UM12393

TAA6065AT 100 W HVLV DC-DC design example

Rev. 1.0 — 15 January 2026 **User manual**

Document information

Information	Content
Keywords	LLC converter, high efficiency, power supply, TAA6065AT, TAA6065ATDB1659, 100 W, HVLV DC-DC, LLC, controller, converter, programmable settings, I2C
Abstract	The TAA6065AT is an AEC-Q100 automotive-qualified, digitally configurable controller for high-efficiency resonant micro-DC-DC converters and local BMS HV supplies.

1 Introduction

The TAA6065AT is an AEC-Q100 automotive-qualified, digitally configurable controller for resonant micro-DC-DC converters and local battery management system (BMS) high-voltage (HV) supplies. It meets the efficiency regulations of Energy Star, the Department of Energy (DoE), the Ecodesign Directive of the European Union, the European Code of Conduct, and other guidelines. To increase the efficiency of a low-voltage supply output, the TEA2095T dual SR controller can be added on the secondary side.

Operation modes and protections can be defined by a number of parameter settings for operation, and protections can be stored/programmed in an internal memory. This feature optimizes controller properties to application-specific requirements or optimizes/corrects performance during power supply production. At start, the IC loads the parameter values for operation. The TAA6065AT version is available to make setting changes on the fly.

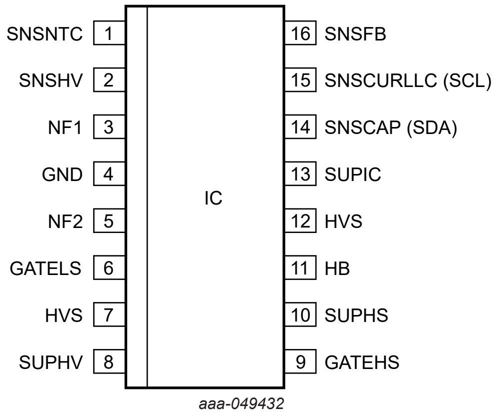

Figure 1. TAA6065AT pinning for the SO16 version

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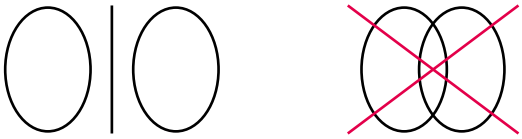
The application board is DC-mains high voltage powered. Avoid touching the board while it is connected to the mains voltage and when it is in operation. An isolated housing is obligatory when used in uncontrolled, non-laboratory environments. Galvanic isolation from the mains phase using a fixed or variable transformer is always recommended.

Figure 2 shows the symbols on how to recognize these devices.



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a. Isolated

019aab174

b. Not isolated

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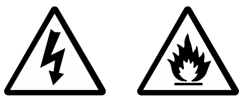
Figure 2. Isolation symbols

WARNING

Lethal voltage and fire ignition hazard



The non-insulated high voltages that are present when operating this product, constitute a risk of electric shock, personal injury, death and/or ignition of fire. This product is intended for evaluation purposes only. It shall be operated in a designated test area by personnel qualified according to local requirements and labor laws to work with non-insulated mains voltages and high-voltage circuits. This product shall never be operated unattended.

2 Finding kit resources and information on the NXP web site

NXP Semiconductors provides online resources for this user manual and its supported devices at https://www.nxp.com.

2.1 Collaborate in the NXP community

In the NXP community, share ideas and tips, ask and answer technical questions, and receive input on just about any embedded design topic.

The NXP community can be found at https://community.nxp.com.

3 Getting ready

3.1 Kit contents

The box contains the TAA6065ATDB1659 design example, which incorporates the TAA6065AT in an SO16 package. Figure 3 and Figure 4 show the top side and bottom side of the design example.

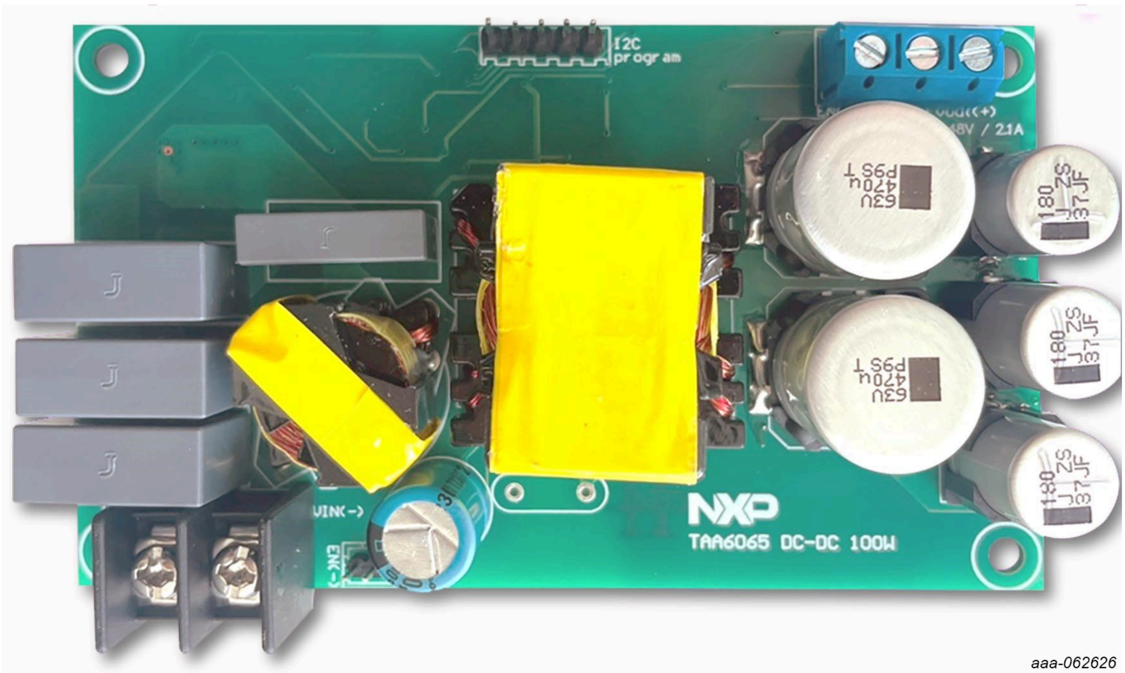


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Figure 3. TAA6065AT 100W HVLV DC-DC design example (A)

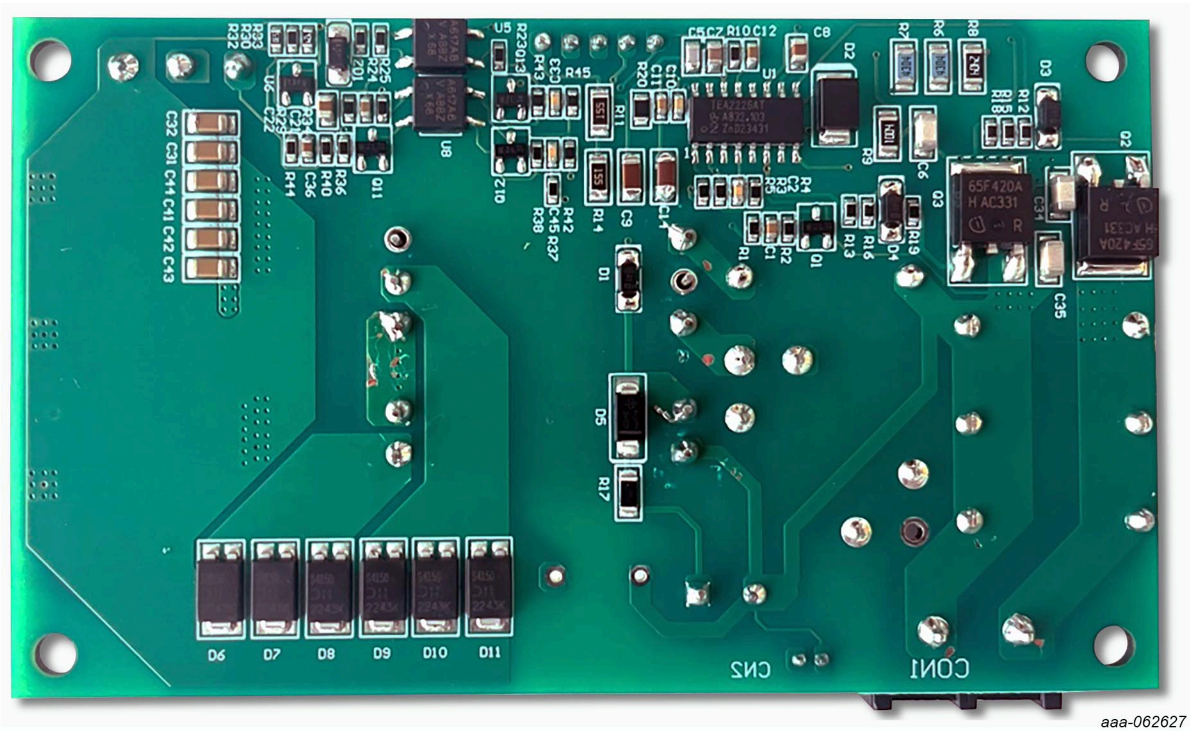

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Figure 4. TAA6065AT 100W HVLV DC-DC design example (B)

4 Getting to know the hardware

4.1 Specifications

Table 1. Specification

Symbol	Parameter	Value	Condition
Input			
V_{mains}	DC mains voltage	220 V to 450 V	DC
Output			
V_{out}	Output voltage	48 V	
I_{out_max}	Maximum output current	2.1 A	
$\eta_{100\%}$	Max load efficiency	> 96.0 %	at 220 VDC – 450 VDC, 100 W Pout
$\eta_{5\%}$	Light load efficiency	> 86.0 %	at 220 VDC – 450 VDC, 5 W Pout
Temperature			
T_{comp}	Components temperature	Refer temp section	-40 °C ~ 85 °C

4.2 Features

- AEC-Q100 grade 1 qualified: −40 °C to +125 °C ambient temperature range
- LLC controller in a single small-size SO16 package
- Integrated high-voltage startup
- Integrated drivers and high-voltage level shifter (LS)
- High-side driver directly supplied from the low-side driver output
- Integrated X-capacitor discharge without additional external components
- Power good function
- Several parameters can easily be configured during evaluation with use of the graphical user interface (GUI), such as:
  – Operating frequencies to be outside the audible area at all operating modes
  – Soft start and soft stop in burst mode, reducing the audible noise
  – Accurate transition levels between operation modes (High-Power mode/Low-Power mode/Burst mode)
  – Enabling/disabling the Lower-Power mode

4.3 Green features

- Zero voltage switching for minimum switching losses
- High efficiency from low load to high load
- Compliant with latest energy-saving standards and directives (Energy Star, EuP)
- No-load input power < 75 mW for TAA6065AT/TEA2095T combination

4.4 Protection features

- Independently configurable levels and timers
- Many protections can independently be set to latched, safe restart, or latched after several attempts to restart
- Supply undervoltage protection (UVP)
- Overpower protection (OPP)
- Internal and external overtemperature protection (OTP)
- Capacitive mode regulation (CMR)
- Overvoltage protection (OVP)
- Overcurrent protection (OCP)
- Brownin/brownout protection
- Disable input
- Input to reset all protections

5 Performance measurement

5.1 Test facilities

- Oscilloscope: Agilent Technologies DSO9064A
- DC power source: Chroma 61502, DC mode
- Electronic load: Chroma 63030-80-60
- Digital power meter: WT210, Line filter, DC mode
- For high/low ambient temp test, SP1500VDC1800W (DC source), EL1200VDC6600W (E-load) and TEMI880 (Chamber) are used.

5.2 Test equipment setup

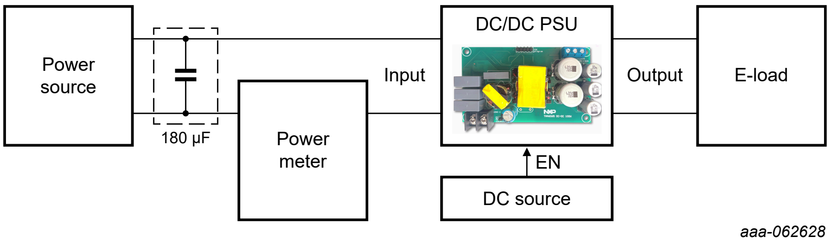

Figure 5. Test equipment setup

5.3 Startup behavior

When the SNSHV voltage exceeds LLC brownin level, the LLC gate starts switching. TAA6065AT implements soft start. During soft start, the peak SNSCAP voltage is gradually increased. The output voltage is increased to 48 V within 200 ms.

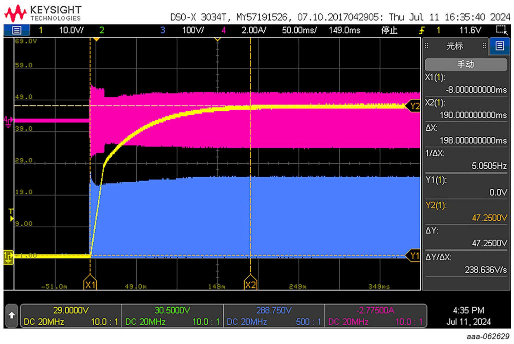

Figure 6. Start-up performance (A)

Start-up at 220 VDC mains and 100 W

CH1: V_{OUT} (10 V/div)

CH3: V_{HB} (100 V/div)

CH4: I_{CR} (2 A/div)

Time: 50 ms/div

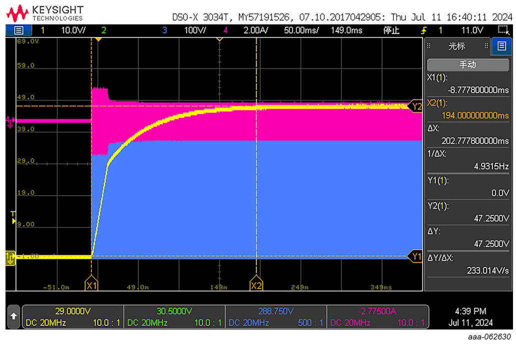

Figure 7. Start-up performance (B)

Start-up at 420 VDC mains and 100 W

CH1: V_{OUT} (10 V/div)

CH3: V_{HB} (100 V/div)

CH4: I_{CR} (2 A/div)

Time: 50 ms/div

5.4 Normal operation

To achieve the best possible efficiency performance, the TAA6065AT incorporates three different operation modes (High-Power mode, Low-Power mode, and Burst mode). Figure 8, Figure 9, Figure 10, Figure 11, Figure 12, and Figure 13 show the waveforms of different operation modes when input 220 VDC and 420 VDC.

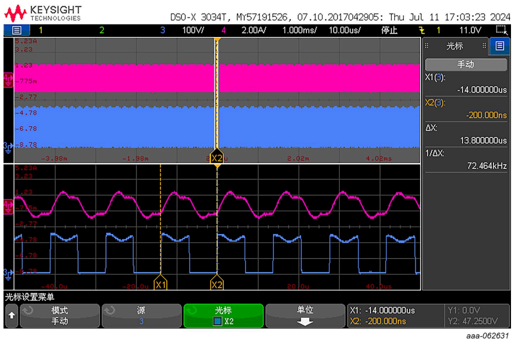

Figure 8. Operation in HP mode (A)

Operation in HP mode at 220 VDC mains

CH3: V_{HB} (100 V/div)

CH4: I_{CR} (2 A/div)

Time: 1 ms/div; 10 us/div

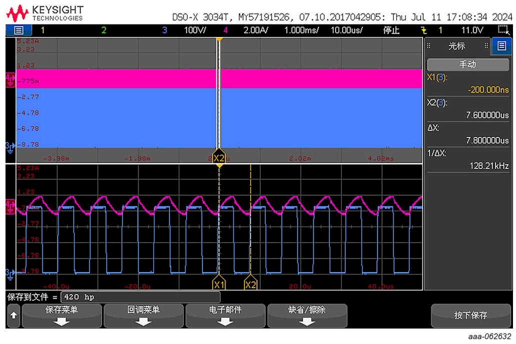

Figure 9. Operation in HP mode (B)

Operation in HP mode at 420 VDC mains

CH3: V_{HB} (100 V/div)

CH4: I_{CR} (2 A/div)

Time: 1 ms/div; 10 us/div

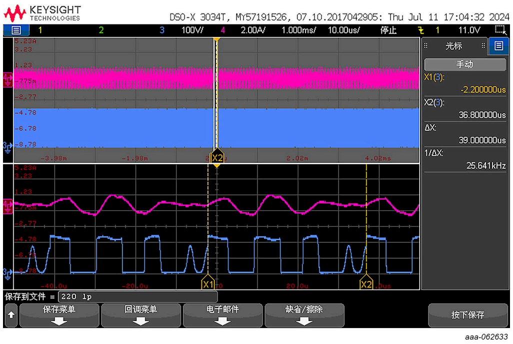

Figure 10. Operation in LP mode (A)

Operation in LP mode at 220 VDC mains

CH3: V_{HB} (100 V/div)

CH4: I_{CR} (2 A/div)

Time: 1 ms/div; 10 us/div

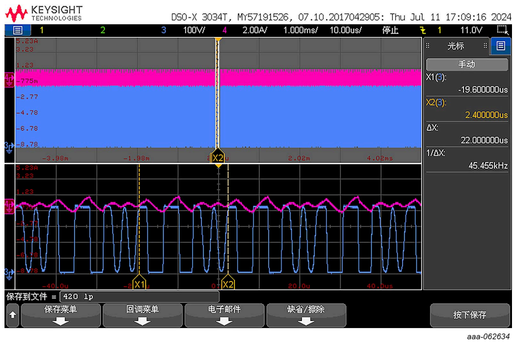

Figure 11. Operation in LP mode (B)

Operation in LP mode at 420 VDC mains

CH3: V_{HB} (100 V/div)

CH4: I_{CR} (2 A/div)

Time: 1 ms/div; 10 us/div

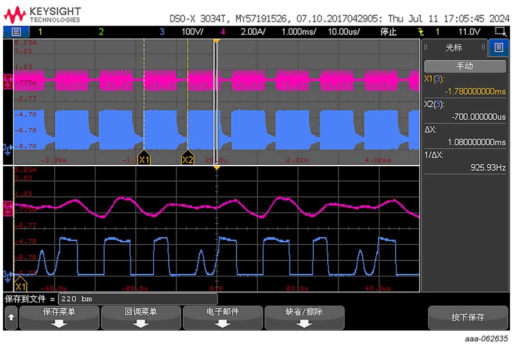

Figure 12. Operation in Burst mode (A)

Operation in Burst mode at 220 VDC mains

CH3: V_{HB} (100 V/div)

CH4: I_{CR} (2 A/div)

Time: 1 ms/div; 10 us/div

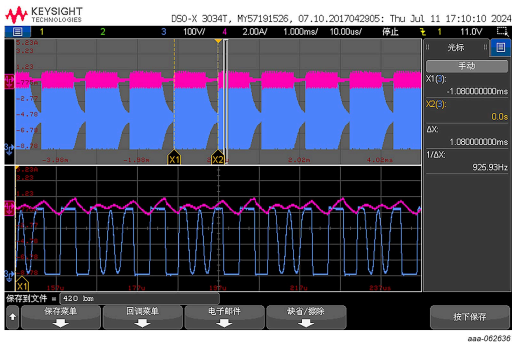

Figure 13. Operation in Burst mode (B)

Operation in Burst mode at 420 VDC mains

CH3: V_{HB} (100 V/div)

CH4: I_{CR} (2 A/div)

Time: 1 ms/div; 10 us/div

5.5 Dynamic load response

The TAA6065AT SNSCAP voltage control (cycle-by-cycle) achieves an output voltage regulation of ±5 % during significant load change statuses. The peak-to-peak value during dynamic load condition is measured at the PCB end. For dynamic load, the output load is changed between maximum nominal load and no load. The slew rate is set as 2.5 A/μs. The load step frequency is 5 Hz.

Table 2. Output voltage peak to peak at load steps

Specification peak to peak value	Output condition	220 VDC	420 VDC
4800 mV	0 A to 2.1 A at 5 Hz	400 mV	400 mV

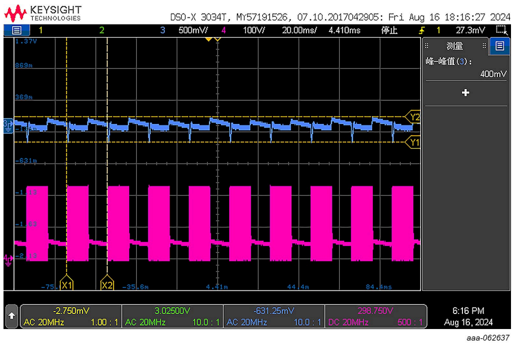

Figure 14. Dynamic load response at 5 Hz step load (A)

Dynamic load response at 220 VDC mains

CH3: V_{OUT} (500 mV/div)

CH4: V_{HB} (100 V/div)

Time: 20 ms/div

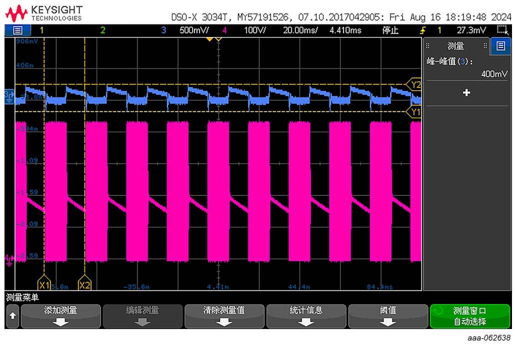

Figure 15. Dynamic load response at 5 Hz step load (B)

Dynamic load response at 420 VDC mains

CH3: V_{OUT} (500 mV/div)

CH4: V_{HB} (100 V/div)

Time: 20 ms/div

5.6 Protections

5.6.1 Overpower protection

The TAA6065AT incorporates OPP protection via the SNSCAP pin. Overpower protection is tested with an increasing output current. To trigger the overpower protection, a 50 ms delay time is required, and TAA6065AT enters the Safe-Restart mode. The Safe-Restart mode secures the fixed restart time at 1 s.

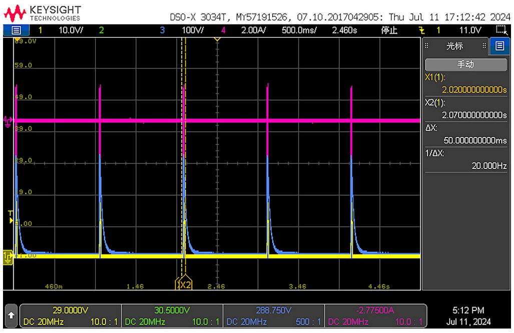

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Figure 16. Overpower protection

CH1: V_{OUT} (10 V/div)
CH3: V_{HB} (100 V/div)
CH4: I_{CR} (2 A/div)
Time: 500 ms/div

5.6.2 Output short protection

The TAA6065AT incorporates OCP protection via the SNSCURLLC pin. This OCP protects the system from output short conditions that occur within a short time. When the SNSCURLLC voltage exceeds 4 V or drops to below 1 V, GATEHS or GATELS is immediately disabled to limit maximum resonant current. After several cycles, which is set by MTP consecutive current limit, the OCP is triggered.

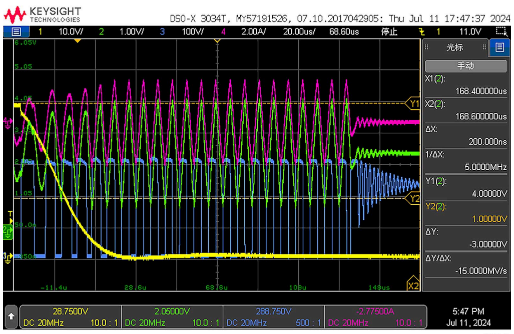

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Figure 17. Output short protection

CH1: V_{OUT} (10 V/div)
CH2: $V_{SNSCURLLC}$ (1 V/div)
CH3: V_{HB} (100 V/div)
CH4: I_{CR} (2 A/div)
Time: 20 us/div

5.7 Efficiency test result

Efficiency is measured at max power rating, and efficiency is over than 96.0 % at whole range DC mains.

Table 3. Table 3. Efficiency test result

Mains condition	Output condition	Specification	Test result
220VDC	100 W, 48 V, 2.1 A	> 96.0 %	95.9 %
300VDC	100 W, 48 V, 2.1 A	> 96.0 %	96.4 %
350VDC	100 W, 48 V, 2.1 A	> 96.0 %	96.6 %
400VDC	100 W, 48 V, 2.1 A	> 96.0 %	96.7 %

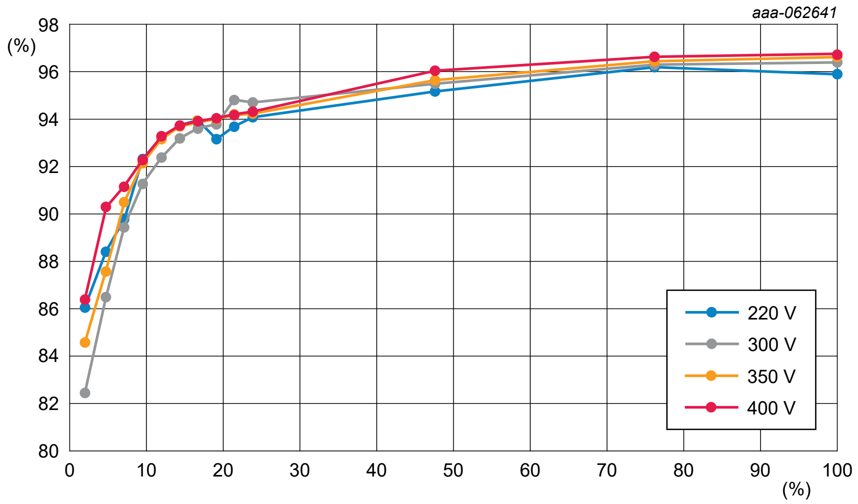

Figure 18. Efficiency

5.8 Output ripple

The output voltage ripple is measured at the PCB end. To reduce spurious noise signal, the end capacitor and the ground lead of the voltage probe are removed. The 0.1 µF/50 V ceramic capacitor and the 10 µF/50 V electrolytic capacitor are placed on the voltage probe. The maximum output voltage ripple is 211 mV.

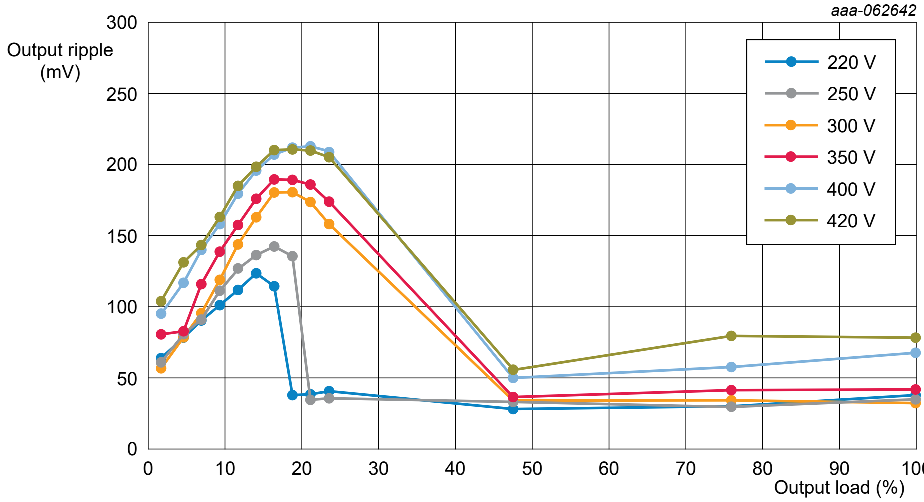

Figure 19. Output ripple

5.9 Audible noise

The audible noise specification and its result are shown in Table 4. Figure 20 shows the audible noise test result at each mains condition and different load conditions.

Table 4. Total harmonic distortion

Mains condition	Output condition	Specification	Test result (max value)
220 VDC	48 V and 0.20 A load	< 25 dB	20.6 dB
350 VDC	48 V and 2.1 A load	< 25 dB	17.6 dB
420 VDC	48 V and 0.7 A load	< 25 dB	14.7 dB

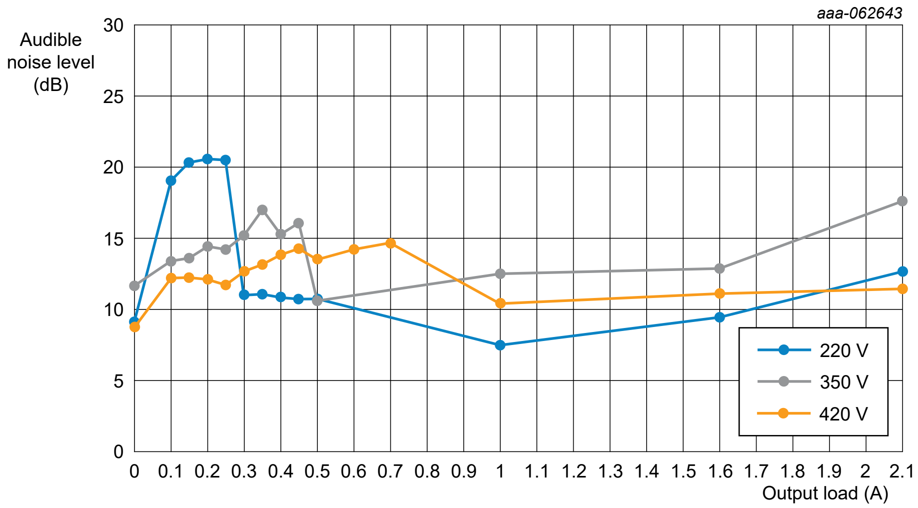

Figure 20. Audible noise

5.10 Components temperature performance

Temperature is measured at -40 °C and +85 °C condition.

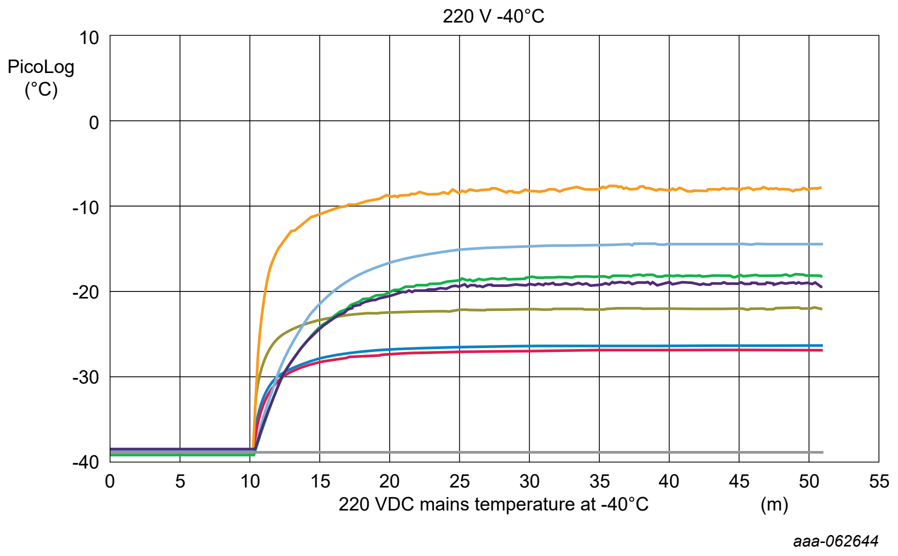

Figure 21. 220 VDC mains temperature at -40 °C

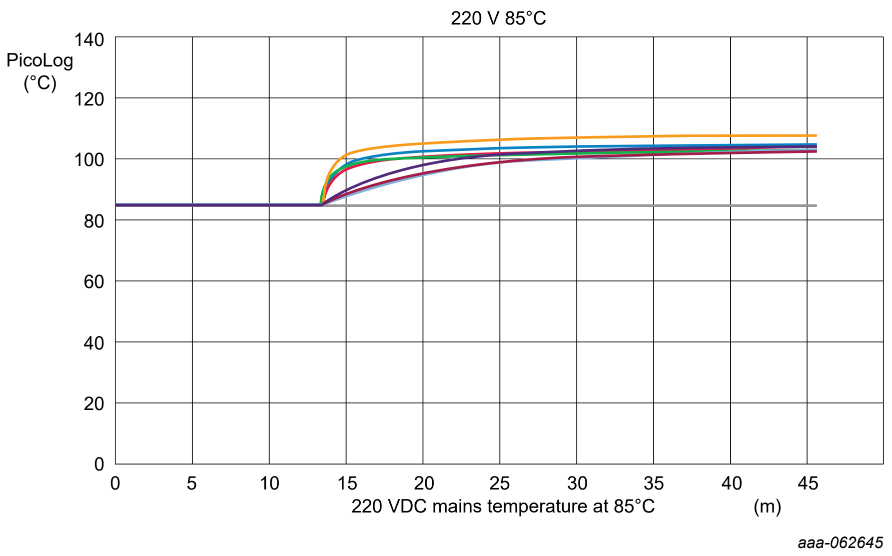

Figure 22. 220 VDC mains temperature at +85 °C

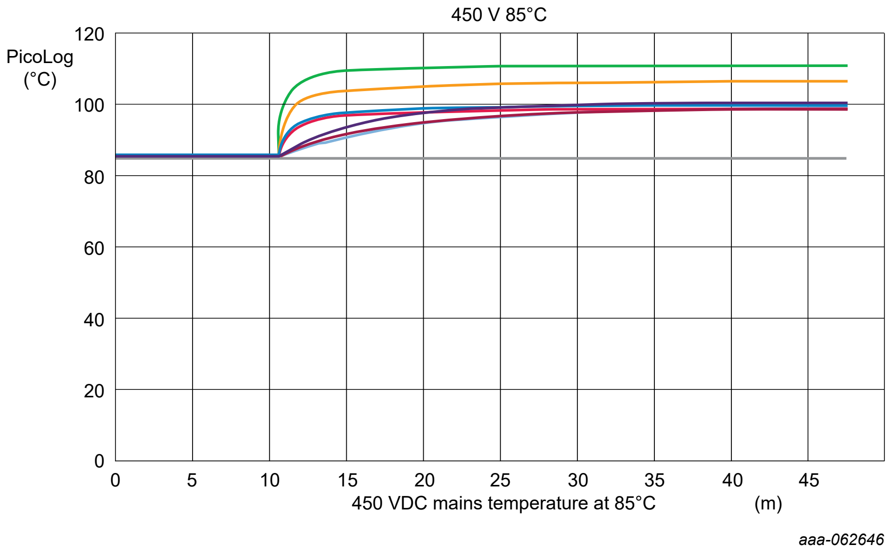

Figure 23. 450 VDC mains temperature at +85 °C

Table 5. Temperature test result at 100 W load and -40 °C and +85 °C condition

Components	Specification	Test result		
		220 VDC at -40 °C ambient	220 VDC at +85 °C ambient	450 VDC at -40 °C ambient
Ambient		-38.9 °C	84.8 °C	84.8 °C
LLC controller	< 120 °C	-22.2 °C	102.1 °C	110.9 °C
LLC MOSFET	< 150 °C	-27.0 °C	104.5 °C	99.6 °C
Output rectifier diodes	< 150 °C	-8.1 °C	107.7 °C	106.3 °C
Transformer core	< 150 °C	-14.6 °C	102.9 °C	98.7 °C
Transformer wire	< 150 °C	-18.3 °C	102.4 °C	98.6 °C
Resonant inductor core	< 150 °C	-19.5 °C	103.9 °C	100.3 °C

6 Schematic and bill of materials

6.1 Schematic

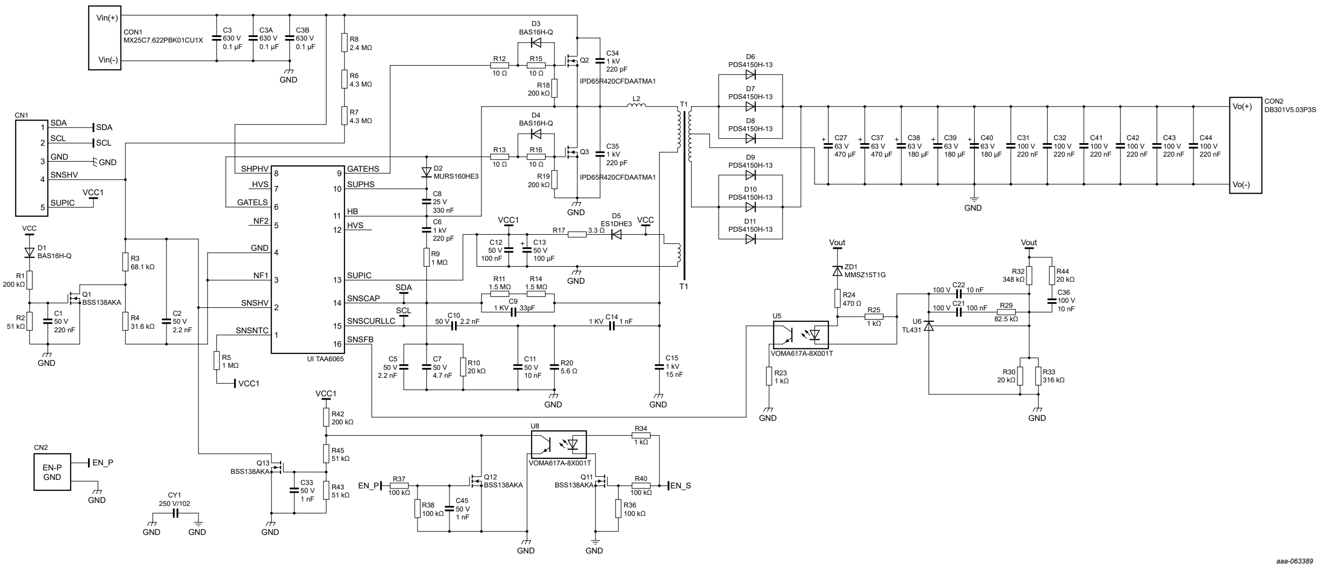

Figure 24. Schematic

6.2 Bill of materials

Table 6. TAA6065ATDB1659 bill of materials (BOM)

Part reference	Description	Manufacturer	Part reference
C1	Capacitor, 50 V, 1 nF, 10 %, X7R, 0603	Yageo	AC0603KRX7R9BB102
C3, C3A, C3B	Capacitor, Film cap, 630 V, 0.1uF, 5%	Kemet	R75PI310050H3J
C5	Capacitor, 50 V, 2.2 nF, 1 %, C0G, 0805	muRata	GCM2165C1H222FA16D
C6	Capacitor, 1 kV, 220 pF, 1 %, C0G, 1206	PSA	FV31N221J102EEG
C7	Capacitor, 50 V, 4.7 nF, 1 %, C0G, 0805	Kemet	C0805C472F5GECAUTO
C8	Capacitor, 25 V, 330 nF, 10 %, X7R, 0805	TAIYO YUDEN	TMK212B7334KGHT
C9	Capacitor, 1 KV, 33 pF, 1 %, C0G, 1206	muRata	GCM31A5C3A330FX01D
C2, C10	Capacitor, 50 V, 2.2 nF, 10 %, X7R, 0603	Yageo	AC0603KRX7R9BB222
C11	Capacitor, 50 V, 10 nF, 10 %, X7R, 0603	muRata	GCM188R71H103KA37D
C12	Capacitor, 50 V, 100 nF, 10 %, X7R, 0603	muRata	GCJ188R71H104KA12D
C13	E-capacitor, 50 V, 100 uF	Rubycon	50RX30100M10X12.5
C14	Capacitor, 1 KV, 1 nF, 1 %, C0G, 1206	muRata	GCM31C5C3A102FX03L
C15	Capacitor, Film cap, 1 kV, 15 nF,	Kemet	R75QI215050H0J
C21	Capacitor, 100 V, 100 nF, 10 %, X7R, 0603	Yageo	AC0603KRX7R0BB104
C22	Capacitor, 100 V, 10 nF, 10 %, X7R, 0805	TAIYO YUDEN	HMK212B7103KGHT
C27, C37	E-capacitor, 63 V, 470 uF	Vishay	MAL224699811E3
C31, C32, C41, C42, C43, C44	Capacitor, 100 V, 220 nF, 10 %, X7R, 1206	muRata	GCM31MR72A224KA37L
C33,C45	Capacitor, 50 V, 1 nF, 10 %, X7R, 0603	Yageo	AC0603KRX7R9BB102
C34, C35	Capacitor, 1 kV, 220 pF, 1 %, C0G, 1206	PSA	FV31N221J102EEG
C36	Capacitor, 100 V, 10 nF, 10 %, X7R,0603	TAIYO YUDEN	HMJ107BB7103KAHT
C38, C39, C40	E-capacitor, 63 V, 180 uF	Panasonic	EEH-ZS1J181UP
CON1	Input connector, two pins	Guanghong	MX25C7.622PBK01CU1X
CON2	Output connector, three pins	Guanghong	DB301V5.03P3S
CN1	I2C programing connector, five pins		

Table 6. TAA6065ATDB1659 bill of materials (BOM)*...continued*

Part reference	Description	Manufacturer	Part reference
CN2	Primary EN/DIS signal connector, two pins		
CY1	N.M.		
D1, D3, D4	High-speed switching diode, 100 V, 0.215 A	Nexperia	BAS16H-Q
D2	Ultrafast diode, 600 V, 1 A	Vishay	MURS160HE3
D5	Ultrafast diode, 200 V, 1 A	Vishay	ES1HDE3_A/H
D6, D7, D8, D9, D10, D11	Schottky, 150 V/4 A	Diodes	PDS4150H-13
L2	150 ± 5 % uH @ 100 KHz	TDG	RM7
Q1, Q11, Q12, Q13	BSS138AKA	Nexperia	BSS138AKA
Q2, Q3	N-channel MOS, 650 V, 420 mΩ	Infineon	IPD65R420CFDAATMA1
R1, R42	Resistor, 200 K, 5%, 0603	Vishay	CRCW0603200KJNEA
R2, R43, R45	Resistor, 51 K, 1%, 0603	Vishay	CRCW060351K0FKEA
R3	Resistor, 68.1 K, 1%, 0603	Vishay	CRCW060368K1FKEA
R4	Resistor, 31.6 K, 1%, 0603	Vishay	CRCW060331K6FKEA
R5	Resistor, 1 M, 1%, 0603	Vishay	CRCW06031M00FKEA
R6, R7	Resistor, 4.3 M, 1%, 1206	KOA	RK73H2BTTD4304F
R8	Resistor, 2.4 M, 1%, 1206	Yageo	AC1206FR-072M4L
R9	Resistor, 1 M, 1%, 1206	Yageo	AC1206FR-071ML
R10, R30, R44	Resistor, 20 K, 1%, 0603	Vishay	CRCW060320K0FKEA
R11, R14	Resistor, 1.5 M, 5%, 1206	ROHM	KTR18EZPJ155
R12, R13, R15, R16	Resistor, 10 R, 1%, 0603	Vishay	CRCW060310R0FKEA
R17	Resistor, 3.3 R, 1%, 1206	Vishay	CRCW12063R30FKEA
R18, R19	Resistor, 200 K, 1%, 0603	Vishay	CRCW0603200KJNEA
R20	Resistor, 5.6 R, 1%, 0805	Vishay	CRCW08055R60FKEA
R23, R25, R34	Resistor, 1 K, 5%, 0603	Vishay	CRCW06031K00JNEA
R24	Resistor, 470 R, 1%, 0603	Vishay	CRCW0603470RFKEA
R29	Resistor, 82.5 K, 1%, 0603	Vishay	CRCW060382K5FKEA
R32	Resistor, 348 K, 1%, 0603	Yageo	AC0603FR-07348KL
R33	Resistor, 316 K, 1%, 0603	Vishay	CRCW0603 e3
R36, R37, R38, R40	Resistor, 100 K, 1%, 0603	Vishay	CRCW0603100KFKEA
T1	400 ± 5 % uH @100 KHz	TDG	PQ2620A
U1	Half-bridge digital LLC controller	NXP	TAA6065AT
U5, U8	Optocoupler, low profile	Vishay	VOMA617A-8X001T
U6	Shunt regulator, Vref = 2.495 V	TI	TL431BQDBZRQ1
ZD1	Zener diode, 15 V, 1 %	On-semi	MMSZ15T1G

6.3 LLC transformer and resonant inductor specification

6.3.1 LLC transformer specification

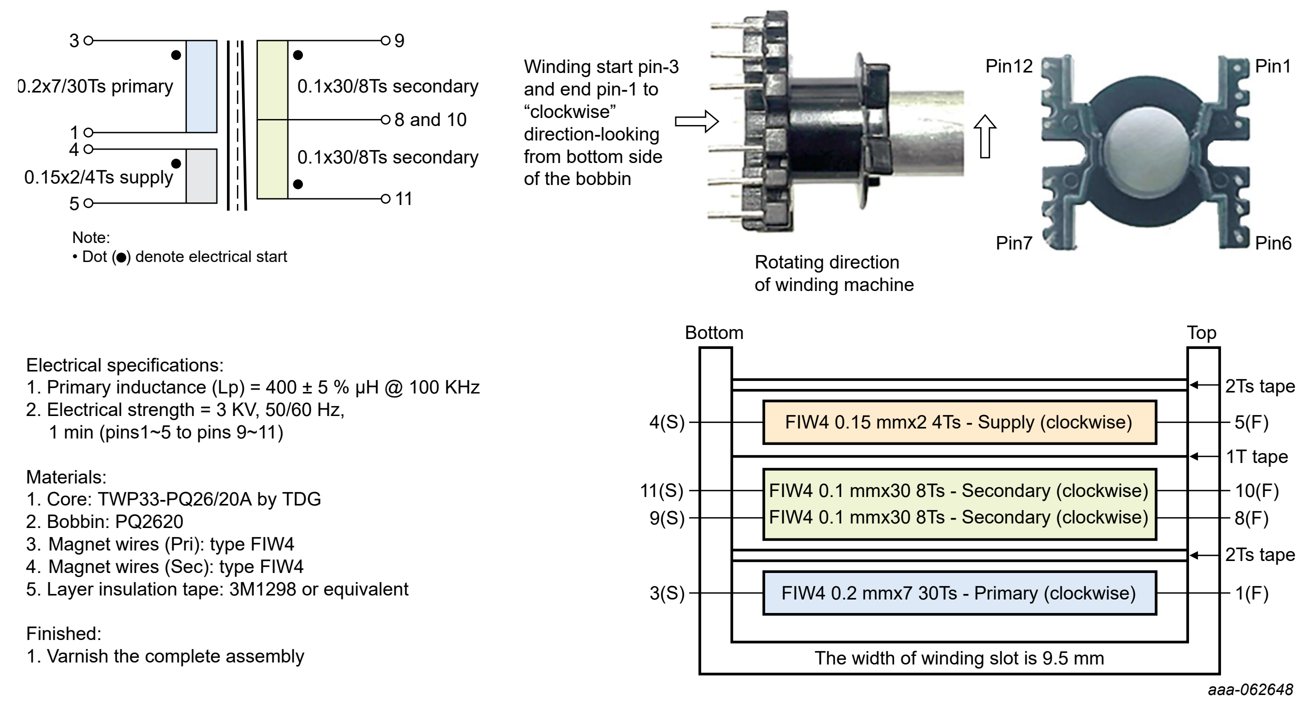

Figure 25. LLC transformer specification

6.3.2 LLC resonant inductor specification

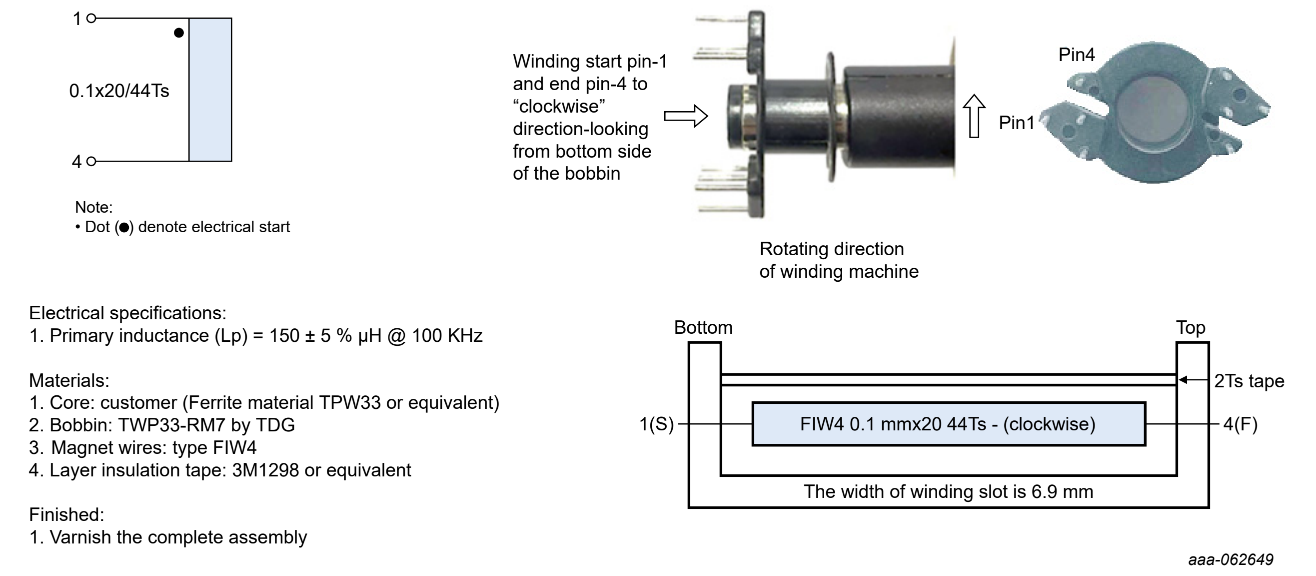

Figure 26. LLC resonant inductor specification

7 Abbreviations

Table 7. Abbreviations

Acronym	Description
LLC	Low loss converter
MOSFET	Metal-oxide semiconductor field-effect transistor
PCB	Printed-circuit board

8 References

1. TAA6065AT data sheet

9 Revision history

Table 8. Revision history

Document ID	Release date	Description
UM12393 v.1.0	15 January 2026	Initial version

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