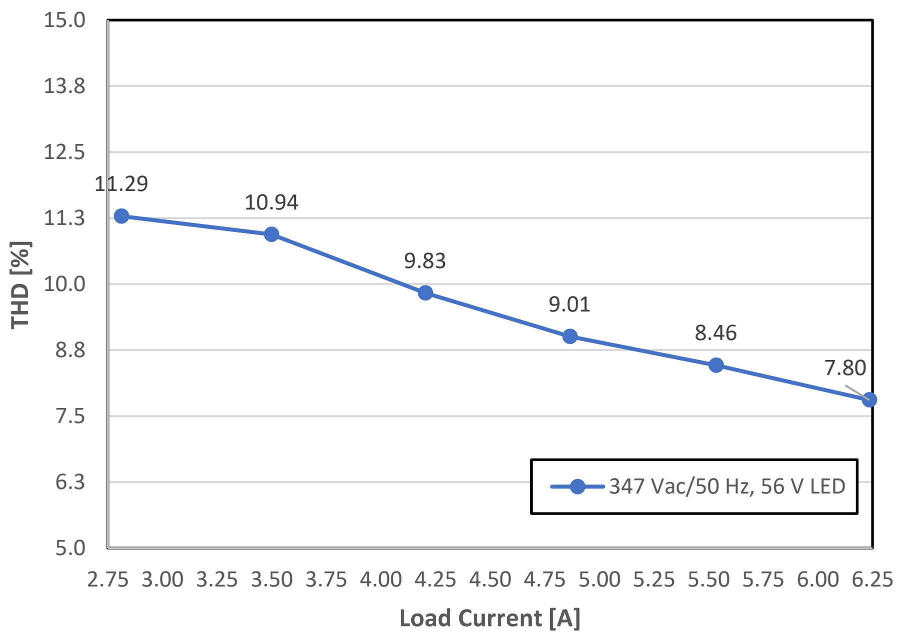


Figure 9 Total harmonic distortion across the load range at $V_{in,nom}$

2.4 Input current harmonics

Input current harmonics are well below the limits according to IEC61000-3-2 Class-C (lighting equipment). Figure 10 shows the results for the full-load and half-load cases at the nominal input voltage.

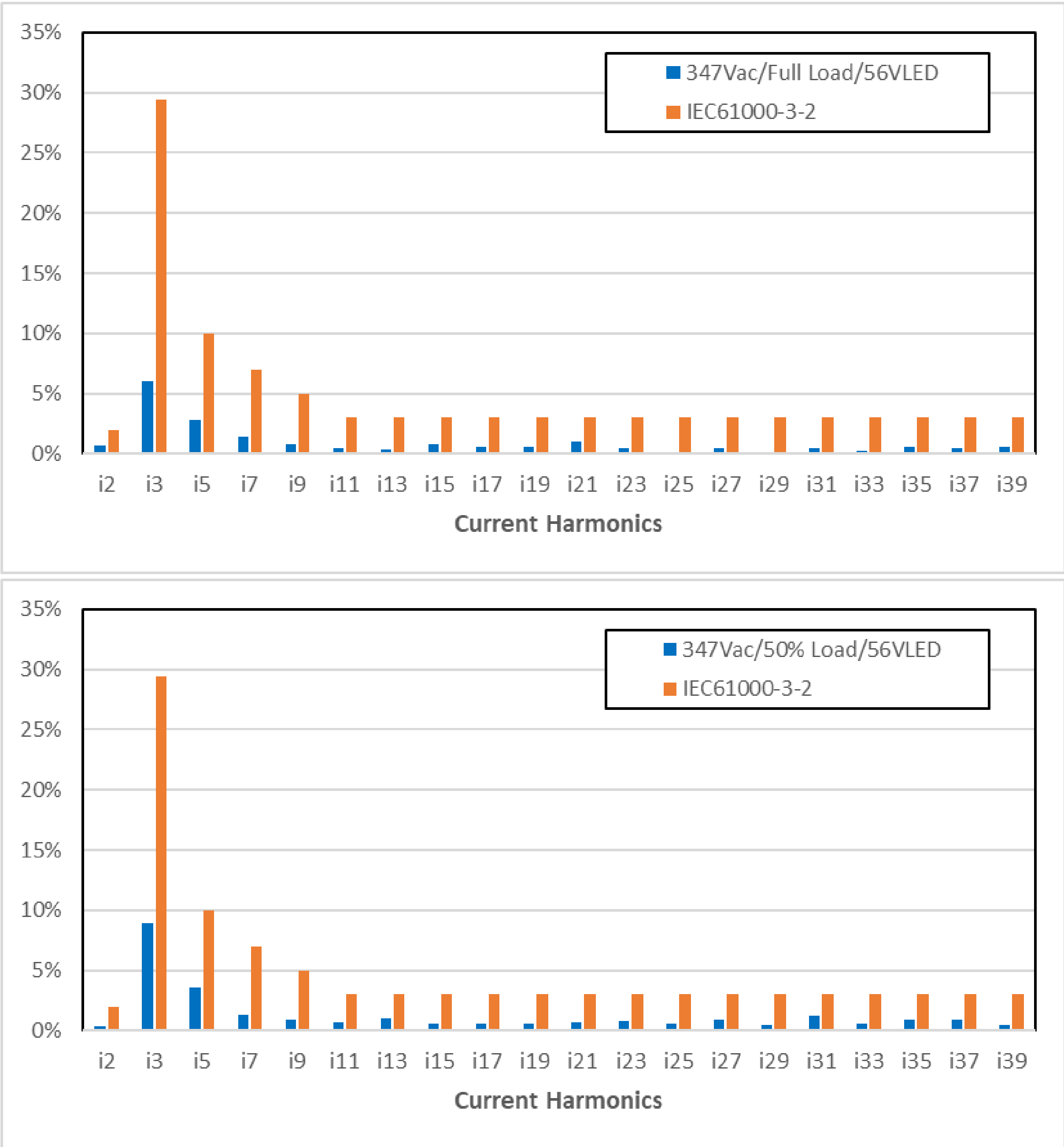


Figure 10 **Input current harmonics according to IEC61000-3-2 Class-C**

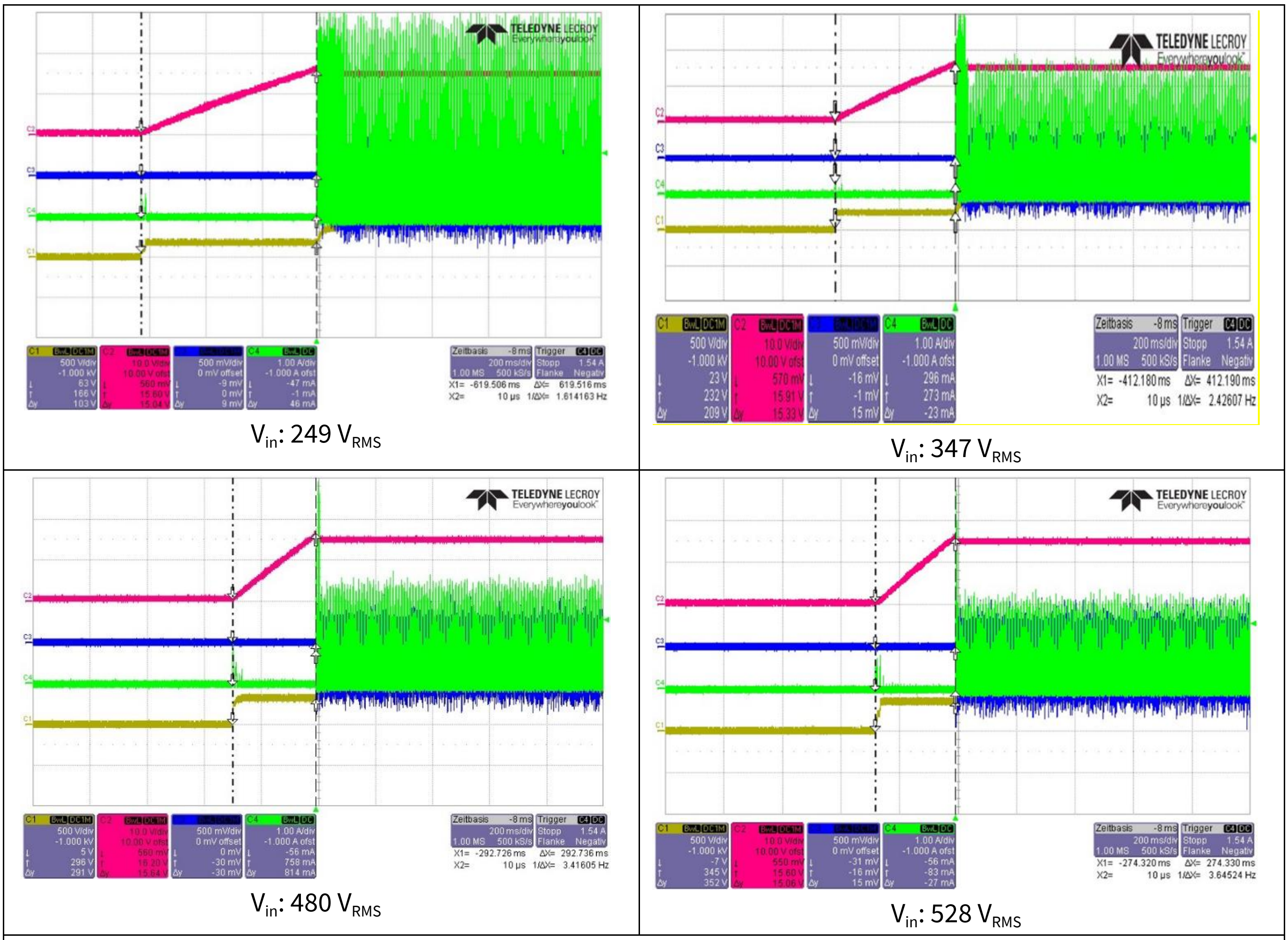
3 Switching waveforms

This section shows switching waveforms for startup and steady-state phases, as well as the protection.

3.1 Start-up

3.1.1 Power factor control

The startup phase is shown in Figure 11 and contains different operating points as well as the measured time-to-light. Please note that time-to-light can be adjusted by compromising the standby power consumption, see [1].

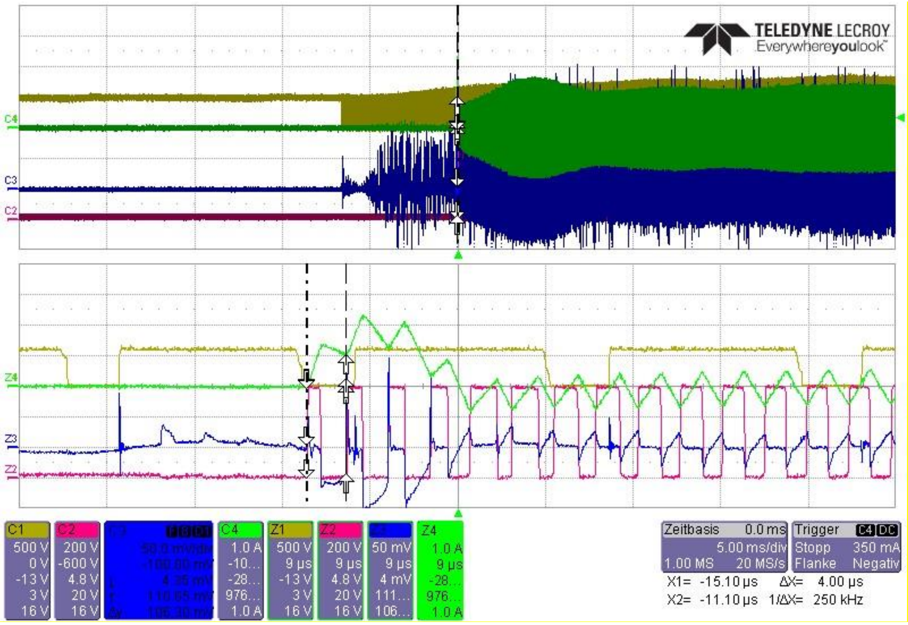


CH1: bus voltage, CH2: VCC voltage, CH3: LCC LSCS pin voltage, CH4: PFC diode current

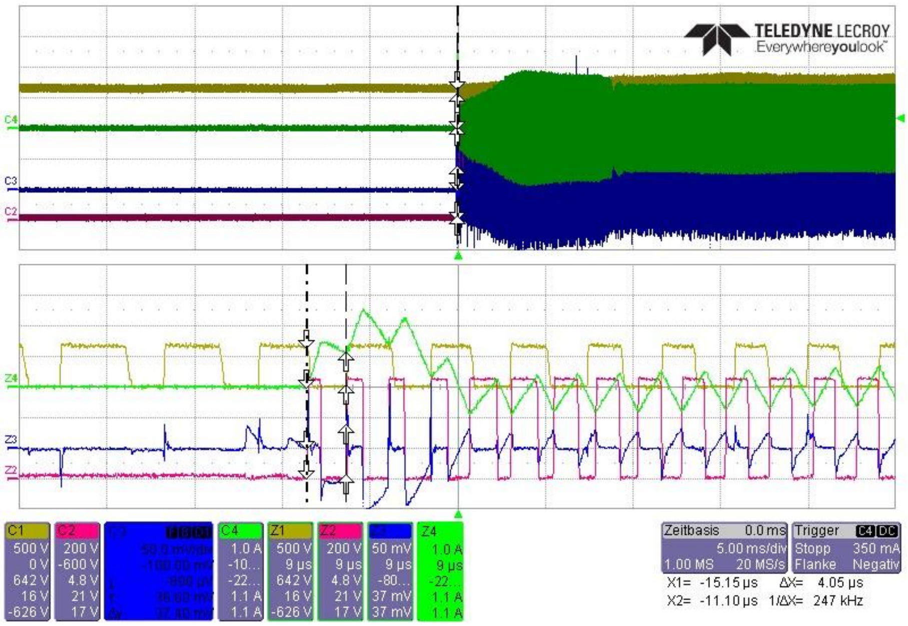
Figure 11 PFC start-up phase at 100% load (56 V_{DC}, 6.25 A) at various input voltages

3.1.2 LCC

The startup phase of the LCC shows the typical behavior with minimized hard-switching events. Those hard-switching events can be observed in Figure 12, which cannot be fully avoided due to the nature of the resonant topology. The phenomenon is further described in our design guide [1]. CoolMOS™ PFD7 is designed to withstand the rigors of hard-switching events, and the integrated fast body-diode ensures reliable performance and protection.



V_{in}: 347 V_{RMS}



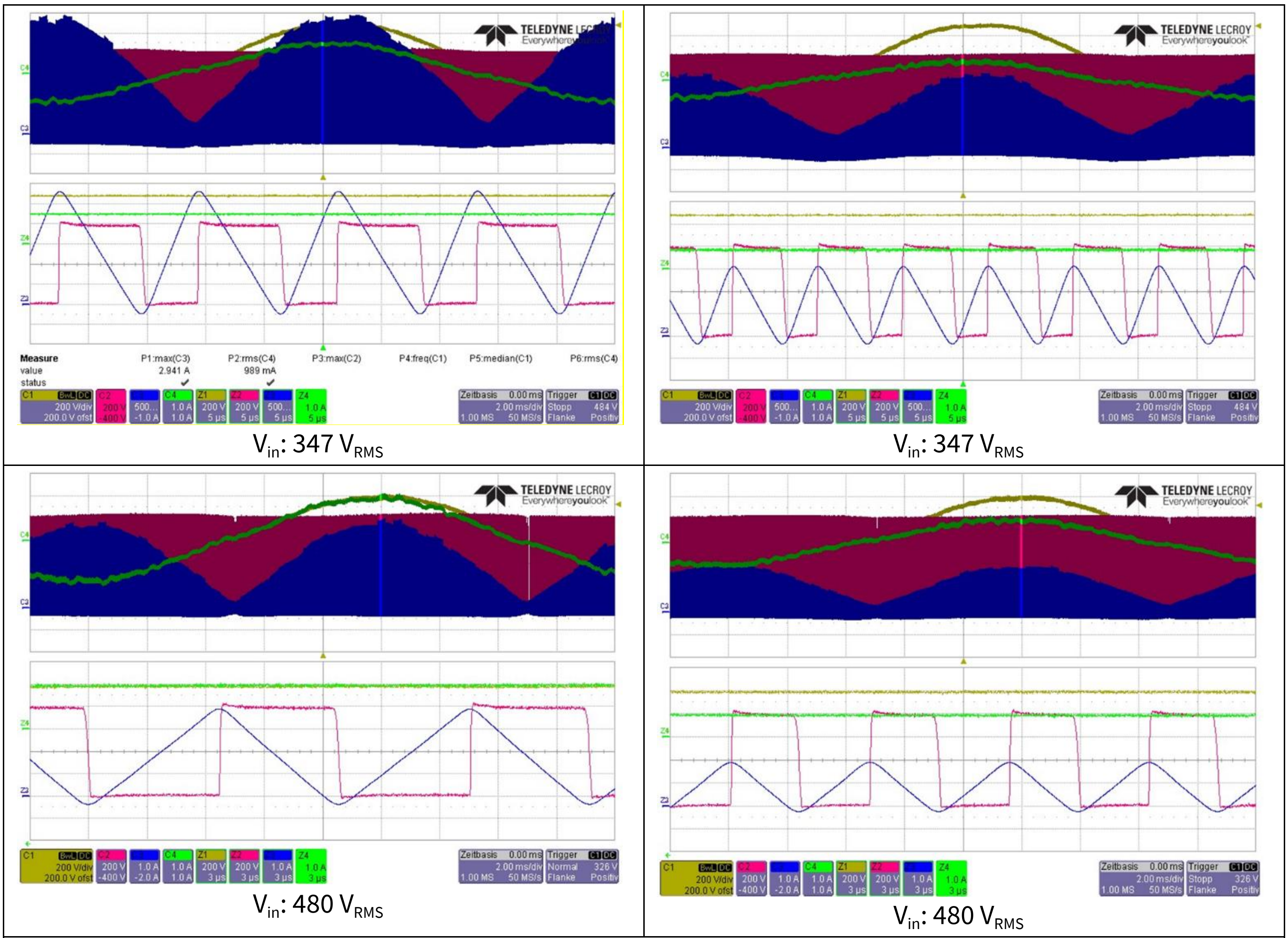
V_{in}: 480 V_{RMS}

CH1: PFC MOSFET VDS, CH2: half-bridge voltage, CH3: LSCS pin voltage, CH4: LCC inductor current

Figure 12 LCC Start-up phase at 100% load (56 VDC, 6.25 A)

3.2 Steady-state

3.2.1 Power factor control



CH1: input Voltage, CH2: PFC MOSFET VDS, CH3: PFCCS pin voltage, CH4: input current

Figure 13 **PFC steady state at 100% load (56 VDC, 6.25 A)**

3.2.2 LCC

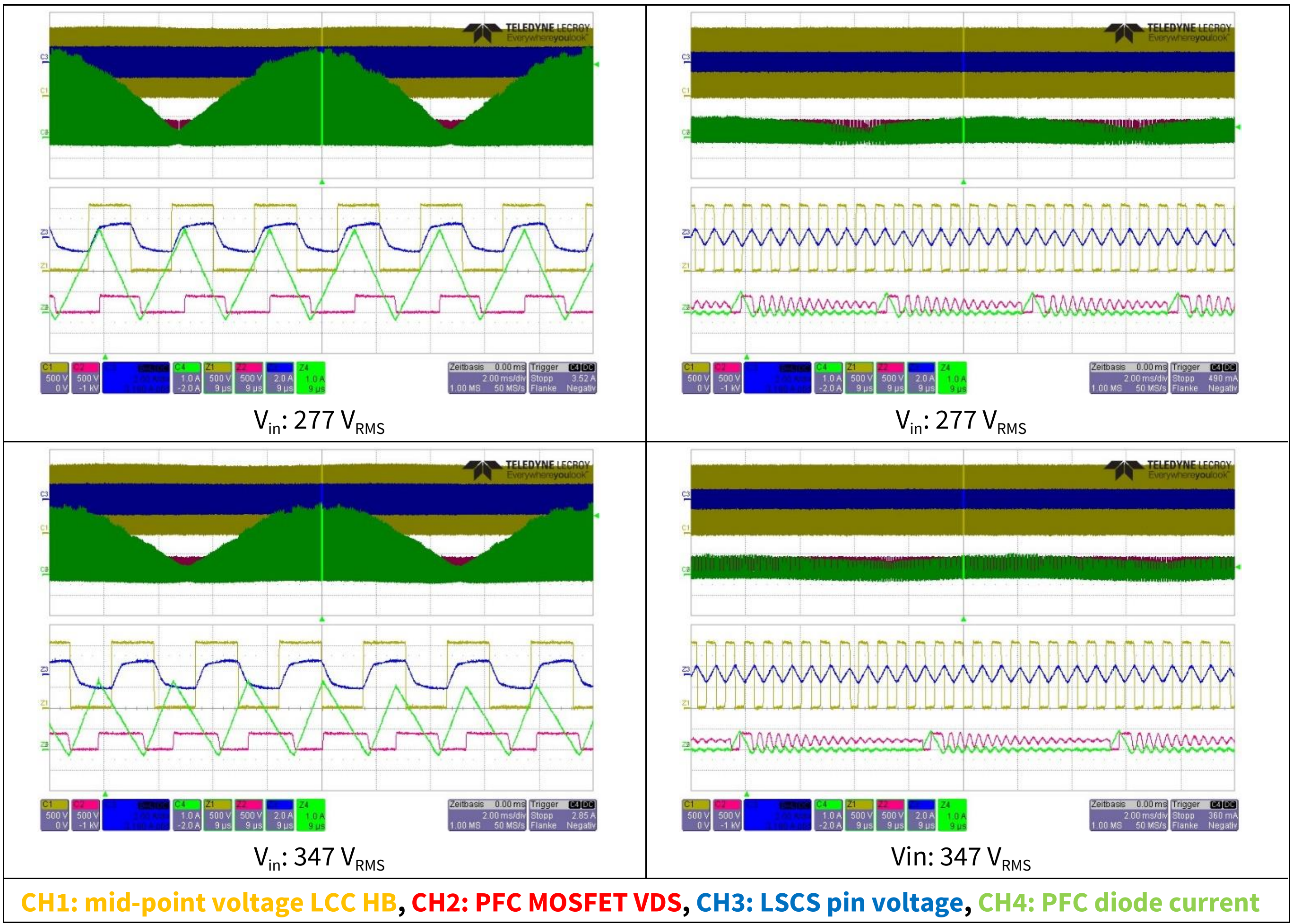
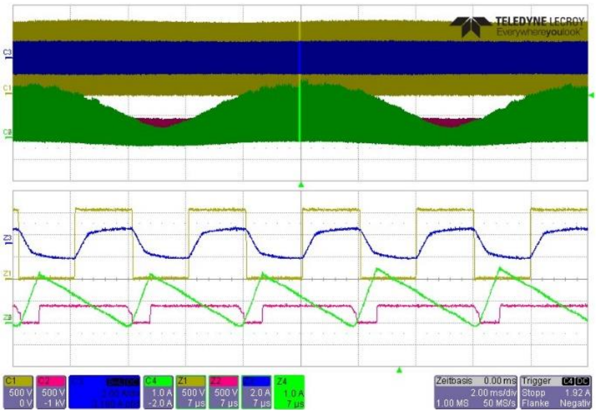
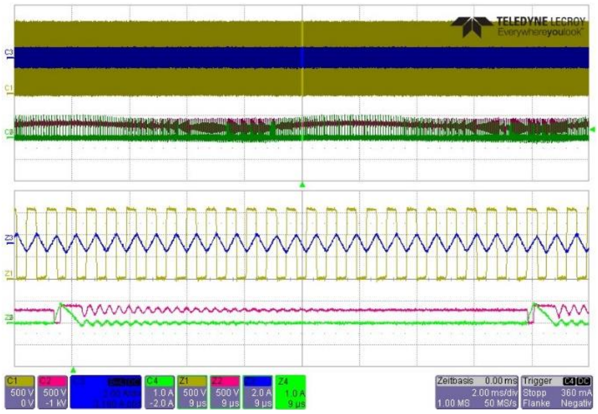
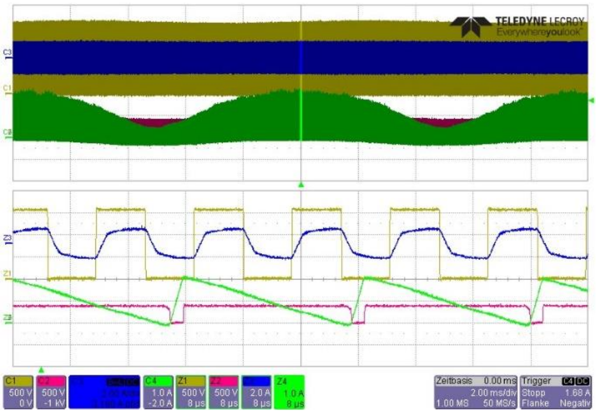
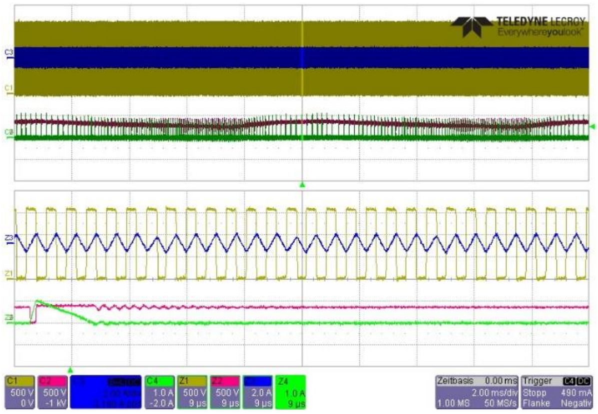


Figure 14 **LCC steady-state waveforms at 100% load (56 VDC, 6.25 A)**

 Vin: 480 V_{RMS}	 Vin: 480 V_{RMS}
 Vin: 528 V_{RMS}	 Vin: 528 V_{RMS}

CH1: mid-point voltage LCC HB, **CH2: PFC MOSFET VDS**, **CH3: LCC choke current**, **CH4: PFC choke current**

Figure 15 LCC steady state at 100% load (56 VDC, 6.25 A) (continued)

3.3 Thermal evaluation

The temperature profile of the board with both devices is given below. The measurements were carried out under the worst-case condition of 249 V AC/50 Hz input with 56 V LED at full-load (6.25 A) and an ambient temperature of 26°C. All critical components are provided with sufficient margins and are well within the safe operation area.

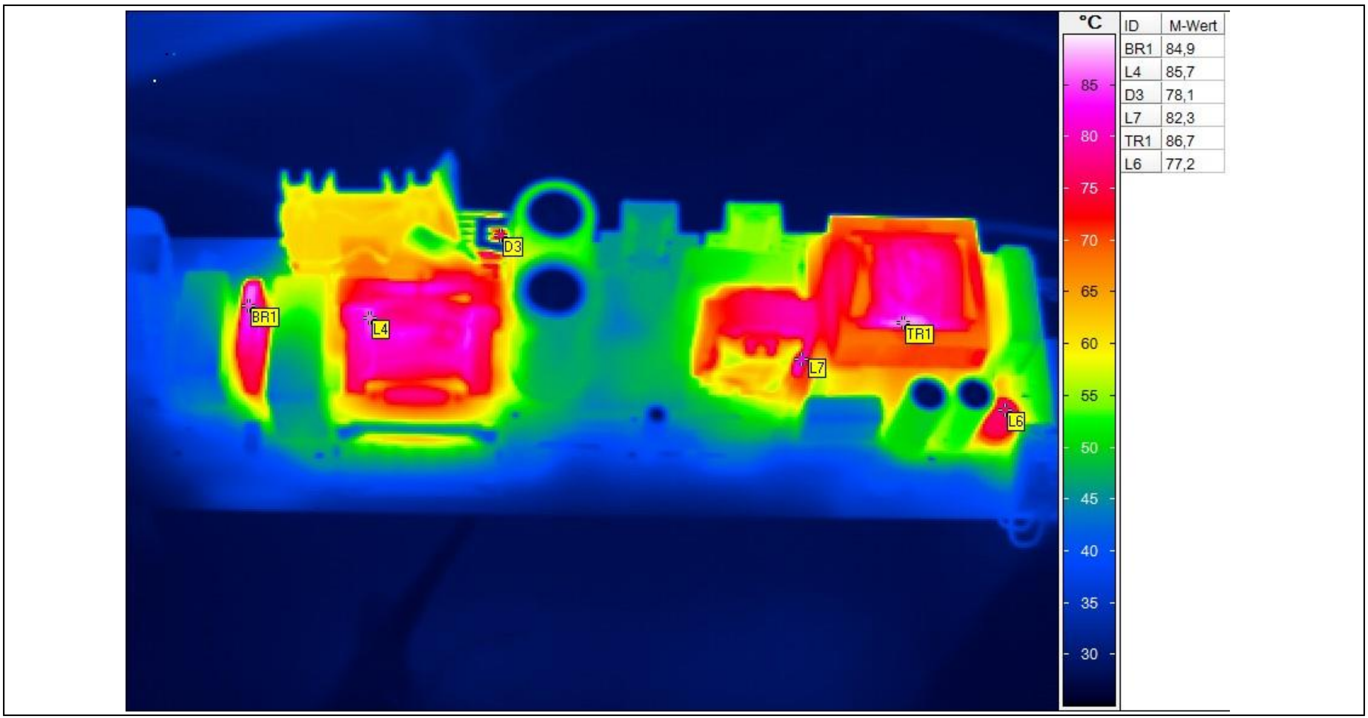


Figure 16 Thermal screening, top-side – full load at $V_{in,min}$

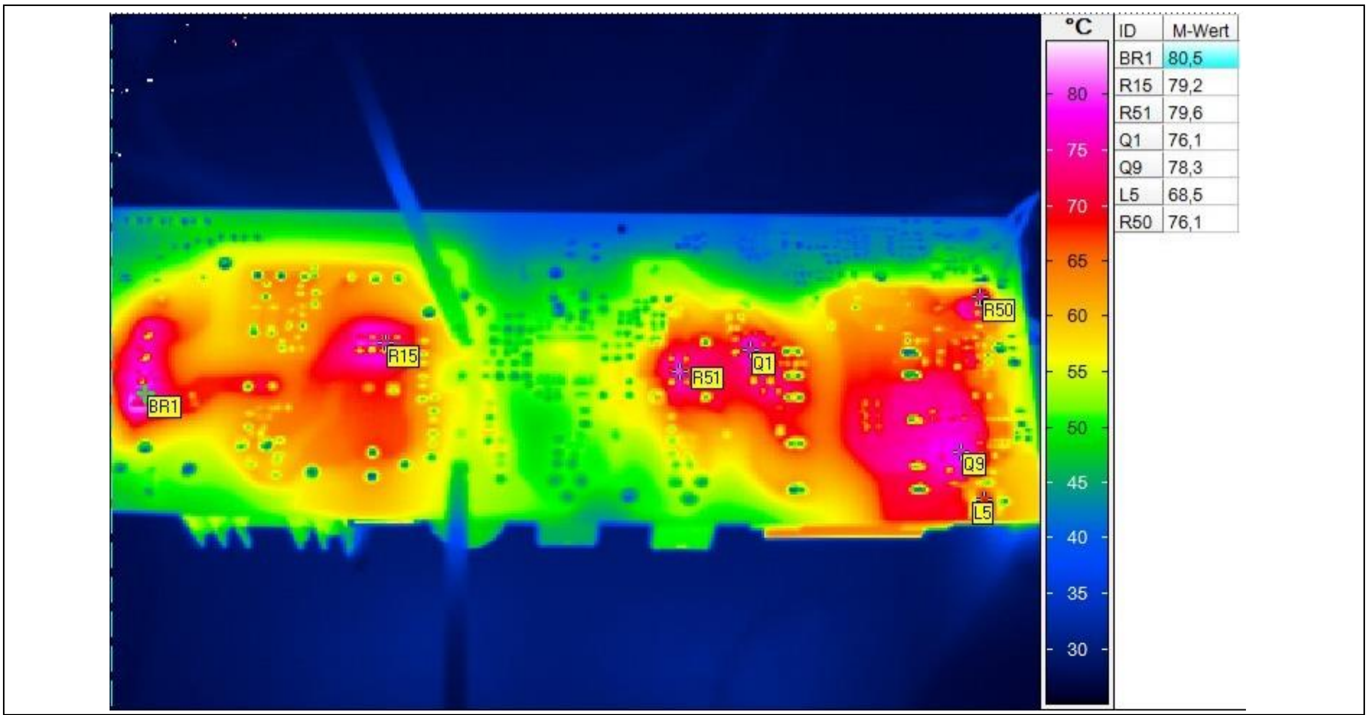


Figure 17 Thermal screening, bottom-side – full load at $V_{in,min}$

3.4 Conducted EMI

Finally, the conducted electromagnetic emissions are measured by a line-impedance stabilization network (LISN) setup on phase L, and the results are compared to the EN 55015 standard, which applies to lighting loads. The measurements were performed at full load (56 V_{DC}, 6.25 A) and shows sufficient margin to the limits.

The first trace is the quasi-peak measurement while the second is the average. Results are presented in Figure 18 and Figure 19.

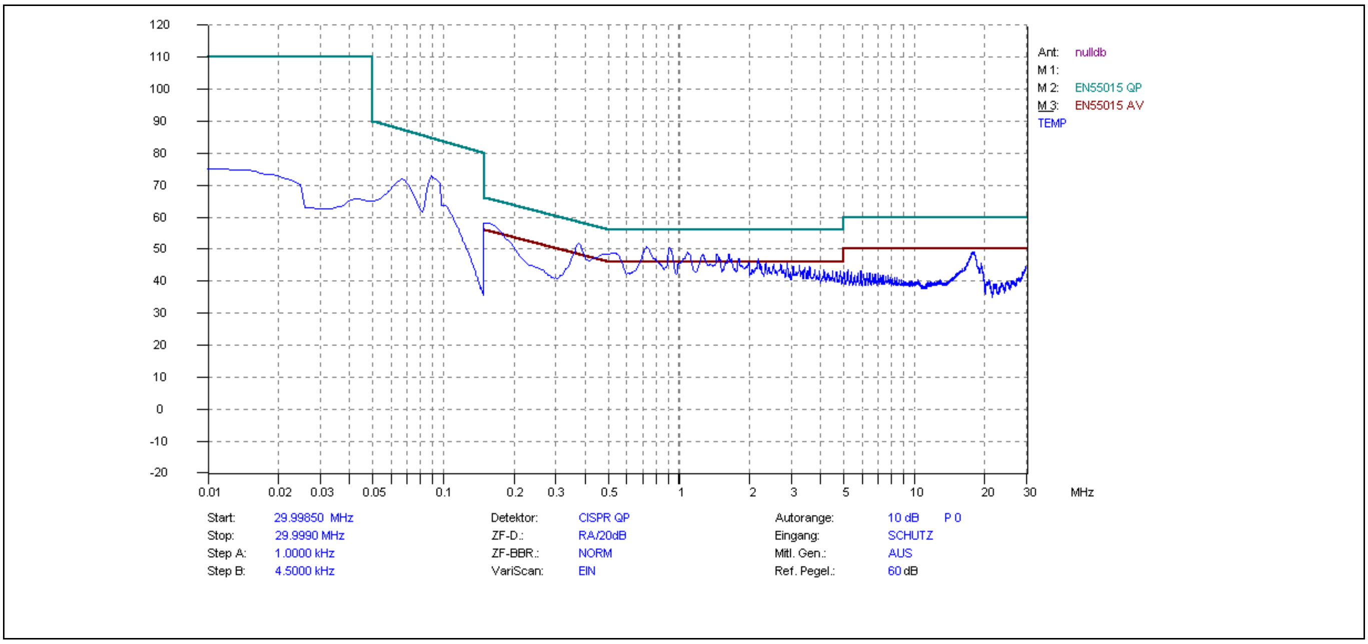


Figure 18 Quasi-peak measurement according to EN55015

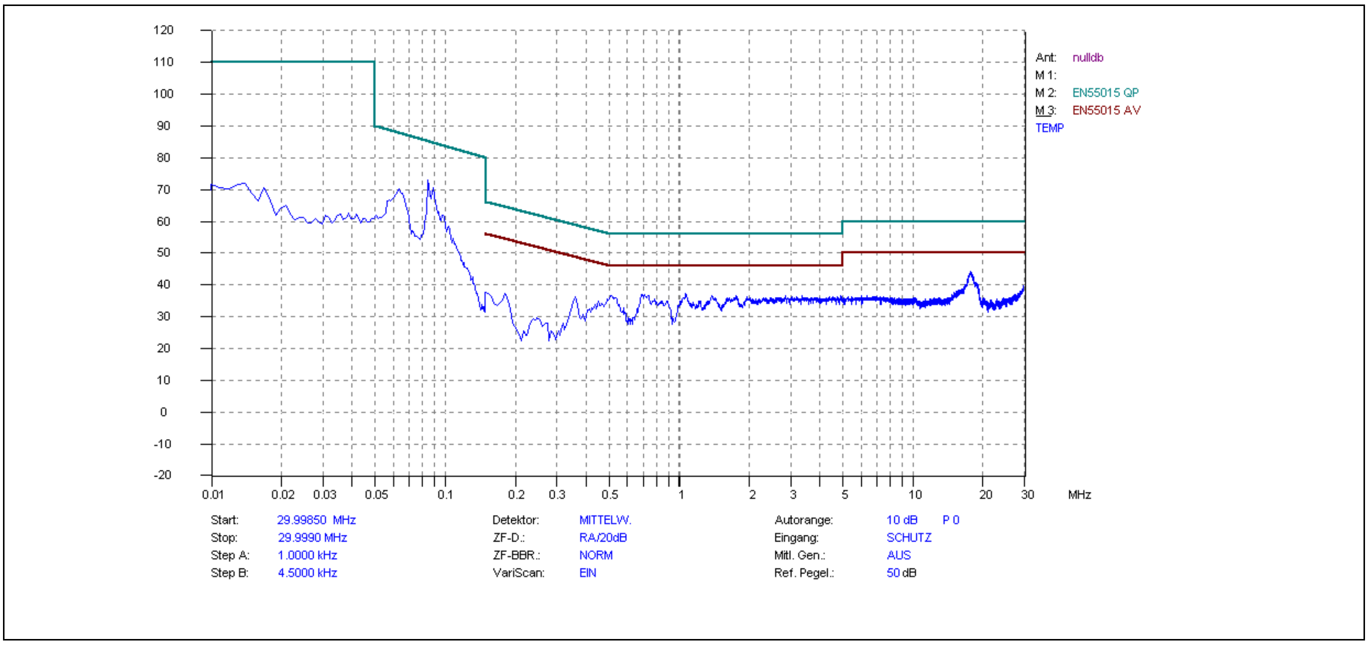


Figure 19 Average measurement according to EN55015

4 Tank design with LCC Design Tool

The tank design for the LCC utilizes the Infineon LCC Design Tool (V 1.0).

This tool is created for engineers to rapidly optimize their resonant tank parameters (series inductance L_S, series capacitance CS, parallel resonant capacitor CP, and transformer turns-ratio nTR) with the given input/output electrical specifications.

The specification inputs for the LCC Design Tool (see Figure 20) include various parameters related to the input DC voltage, output voltage range, power, frequency, and the forward voltage of the output rectifier. To provide the correct values for these inputs, here are the general guidelines for each parameter:

1. **Average bus voltage (V)**: This is the average voltage supplied to the converter. Typically, this value should be based on the input-power source specifications and PFC design. The bus voltage should at least be as high as the peak value of the input voltage. For the converter corresponding to this document, 800 V is selected.
2. **Maximum output voltage (V)**: This is the highest voltage that the converter is expected to output. Ensure that this value matches the requirements of your load or application. For the converter corresponding to this document, a 56 V LED load is the maximum.
3. **Minimum output voltage (V)**: This is the lowest voltage that the converter should output. This value should also be based on the requirements of your load or application. For the LED load corresponding to this document, it is set to 35 V.
4. **Maximum output power (W)**: This is the maximum power that the converter needs to deliver. Ensure that this value is adequate for your load and takes losses in consideration. For instance, a value could be 365 W for the desired output of 350 W.
5. **Minimum output power (W)**: This is the minimum power that the converter needs to handle. Depending on the application's requirements, this is set to 1 percent for the minimum output voltage.
6. **Minimum frequency (kHz)**: This is the lowest switching frequency of the converter. This value can be chosen based on the design requirements to ensure efficiency and performance. For example, you might set this to 80 kHz.
7. **Maximum frequency (kHz)**: This is the highest switching frequency of the converter. This value should be chosen to ensure that the converter operates within safe limits while maintaining efficiency. For example, you might set this to 380 kHz. This is up to the design engineer. Selecting a wider frequency range will lead to an overall better resonant tank behavior in terms of (reactive) current, but higher stresses on the semiconductor devices and passive components.
8. **Forward voltage of the output rectifier (diode or MOSFET) at max. output power (V)**: This is the forward voltage drop of the rectifying component at maximum output power. This value depends on the rectifier used in the design. For instance, a drop of 0.5 V is kept here.

To insert the values correctly, you should:

1. Determine the specific requirements of your application (e.g., voltage and power specifications).
2. Consult the datasheets and specifications of the components you are using.
3. Ensure that the selected values fall within the safe operating range for the components and application.

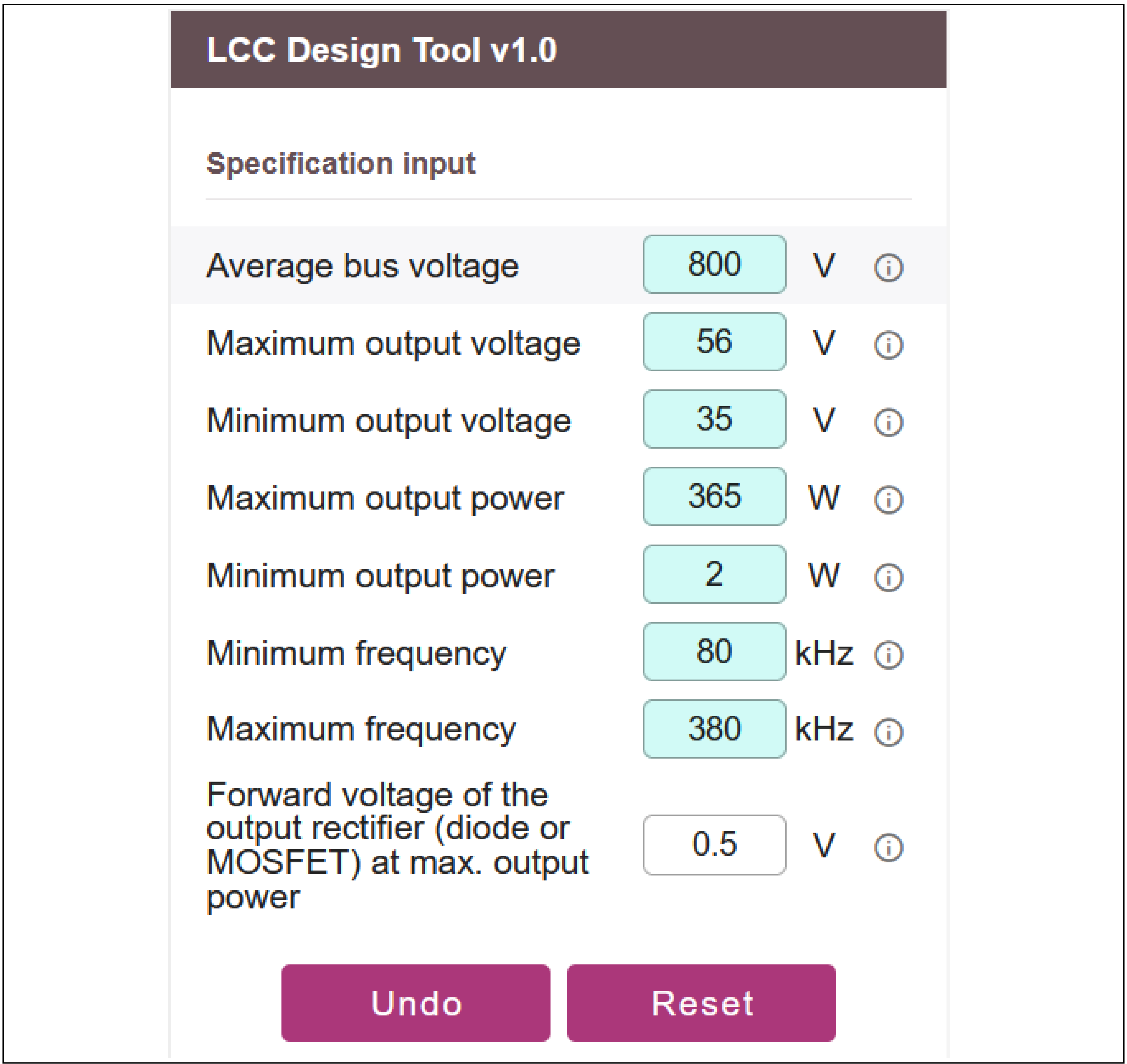


Figure 20 **LCC Design Tool: Input specifications**

On the second page the LCC Design Tool displays the generated design charts (see Figure 21) based on the inputs provided on the first page:

4. Transformer ratio: A transformer ratio must be determined using the following equation:

$$N = \frac{V_{in}}{V_{out,max}}$$

Equation 1 Transformer turns ratio

Use Equation 1 to operate the LCC converter in the buck mode range. The design tool will also provide a recommendation following the rule above. It is possible to change this value as wished by the design engineer. In the reference design, N=76/12=6.33 is selected.

5. Display scale:
   - Ranges of capacitance ratio Ac and series inductance Ls (including leakage inductance of the transformer) must be selected.
   - Discrete values of series capacitance Cs must be written as Cs steps.
   - Click **Get results** to display the charts on the right-half of the screen.
6. Design charts:
   - The top chart shows the **RMS/AVG ratio** for different values of the design parameter Cs, which is plotted against the capacitance ratio Ac.
   - The bottom chart titled **Ls for max. frequency and min. frequency requirement** displays two types of curves. One curve represents the Ls that achieves the maximum power at the specified maximum output voltage $V_{Omax.Pmax}$ and minimum frequency $f_{Pmax.Omax}$, and the other curve is for zero power at the minimum output voltage V_{Omin} and virtual maximum frequency $f_{max.0W}$. The crossing points of the two curves of the same color represent the Ls, CS, and AC values that are able to fulfill both the maximum-power and zero-power requirements [1].

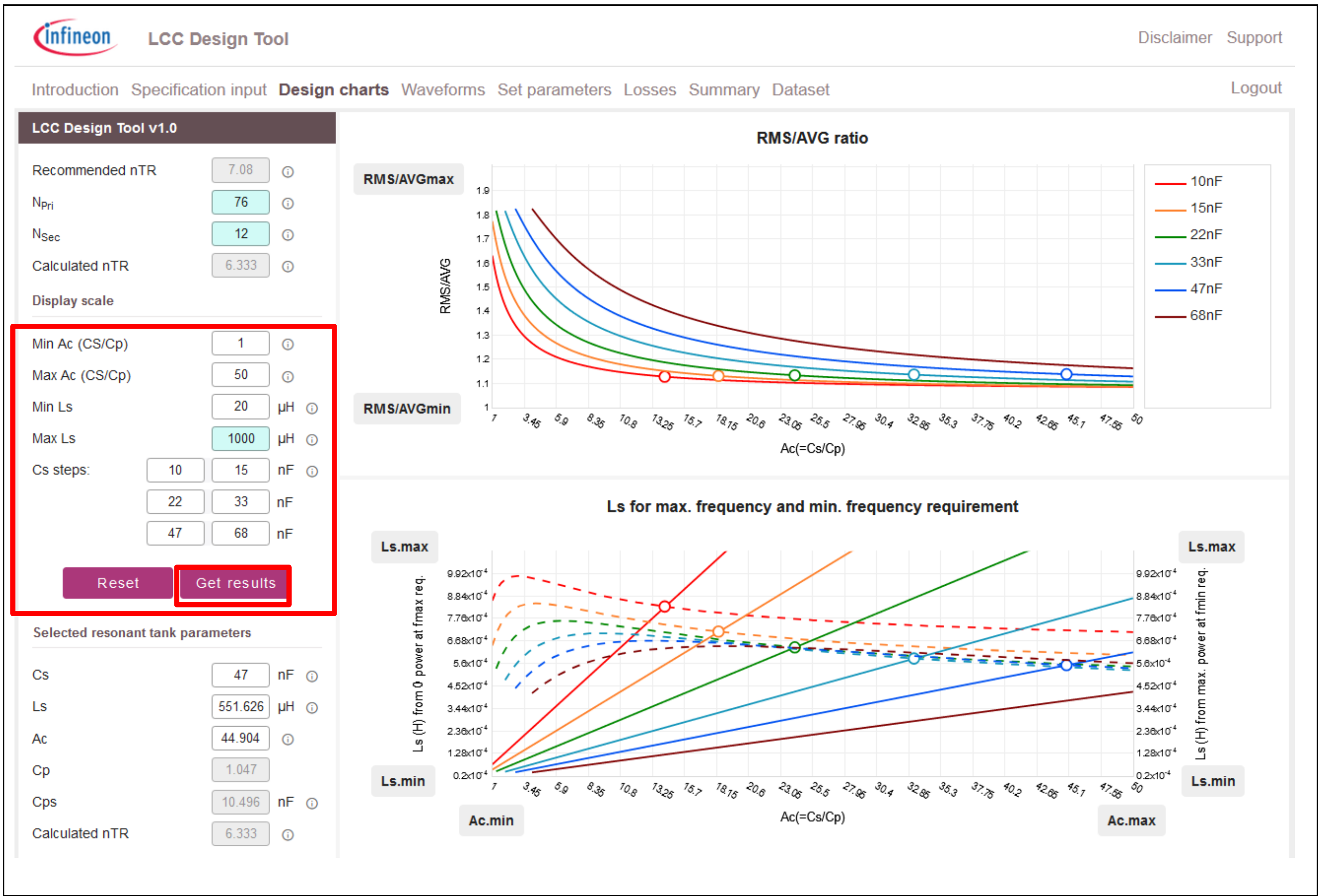


Figure 21 LCC Design Tool: Providing the tank design specifications

7. Selected tank parameters:
   - The box in the bottom chart highlights a specific design point, chosen for its optimal performance while meeting the design criteria. Clicking on the point in the graphs transfers the values to the window **Selected resonant tank parameters**.
   - Ensure that the parasitic capacitance of the transformer is considered in addition to the used Cps capacitor. Especially for high-voltage applications, the transformer capacitance should not be neglected.
   - Small changes for those values can be made here (adjustments due to real passive components), as shown in Figure 22.

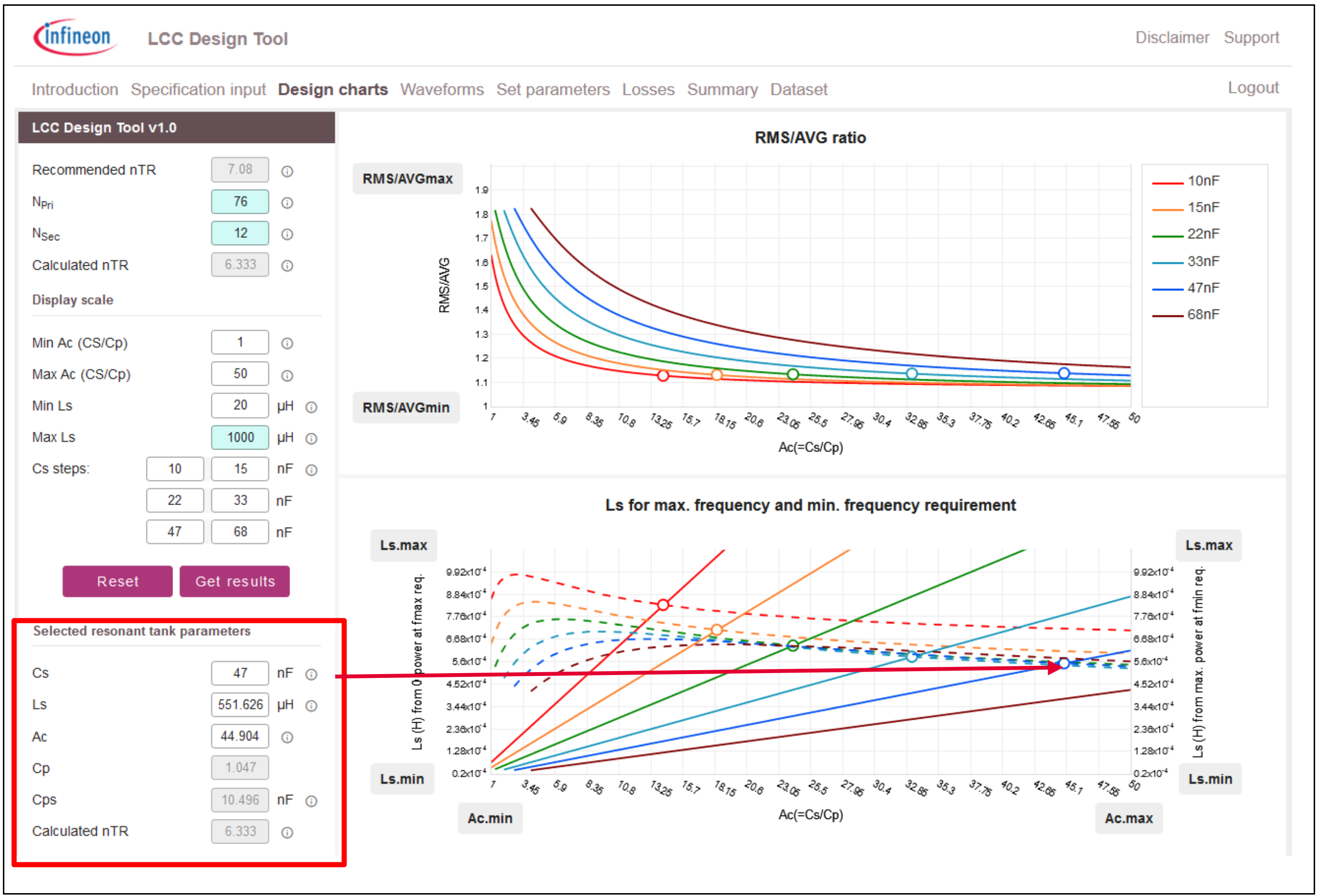


Figure 22 LCC Design Tool: Fine-tuning the tank design specifications

On the next page, **Waveforms** (see Figure 23), the current waveforms for different components of the LCC converter at maximum power and output voltage are displayed. Here is an overview of each waveform presented:

1. **LCC transformer input current waveform (Top):** This graph shows the input current through the transformer over time. The waveform is ideally trapezoidal without a further rise at the maximum point, if the design is correct.
2. **Half-bridge MOSFET current waveform (Middle):** This plot illustrates the current through the half-bridge MOSFETs. The waveform helps select an appropriate MOSFET.
3. **Output-switch current waveform (Bottom):** This chart presents the current through the output switch, which is a part of the output rectification. The waveform helps select an appropriate MOSFET or diode.

Overall, these waveforms illustrated in Figure 23 provide insights into the current stress of the LCC converter's active and passive components for the maximum-power condition. They are crucial for analyzing the efficiency and thermal management of the semiconductor switches. This can also help in designing the resonant tank components (transformer and resonant choke) or semiconductor devices (MOSFETs and diodes).

Alternatively, the **Losses** page can be used for an approximate MOSFET/diode design process. It is important to notice that solely conduction losses based on one given $R_{DS(on)}$ (for MOSFETs) or V_F and r_D (for diodes) are calculated. The temperature increase is calculated based on a given case-temperature and the thermal resistance can deviate significantly from the actual temperatures of the chips.

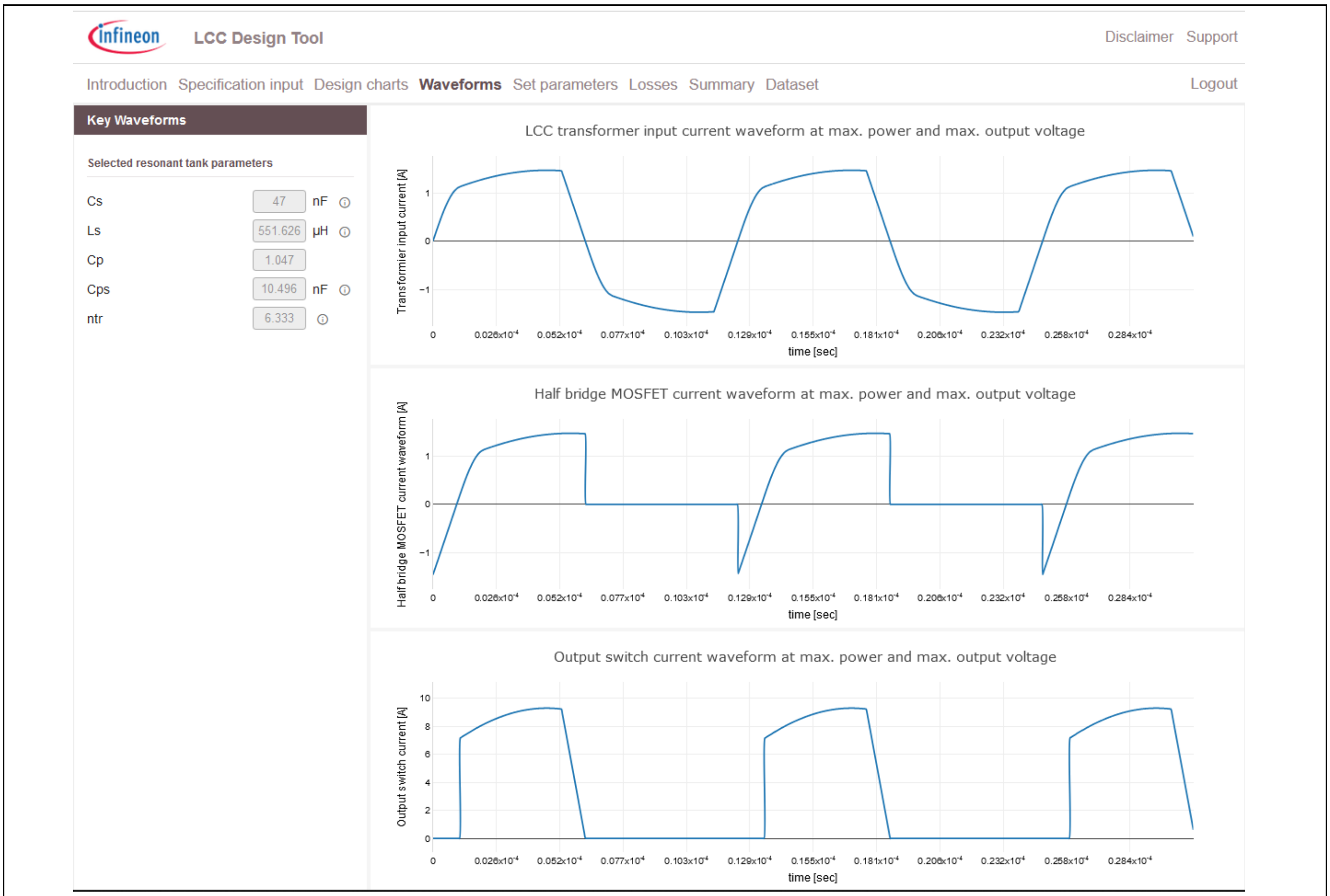


Figure 23 **LCC Design Tool: Waveforms**

On the **Set parameters** section (Figure 24) of the LCC Design Tool, the configuration for setting operating frequencies and corresponding resistors' network values for the frequency control of the ICL5102HV pins BM and RF is featured. The key areas displayed are:

1. Desired operating frequency:
   - These settings are used to configure the desired range and startup conditions for the converter's operation. The frequencies define the switching behavior of the power electronics, which in turn impact the efficiency and performance.
   - **fmin** and **fmax:** These are carried forward from the "Specification Input" to the "Set Parameters" page.
   - **fstartup**: Additionally, a startup frequency must be selected. It is recommended to choose a startup frequency below the maximum frequency to avoid/minimize the number of hard switchings for the MOSFETs during startup.
   - **VCE,sat**: Saturation voltage of the opto-coupler. It is kept at 0.25 V for the converter corresponding to this document.
   - **RBM_DA/RBM**: Ratio of the resistor values R_{BM_DA} and R_{BM}. This ratio should always be greater than 3/8 to avoid entering the burst mode of the ICL5102HV. It is kept at 3/7 (default value) for the converter corresponding to this document.
2. Calculated frequency set resistor values:
   - These calculated values represent the resistor settings required to achieve the specified operating frequencies.
3. Selected frequency set resistor values:
   - This panel shows the selected resistor values that have been input or adjusted. These resistors are a part of the frequency control network.
4. Calculated operating frequency:
   - This section displays the resulting operating frequencies based on the selected resistor values. These frequencies are critical for ensuring the proper function and control of the LCC converter.

This interface allows the designer to set and fine-tune the operating frequencies of the LCC converter by adjusting the corresponding resistors.

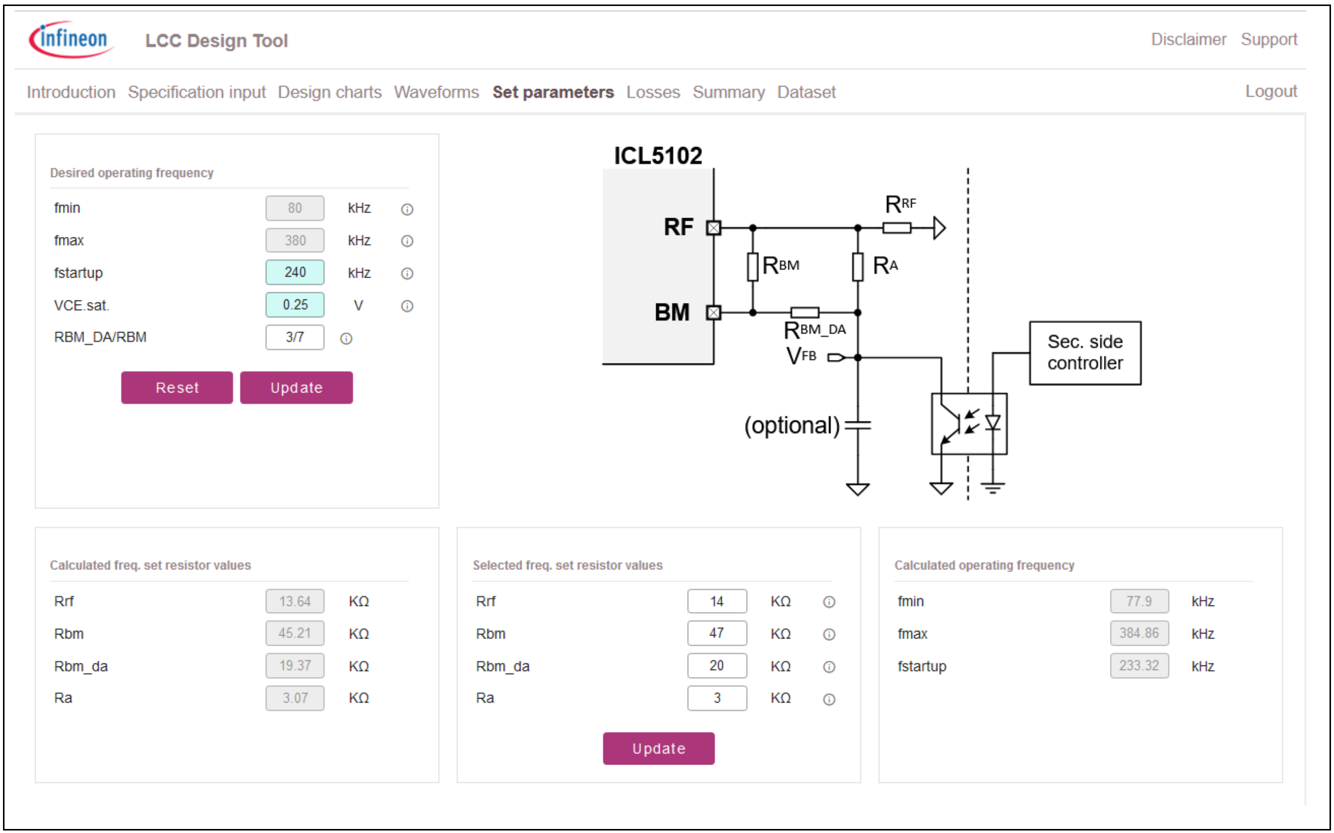


Figure 24 LCC Design Tool: Setting the operating frequency parameters

Attention: ***This LCC Design Tool is given as a hint for the implementation of the product only and shall in no event be regarded as a description or warranty of a certain functionality, accuracy, condition, or quality of the product and design. Before implementation of the design tool, the user of this tool must verify any function and other technical information given herein in the real application. Infineon Technologies hereby disclaims any and all warranties and liabilities of any kind (including, without limitation, warranties of non-infringement of intellectual property rights of any third party) with respect to any and all information given in this design tool.***

5 Schematic and layout

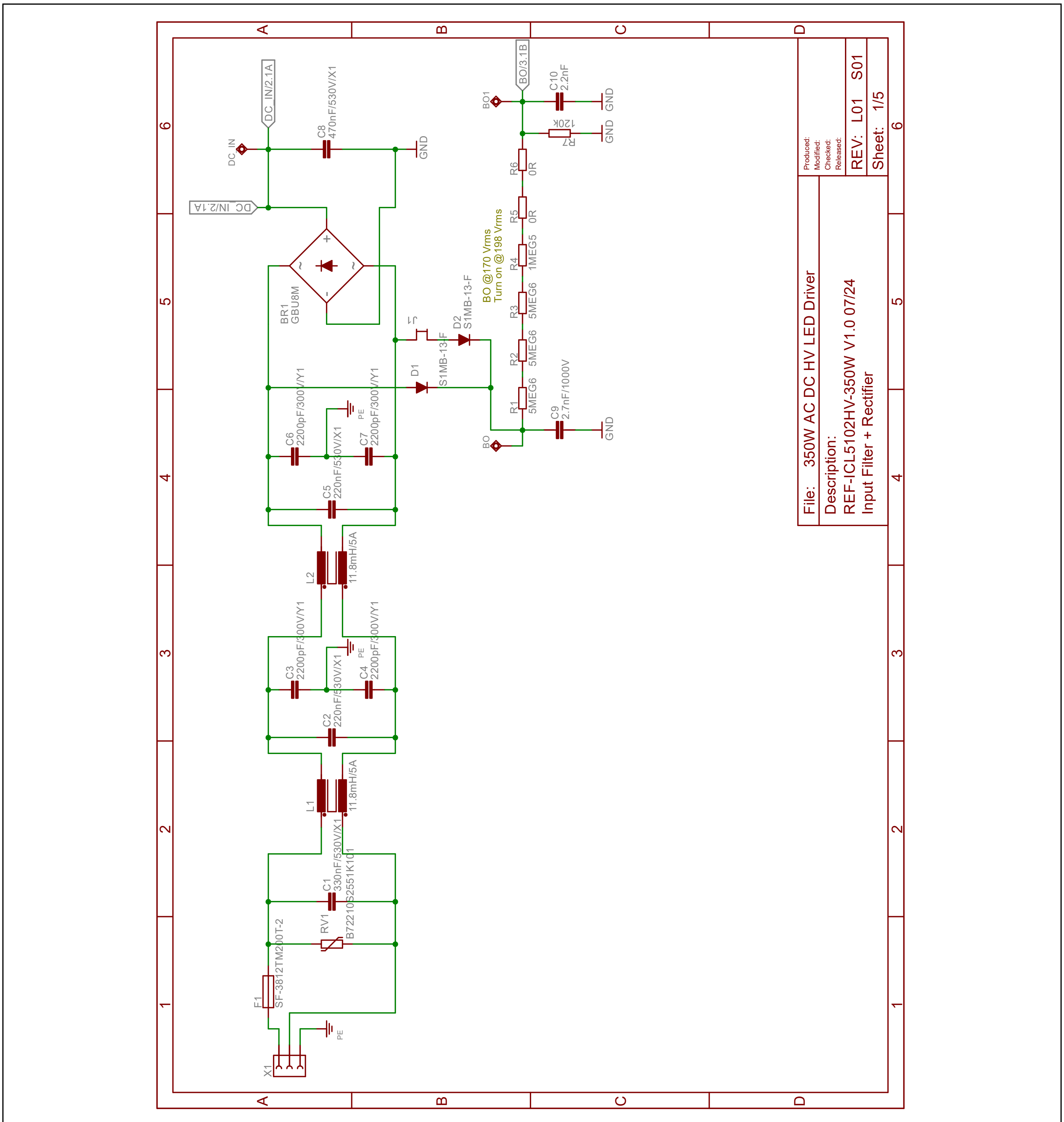


Figure 25 **Schematic of the input filter with rectifier**

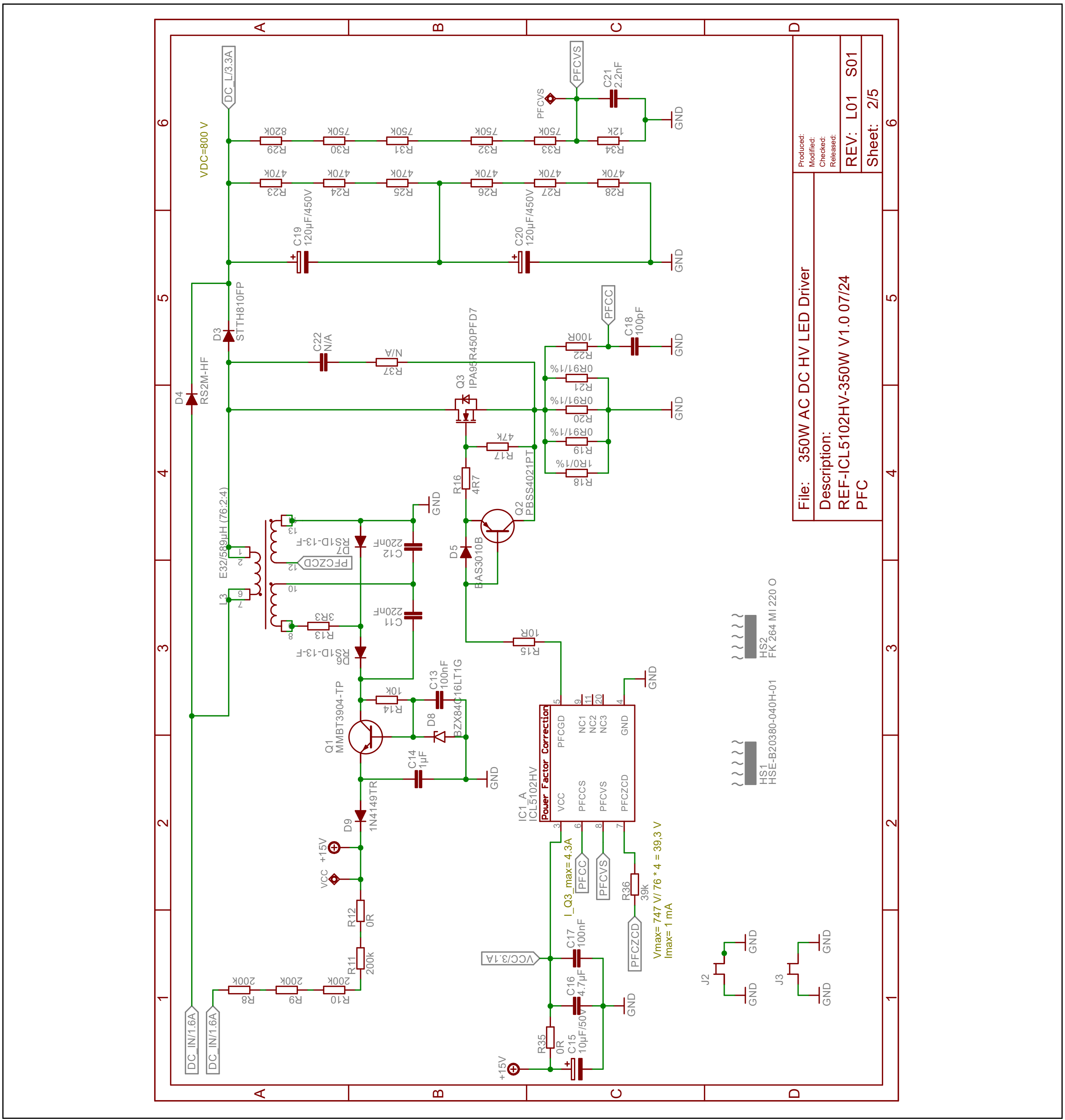


Figure 26 Schematic of the PFC

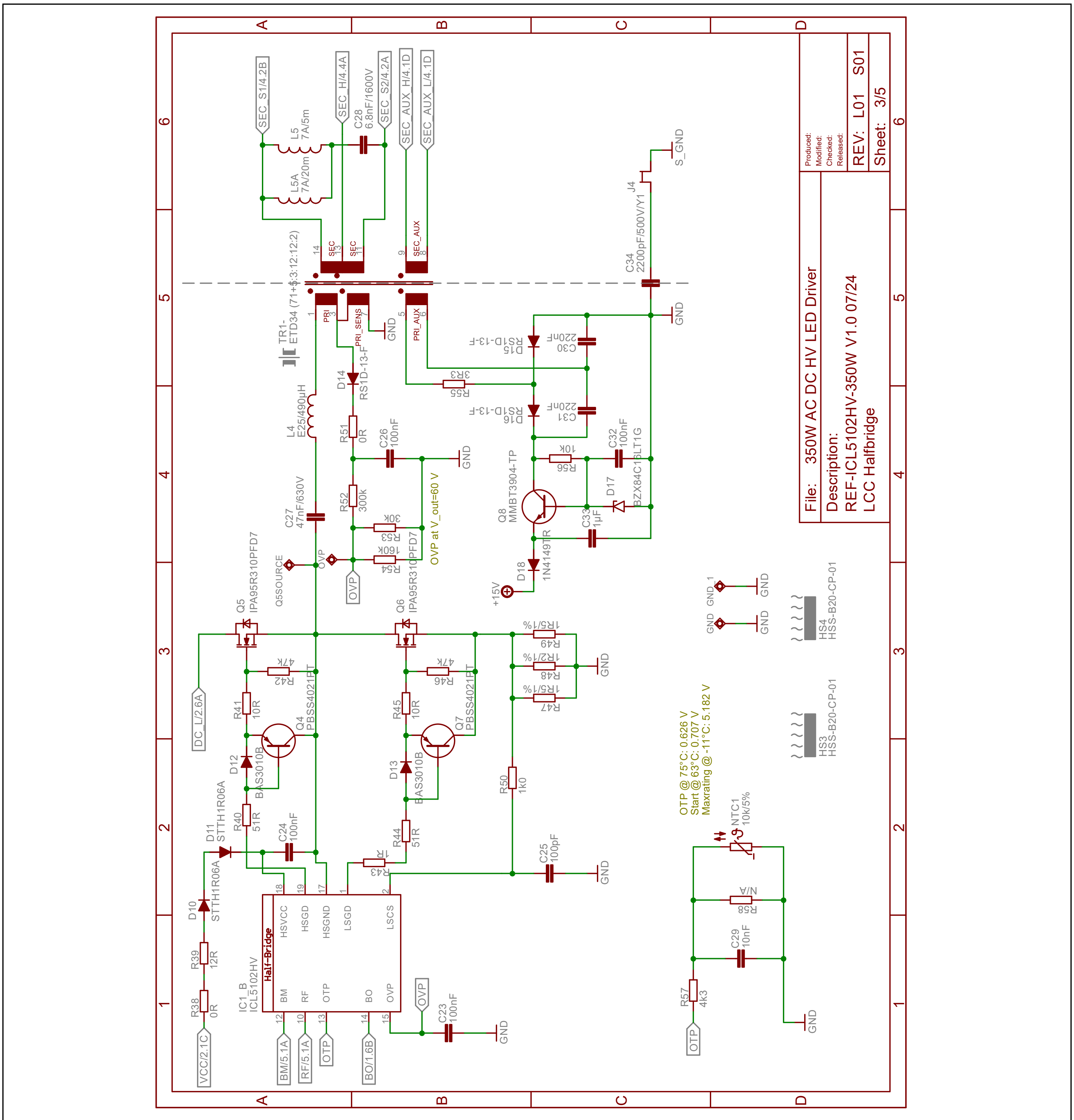


Figure 27 Schematic of the LCC half-bridge

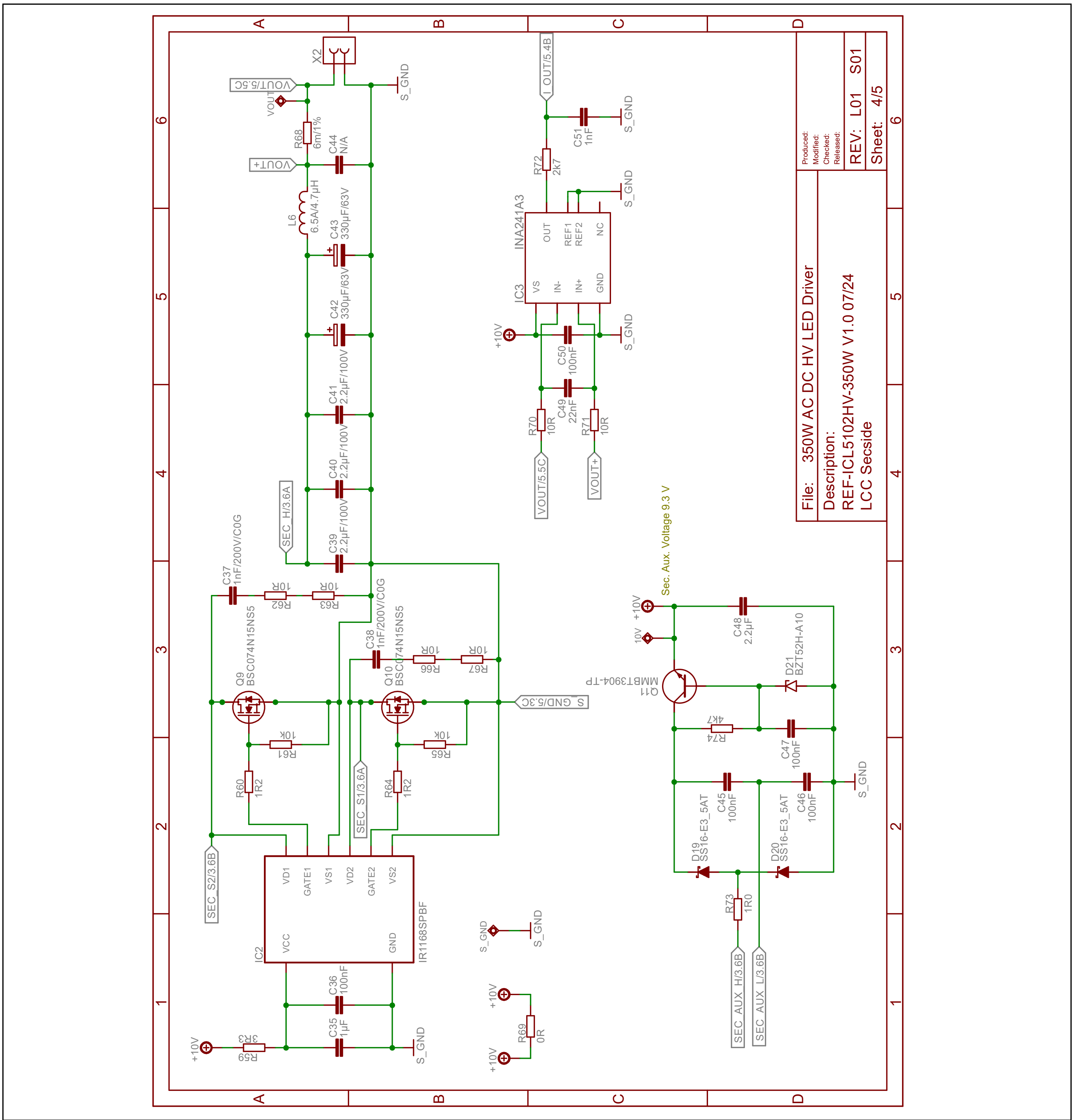


Figure 28 Schematic of the LCC's secondary side

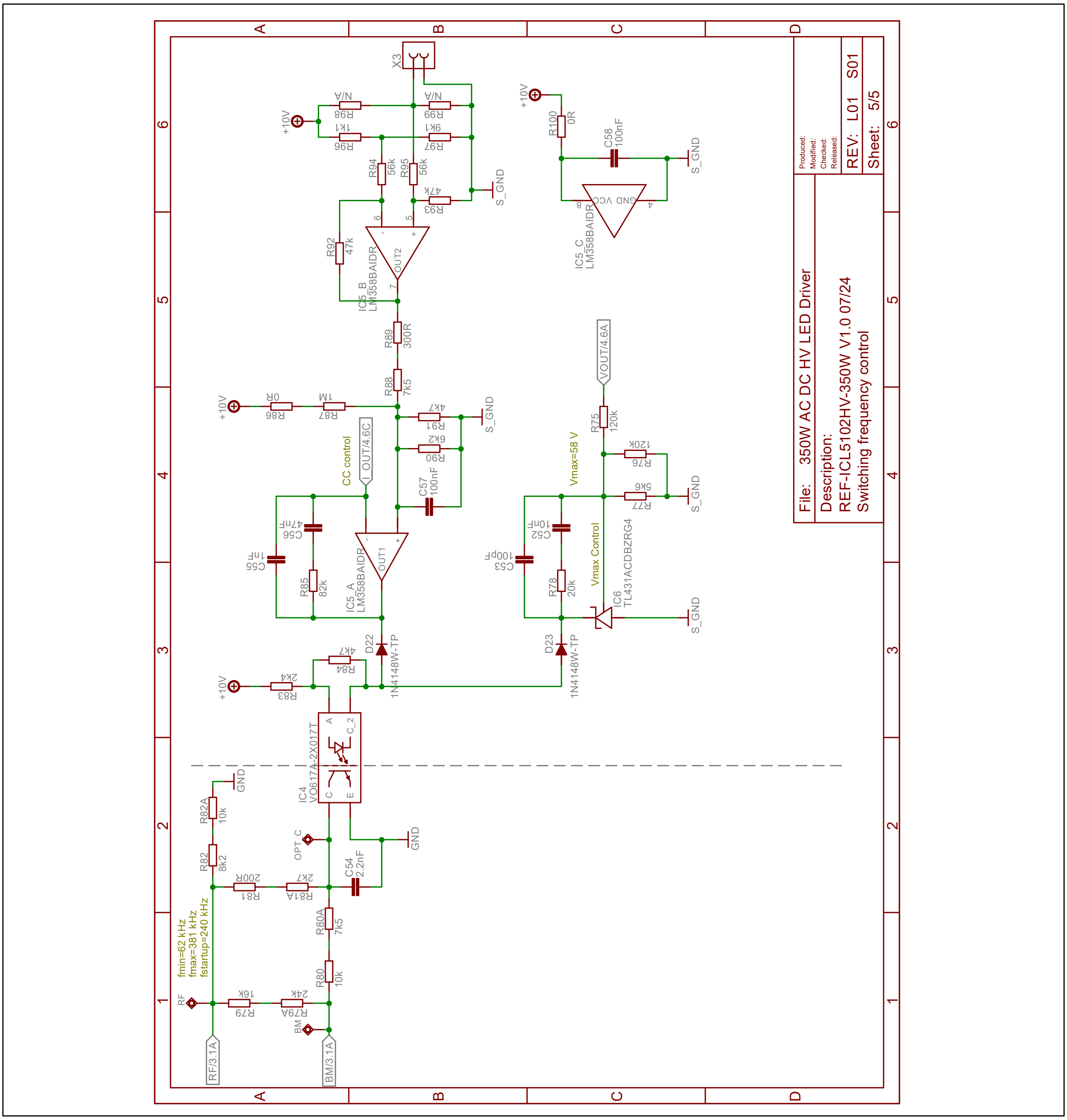


Figure 29 Schematic of the switching frequency control

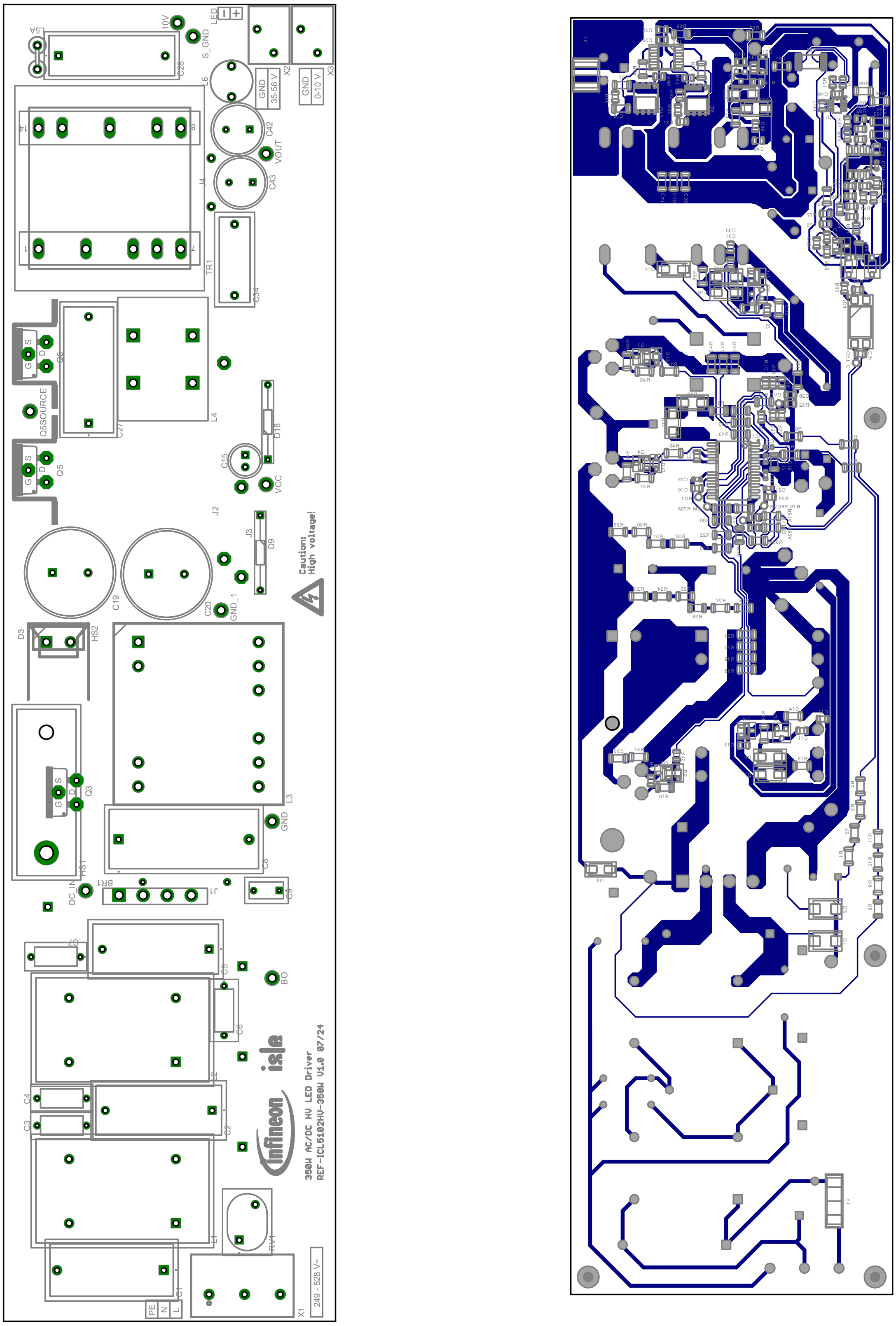


Figure 30 PCB layouts, top-side and bottom-side

6 Bill of materials

Table 5 Bill of materials

Qty	Designator	Description	Manufacturer	Manufacturer's part No.
1	BR1	Diode Rectifier Bridge GBU8M/1 kV	Diotec Semiconductor	GBU8M
1	C1	Capacitor 330 nF/530 V/X1	TDK	B32913A5334M
2	C2, C5	Capacitor 220 nF/530 V/X1	TDK	B32913B5224K
4	C3, C4, C6, C7	Capacitor 2200 pF/300 V/Y1	muRata	DE1E3RA222MJ4BP01F
1	C8	Capacitor 470 nF/530 V/X1	TDK	B32914A5474M000
1	C9	Capacitor 2.7 nF/1 kV/MKK	KEMET	MMK5272J1000J02L4BULK
2	C10, C54	Capacitor 2.2 nF/50 V/X7R/10%	–	C-EU0805
4	C11, C12, C30, C31	Capacitor 220 nF/50 V/X7R/10%	–	C-EU0805
11	C13, C24, C26, C32, C36, C45, C46, C47, C50, C57, C58	Capacitor 100 nF/50 V/X7R/10%	–	C-EU0805
2	C14, C33	Capacitor 1 µF/50 V/X7R/10%	–	C-EU1206
1	C15	Capacitor 10 µF/50 V/Radial/20%	Würth Elektronik	860020672010
1	C16	Capacitor 4.7 µF/50 V/X7R/10%	–	C-EU1206
2	C17, C23	Capacitor 100 nF/50 V/X7R/10%	–	C-EU0603
2	C18, C25	Capacitor 100 pF/50 V/X7R/10%	–	C-EU0603
2	C19, C20	Capacitor 120 µF/450 V/Radial/20%	United Chemi-Con	EKXL451ELL121MM35S
1	C21	Capacitor 2.2 nF/50 V/X7R/10%	–	C-EU0603
1	C22	N/A	–	C-EU1206
1	C27	Capacitor 47 nF/630 V/FKP1/5%	WIMA	FKP1J024705H00JSC9
1	C28	Capacitor 6.8 nF/1600 V/FKP1/5%	WIMA	FKP1T016805F00JSSD
2	C29, C52	Capacitor 10 nF/50 V/X7R/10%	–	C-EU0805
1	C34	Capacitor 2200 pF/500 V/Y1	KEMET	P295BJ222M500A
1	C35	Capacitor 1 µF/50 V/X7R/10%	–	C-EU0805
1	C37	Capacitor 1 nF/200 V/C0G/5%	–	C-EU0805
1	C38	Capacitor 1 nF/200 V/C0G/5%	-	C-EU1206
3	C39, C40, C41	Capacitor 2.2 µF/100 V/X7R/10%	–	C-EU1206
2	C42, C43	Capacitor 330 µF/63 V/Radial/20%	United Chemi-Con	EKZN630ELL331MJ25S
1	C44	N/A	–	C-EU1206

Qty	Designator	Description	Manufacturer	Manufacturer’s part No.
1	C48	Capacitor 2.2 µF/50 V/X7R/10%	–	C-EU0805
1	C49	Capacitor 22 nF/50 V/X7R/10%	–	C-EU0805
1	C51	Capacitor 1 nF/50 V/X7R/10%	–	C-EU0603
1	C53	Capacitor 100 pF/50 V/X7R/10%	–	C-EU0805
1	C55	Capacitor 1 nF/50 V/X7R/10%	–	C-EU0805
1	C56	Capacitor 47 nF/50 V/X7R/10%	–	C-EU0805
2	D1, D2	Diode S1MB-13-F/1 kV/SMB-2	Diodes Inc.	S1MB-13-F
1	D3	Diode STTH810FP/1 kV/TO220	STMicroelectronics	STTH810FP
1	D4	Diode RS2M-HF/1 kV/DO-214AC-2	Comchip Technology	RS2M-HF
3	D5, D12, D13	Diode BAS3010B/30 V/SOD-323-2	Infineon Technologies	BAS3010B03WE6327HTS A1
5	D6, D7, D14, D15, D16	Diode RS1D-13-F/200 V/SMA-2	Diodes Inc.	RS1D-13-F
2	D8, D17	Diode BZX84C16LT1G/16 V/SOT23-3	Onsemi	BZX84C16LT1G
2	D9, D18	Diode 1N4149TR/100 V/DO-35	Onsemi	1N4149TR
2	D10, D11	Diode STTH1R06A/600 V/SMA	STMicroelectronics	STTH1R06A
2	D19, D20	Diode SS16-E3_5AT/60 V/DO-214AC	Vishay	SS16-E3_5AT
1	D21	Diode BZT52H-A10/10 V/SOD-123F-2	Nexperia	BZT52H-A10-QX
2	D22, D23	Diode 1N4148W-TP/100 V/SOD-123	MCC	1N4148W-TP
1	F1	Fuse SF-3812TM200T-2/600 VAC/2A	Bourns	SF-3812TM200T-2
1	HS1	Heatsink HSE-B20380-040H-01	CUI Devices	HSE-B20380-040H-01
1	HS2	Heatsink FK 264 MI 220 O	Fischer Elektronik	HSS-B20-CP-01PFC3
2	HS3, HS4	Heatsink HSS-B20-CP-01	CUI Devices	HSS-B20-CP-01
1	IC1	ICL5102HV/DSO-16	Infineon Technologies	ICL5102HVXUMA1
1	IC2	IR1168STRPBF/SOIC-8	Infineon Technologies	IR1168SPBF
1	IC3	INA241A3/SOT-23	Texas Instruments	INA241A3QDDFRQ1
1	IC4	VO617A-2X017T/SMD-4	Vishay	VO617A-2X017T
1	IC5	LM358BAIDR/SOIC-8	Texas Instruments	LM358BAIDR
1	IC6	TL431ACDBZRG4	Texas Instruments	TL431ACDBZRG4
1	J1	JUMPERWIREDIODE	–	JUMPERWIREDIODE
1	J2	JUMPERWIRE2	–	JUMPERWIRE2
1	J3	JUMPERWIREGND1	–	JUMPERWIREGND1
1	J4	JUMPERWIREWWR1W	–	JUMPERWIREWWR1W
2	L1, L2	Inductor 1000 V/11.8 mH/5 A	KEMET	SCR29XV-050-1R0A044JV
1	L3	Inductor E32/589 µH	Würth Elektronik	750371813r00

Qty	Designator	Description	Manufacturer	Manufacturer's part No.
1	L4	Inductor E25/490 µH	Würth Elektronik	750371812r01
1	L5	Ferrite Bead 7 A/5m	Würth Elektronik	78279224101
1	L5A	Ferrite Bead 7 A/20m	Würth Elektronik	7427620
1	L6	Inductor 4.7 µH/6.5 A/12.5 m	Würth Elektronik	744750230047
1	NTC1	NTC 10 k/3430 K/5%	–	NTC-0805
3	Q1, Q8, Q11	Transistor MMBT3904-TP/SOT-23-3	MCC	MMBT3904-TP
3	Q2, Q4, Q7	Transistor PBSS4021PT/SOT-23-3	Nexperia	PBSS4021PT,215
1	Q3	Transistor IPA95R450PFD7/TO-220FP-3	Infineon Technologies	IPA95R450PFD7XKSA1
2	Q5, Q6	Transistor IPA95R310PFD7/TO-220FP-3	Infineon Technologies	IPA95R310PFD7XKSA1
2	Q9, Q10	Transistor BSC074N15NS5/TSON-8-3	Infineon Technologies	BSC074N15NS5ATMA1
3	R1, R2, R3	Resistor 5MEG6/1%	–	R-EU_1206
1	R4	Resistor 1MEG5/1%	–	R-EU_1206
9	R5, R6, R12, R35, R38, R51, R69, R86, R100	Resistor 0R/1%	–	R-EU_1206
2	R7, R76	Resistor 120k/1%	–	R-EU_0805
4	R8, R9, R10, R11	Resistor 200k/1%	–	R-EU_1206
3	R13, R55, R59	Resistor 3R3/1%	–	R-EU_1206
4	R14, R56, R80, R82A	Resistor 10k/1%	–	R-EU_1206
6	R15, R62, R63, R66, R70, R71	Resistor 10R/1%	–	R-EU_0805
1	R16	Resistor 4R7/1%	–	R-EU_1206
3	R17, R92, R93	Resistor 47k/1%	–	R-EU_0805
1	R18	Resistor 1R0/1%	–	R-EU_1206
3	R19, R20, R21	Resistor 0R91/1%	–	R-EU_1206
1	R22	Resistor 100R/1%	–	R-EU_1206
6	R23, R24, R25, R26, R27, R28	Resistor 470k/1%	–	R-EU_1206
1	R29	Resistor 820k/1%	–	R-EU_1206

Qty	Designator	Description	Manufacturer	Manufacturer's part No.
4	R30, R31, R32, R33	Resistor 750k/1%	–	R-EU_1206
1	R34	Resistor 12k/1%	–	R-EU_0805
1	R36	Resistor 39k/1%	–	R-EU_1206
3	R37, R98, R99	Resistor N/A/1%	–	R-EU_1206
1	R39	Resistor 12R/1%	–	R-EU_1206
2	R40, R44	Resistor 51R/1%	–	R-EU_1206
3	R41, R45, R67	Resistor 10R/1%	–	R-EU_1206
2	R42, R46	Resistor 47k/1%	–	R-EU_1206
1	R43	Resistor 1R/1%	–	R-EU_1206
2	R47, R49	Resistor 1R5/1%	–	R-EU_1206
1	R48	Resistor 1R2/1%	–	R-EU_1206
1	R50	Resistor 1k0/1%	–	R-EU_1206
1	R52	Resistor 300k/1%	–	R-EU_0805
1	R53	Resistor 30k/1%	–	R-EU_0805
1	R54	Resistor 160k/1%	–	R-EU_0805
1	R57	Resistor 4k3/1%	–	R-EU_1206
1	R58	Resistor N/A/1%	–	R-EU_0805
2	R60, R64	Resistor 1R2/1%	–	R-EU_1206
2	R61, R65	Resistor 10k/1%	–	R-EU_0805
1	R68	Resistor 6m/1%	–	R-EU_2512
1	R72	Resistor 2k7/1%	–	R-EU_0805
1	R73	Resistor 1R0/1%	–	R-EU_1206
3	R74, R84, R91	Resistor 4k7/1%	–	R-EU_0805
1	R75	Resistor 120k/1%	–	R-EU_1206
1	R77	Resistor 5k6/1%	–	R-EU_0805
1	R78	Resistor 20k/1%	–	R-EU_0805
1	R79	Resistor 16k/1%	–	R-EU_1206
1	R79A	Resistor 24k/1%	–	R-EU_1206
1	R80A	Resistor 7k5/1%	–	R-EU_1206
1	R81	Resistor 200R/1%	–	R-EU_0805
1	R81A	Resistor 2k7/1%	–	R-EU_1206
1	R82	Resistor 8k2/1%	–	R-EU_0805
1	R83	Resistor 2k4/1%	–	R-EU_0805
1	R85	Resistor 82k/1%	–	R-EU_0805

Qty	Designator	Description	Manufacturer	Manufacturer's part No.
1	R87	Resistor 1M/1%	–	R-EU_0805
1	R88	Resistor 7k5/1%	–	R-EU_0805
1	R89	Resistor 300R/1%	–	R-EU_0805
1	R90	Resistor 6k2/1%	–	R-EU_0805
2	R94, R95	Resistor 56k/1%	–	R-EU_0805
1	R96	Resistor 1k1/1%	–	R-EU_1206
1	R97	Resistor 9k1/1%	–	R-EU_0805
1	RV1	Varistor 745 V/Radial	TDK	B72210S2551K101
1	TR1	Transformer ETD34 (71+5:3:12:12:2)	Würth Elektronik	750371814r01
1	X1	Connector 250-603/1 kV/THT	WAGO	250-603
2	X2, X3	Connector 250-202/630 V/THT	WAGO	250-202
6	10V, GND, GND_1, S_GND, VCC, VOUT	PCB Test Point/black	Keystone Electronics	5001_BLACK
2	BO, DC_IN	PCB Test Point/orange	Keystone Electronics	5003_ORANGE
1	Q5SOURCE	PCB Test Point/yellow	Keystone Electronics	5004_YELLOW
6	BM, BO1, OPT_C, OVP, PFCVS, RF	Testpad/1.27 mm	–	–

7 Magnetics specifications

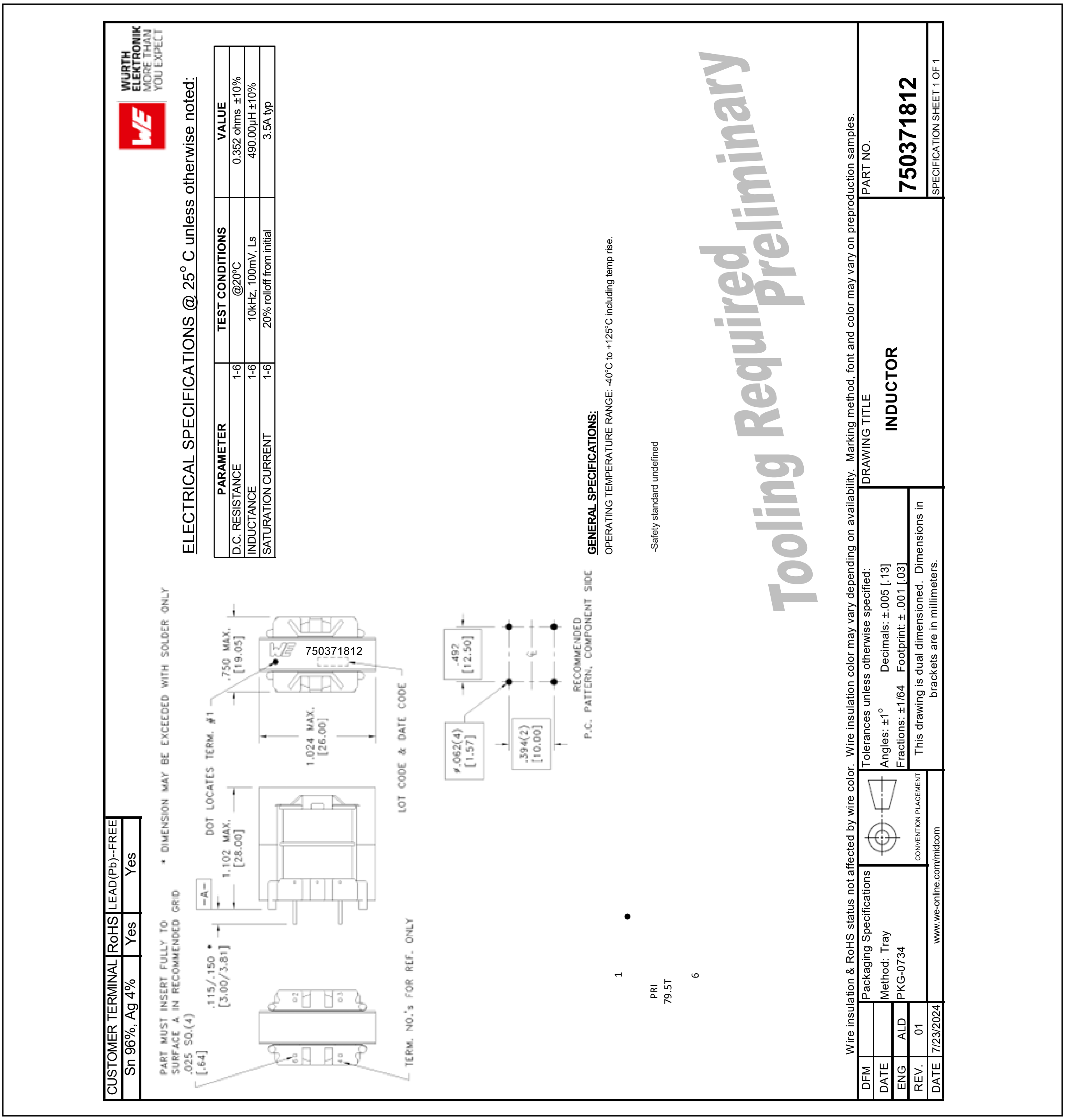
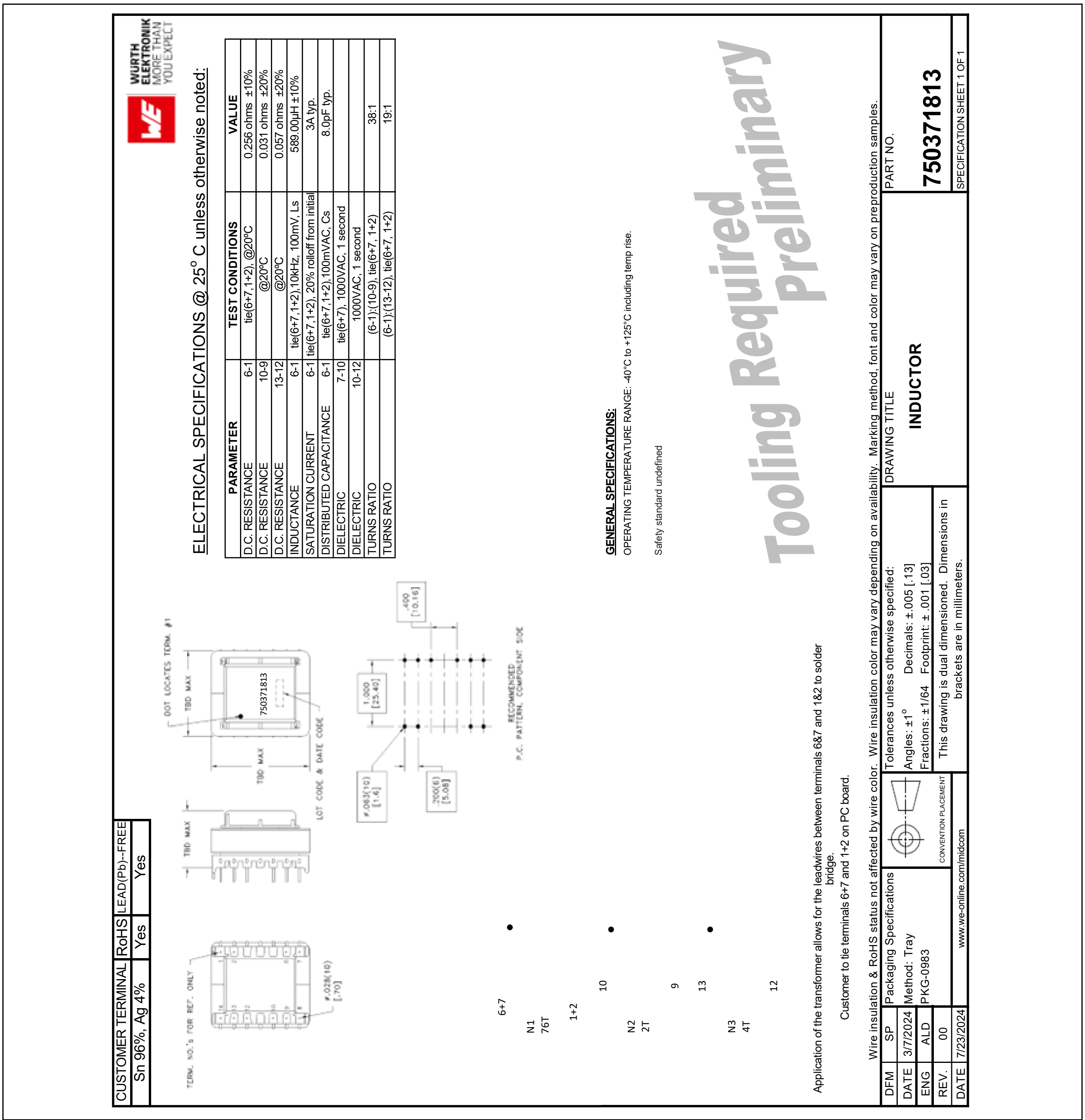


Figure 31 **Specification of the LCC inductor choke 750371812**



CUSTOMER TERMINAL	RoHS	LEAD(Pb)-FREE
Sn 96%, Ag 4%	Yes	Yes

WURTH ELEKTRONIK MORE THAN YOU EXPECT

ELECTRICAL SPECIFICATIONS @ 25° C unless otherwise noted:

PARAMETER		TEST CONDITIONS	VALUE
D.C. RESISTANCE	6-1	tie(6+7,1+2), @20°C	0.256 ohms ±10%
D.C. RESISTANCE	10-9	@20°C	0.031 ohms ±20%
D.C. RESISTANCE	13-12	@20°C	0.057 ohms ±20%
INDUCTANCE	6-1	tie(6+7,1+2),10kHz, 100mV, Ls	589.00µH ±10%
SATURATION CURRENT	6-1	tie(6+7,1+2), 20% rolloff from initial	3A typ.
DISTRIBUTED CAPACITANCE	6-1	tie(6+7,1+2),100mVAC, Cs	8.0pF typ.
DIELECTRIC	7-10	tie(6+7), 1000VAC, 1 second	
DIELECTRIC	10-12	1000VAC, 1 second	
TURNS RATIO		(6-1):(10-9), tie(6+7, 1+2)	38:1
TURNS RATIO		(6-1):(13-12), tie(6+7, 1+2)	19:1

GENERAL SPECIFICATIONS:

OPERATING TEMPERATURE RANGE: -40°C to +125°C including temp rise.

Safety standard undefined

Tooling Required Preliminary

TERM. NO.'s FOR REF. ONLY

DOT LOCATES TERM. #1

TBD MAX

750371813

LOT CODE & DATE CODE

RECOMMENDED P.C. PATTERN, COMPONENT SIDE

6+7 N1 76T 1+2

10 N2 2T 9

13 N3 4T 12

Application of the transformer allows for the leadwires between terminals 6&7 and 1&2 to solder bridge.

Customer to tie terminals 6+7 and 1+2 on PC board.

Wire insulation & RoHS status not affected by wire color. Wire insulation color may vary depending on availability. Marking method, font and color may vary on preproduction samples.

DFM	SP	Packaging Specifications		Tolerances unless otherwise specified:	DRAWING TITLE	PART NO.
DATE	3/7/2024	Method: Tray		Angles: ±1° Decimals: ±.005 [.13]	INDUCTOR	750371813
ENG	ALD	PKG-0983		Fractions: ±1/64 Footprint: ±.001 [.03]		
REV.	00		CONVENTION PLACEMENT	This drawing is dual dimensioned. Dimensions in brackets are in millimeters.		
DATE	7/23/2024	www.we-online.com/midcom				SPECIFICATION SHEET 1 OF 1

Figure 32 Specification of the PFC choke 750371813

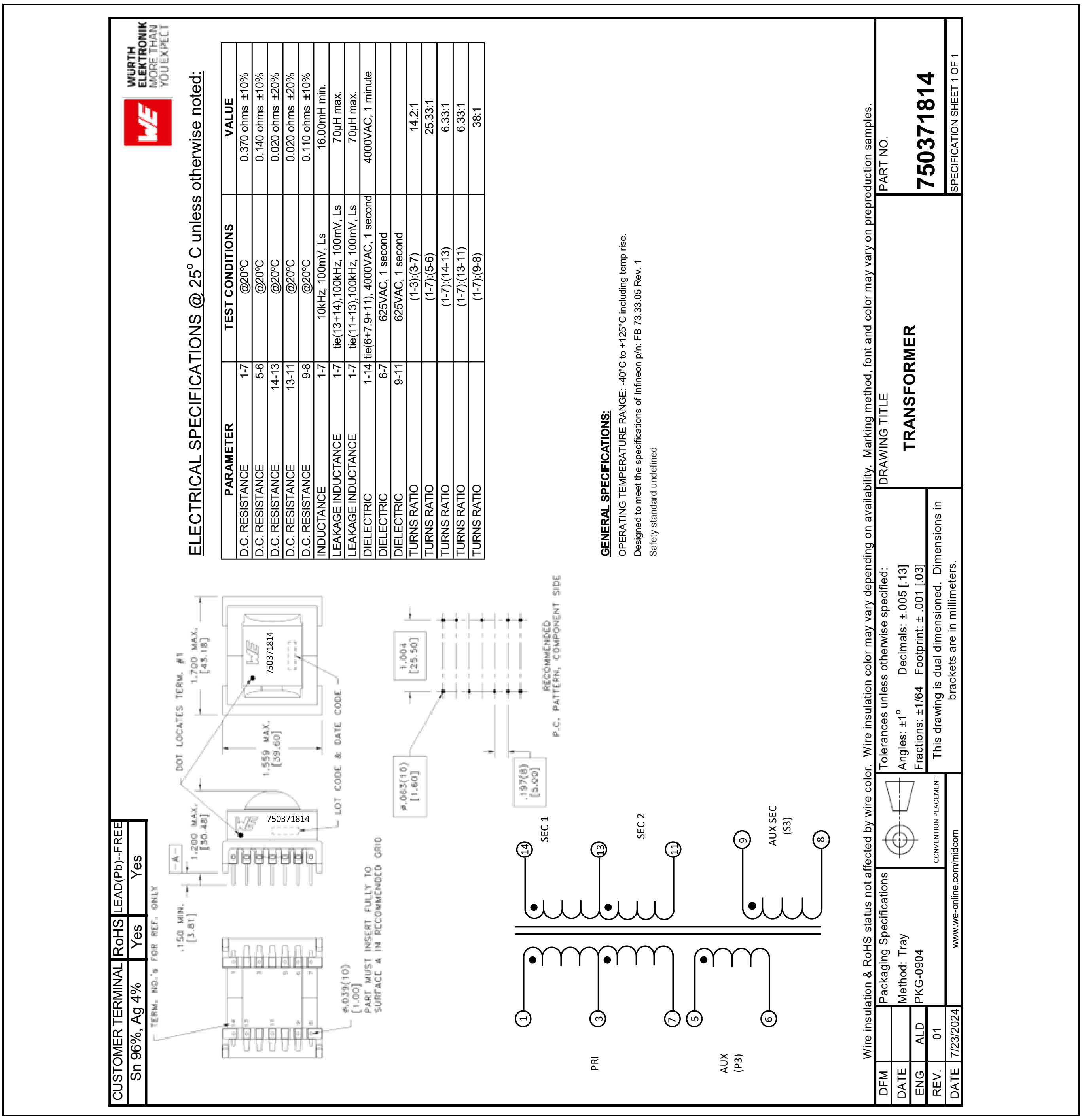


Figure 33 **Specification of LCC transformer 750371814**

References

[1] Infineon Technologies AG: *Design of efficient LCC based on ICL5102/HV combo controller IC (1.0)*; Available online

Revision history

Document revision	Date	Description of changes
V 1.0	2024-12-12	Initial version

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Edition 2024-12-12

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