# Detailed Analysis of the Resonant Transformer Core and Bobbin in the Infineon 200W LLC Converter Board

## 1. Introduction

### Overview of the Infineon EVAL-2ED2101-HB-LLC Converter Board

The Infineon EVAL-2ED2101-HB-LLC is a sophisticated power stage designed as a fast-switching, resonant Zero Voltage Switching (ZVS) 200W LLC-converter.1 This evaluation board serves as a demonstration platform for Infineon's advanced technologies, particularly highlighting the benefits of operating power converters at high switching frequencies. The design targets frequencies up to 500 kHz, which yield several system advantages, including reduced electromagnetic interference (EMI), a smaller footprint due to decreased passive component size, and an overall reduction in Bill of Materials (BOM) cost.1

Functionally, the EVAL-2ED2101-HB-LLC board is engineered to provide a stable 12V output voltage, capable of delivering up to 16.7A of current. This is achieved while operating from a flexible DC input voltage range of 360V to 425V.1 Such performance characteristics make this topology suitable for a diverse array of DC-DC applications, including high-power lighting, switch-mode power supplies (SMPS), uninterruptible power supplies (UPS), server supplies, and power bricks for consumer electronics, as well as low-power electric vehicle charging applications.1

### Purpose of the Report

The primary objective of this report is to conduct a precise identification and detailed analysis of the core and bobbin components of the resonant transformer integrated within this high-frequency LLC converter. The transformer in question is visually marked "A2005016" in the provided image. Through cross-referencing with the Bill of Materials (BOM) for the EVAL-2ED2101-HB-LLC main board, its full part number is confirmed as Sunlord ATWPPQ273230A300P-02.1 This analysis will systematically leverage the physical dimensions provided in the user's image and all available research material to offer a comprehensive technical overview, addressing any ambiguities encountered in the data.

## 2. Transformer Identification and General Specifications

### Confirmation of Transformer Identity

The transformer depicted in the user's image is clearly marked with the code "A2005016." A direct cross-reference with the Bill of Materials (BOM) for the Infineon EVAL-2ED2101-HB-LLC main board confirms that the "Resonant transformer" component corresponds to the manufacturer's part number "Sunlord ATWPPQ273230A300P-02".1 This establishes that "A2005016" is the specific product code or internal designation used for this particular Sunlord component within the Infineon design. Sunlord is a reputable manufacturer known for its expertise in winding and planar transformers, utilizing automated production lines to ensure consistent product quality and adherence to relevant standards, making them a suitable supplier for critical power supply components.2

### Role in LLC Converter Topology

This transformer is a fundamental component serving as the resonant transformer within the LLC (Inductor-Inductor-Capacitor) resonant converter topology. Its primary functions are multifaceted: it facilitates efficient energy transfer from the primary side to the secondary side, provides essential galvanic isolation between the input and output, and critically contributes to the resonant tank circuit. This resonant tank is vital for enabling Zero Voltage Switching (ZVS) operation, which significantly reduces switching losses and enhances overall converter efficiency, especially at high frequencies.1 The LLC converter on this board is specifically designed to operate at a high maximum inverter switching frequency (fPWM) of up to 500 kHz.1 This high-frequency operation is a crucial design parameter that directly dictates the stringent requirements for the transformer's core material selection and winding design to minimize losses and maintain performance.

### Key Electrical Parameters and Operating Conditions

The resonant transformer possesses specific electrical characteristics essential for its operation within the LLC converter. The specified primary inductance (Lp) is 168 μH, with a tight tolerance of ±3 percent. This inductance is measured between pin 1 and pin 5 of the transformer.1 This measurement directly aligns with the primary winding depicted in the provided winding schematic, which explicitly connects these two pins. Furthermore, the transformer is engineered to operate reliably across a broad temperature range, from -40°C to +125°C.1 This wide thermal tolerance underscores the component's robustness and its suitability for demanding power electronics applications where significant temperature fluctuations are expected.

### External Dimensions

The provided image includes a comprehensive table detailing the external dimensions of the transformer, which are critical for its physical integration and compatibility with the Printed Circuit Board (PCB) layout. The key dimensions are: A: 28.0 Max, B: 31.5 Max, C: 29.5 Max, D: 5.5±0.5, E: 25.0±0.3, F: 5.0±0.2, G: 20.0±0.3, H: 1.0±0.2, J: 2.4 Ref, and K: 3.4 Ref. The recommended PCB pattern, also shown in the image, indicates a mounting footprint of approximately 20mm x 25mm. This pattern specifies various pin diameters (Ø1.5mm, Ø3.2mm, Ø4.2mm) and a consistent pin pitch, confirming its Through-Hole Technology (THT) design, which implies vertical mounting on the PCB.

The following table summarizes the identified transformer's part numbers and key electrical parameters:

| Item | Value | Conditions / Comments | Source |
| --- | --- | --- | --- |
| Manufacturer | Sunlord | 1 |  |
| Full Part Number | ATWPPQ273230A300P-02 | Identified from BOM | 1 |
| Marking | A2005016 | Visible on component image | User Image |
| Component Type | Resonant Transformer | Role in LLC converter | 1 |
| Primary Inductance (Lp) | 168 μH (±3%) | Measured between pin 1 and pin 5 | 1 |
| Operating Temp. Range | -40°C to +125°C | Including self-heating | 1 |
| Max. Switching Frequency | 500 kHz | Maximum inverter switching frequency of the converter | 1 |

## 3. Core Details and Material Properties

### Core Type Identification (PQ-Type)

Based on the external dimensions provided in the user's image, particularly the "G" dimension of 20.0±0.3mm and the overall package dimensions (A=28.0 Max, C=29.5 Max), the core can be confidently identified as a PQ-type ferrite core. More specifically, these dimensions strongly suggest a **PQ27/20 core**. Standard PQ27/20 cores are documented with a length of approximately 27.5mm and a height of around 19.0mm.6 The "G" dimension of 20.0±0.3mm from the user's image is particularly indicative of the "20" in PQ27/20, which typically denotes the core's height or a related critical internal dimension. The overall transformer package dimensions (A=28.0mm, C=29.5mm) are consistent with housing a PQ27/20 core along with its bobbin and protective casing. PQ cores are a popular choice for power transformers due to their compact, self-shielding design, which inherently minimizes leakage flux and external electromagnetic interference (EMI), while also providing efficient utilization of winding space.7

### Core Material: Mn-Zn Ferrite DMR50

The Bill of Materials (BOM) for the Infineon board explicitly specifies the core material as "Mn-Zn Ferrite DMR50".1 The selection of Manganese-Zinc (Mn-Zn) ferrite for the core material in this high-frequency LLC converter is a critical engineering decision driven by the operational requirements of the Infineon EVAL-2ED2101-HB-LLC board. This board is characterized by its high switching frequency operation, reaching up to 500 kHz.1 For power transformers operating at such elevated frequencies, the choice of core material is paramount to ensure high efficiency and effective thermal management.

Mn-Zn ferrite compositions are specifically engineered for power applications at these frequencies due to their inherently low core losses. Research indicates that the DMR50 material exhibits core losses around 200 kW/m³ at 3 MHz 10, which is a strong indicator of its excellent high-frequency performance. This low core loss characteristic directly translates to higher efficiency for the transformer and reduced heat generation, which is critical for achieving the "fast-switching" and compact design goals of the Infineon board.1 Furthermore, the high Curie temperature (Tc) of Mn-Zn ferrites, typically exceeding 200°C (e.g., >230°C for PC40/PC44, a comparable Mn-Zn material, as noted in 11, and 230°C for MN80 in 12), ensures that the magnetic properties remain stable and predictable across the specified operating temperature range of -40°C to +125°C.1 This thermal stability is essential to prevent thermal runaway or performance degradation during prolonged operation. The choice of Mn-Zn ferrite DMR50 therefore represents a deliberate engineering selection to meet the demanding performance requirements of a high-frequency LLC converter.

### Key Magnetic Properties (Inferred/Typical for Mn-Zn Ferrite)

While a dedicated datasheet for "DMR50" was not explicitly found in the provided snippets, general characteristics of high-frequency Mn-Zn ferrites (such as PC40/PC44, N87, N95) can be inferred to understand the expected performance of the DMR50 material.11

* **Initial Permeability (µi):** For power ferrites optimized for high frequencies, initial permeability typically ranges from 1000 to 2500. For instance11 mentions an initial magnetic permeability of 2300±25% for PQ27\*20 PC40/PC44 core, which serves as a strong proxy for the expected properties of DMR50. A higher permeability generally allows for fewer winding turns to achieve a desired inductance, contributing to reduced copper losses and a smaller transformer size.
* **Saturation Flux Density (Bsat):** This property is crucial to ensure the core does not saturate under peak operating currents, which would lead to a sharp drop in inductance and increased losses. For power-grade Mn-Zn ferrites, Bsat typically falls within the range of 4000 to 5300 Gauss.12 Maintaining operation below the saturation flux density is essential for the linear and efficient operation of the transformer.
* **Curie Temperature (Tc):** As previously discussed, the Curie temperature is the point at which the material loses its ferromagnetic properties. For Mn-Zn ferrites used in power applications, Tc is generally well above the operational temperature, often exceeding 200°C (e.g., >230°C for PC40/PC44 in 11, 230°C for MN80 in 12). This provides a substantial thermal margin, ensuring stable magnetic performance even at the maximum specified operating temperature of +125°C.1
* **Volume Resistivity (ρ):** Mn-Zn ferrites possess relatively high volume resistivity 12, which is essential for minimizing eddy current losses within the core. Eddy current losses become more significant at higher operating frequencies, and a high resistivity helps to contain these losses, contributing to the overall efficiency of the transformer.

The following table presents the external dimensions of the transformer as provided in the user's image:

| Item | Sunlord Spec |
| --- | --- |
| A | 28.0 Max |
| B | 31.5 Max |
| C | 29.5 Max |
| D | 5.5±0.5 |
| E | 25.0±0.3 |
| F | 5.0±0.2 |
| G | 20.0±0.3 |
| H | 1.0±0.2 |
| J | 2.4 Ref |
| K | 3.4 Ref |

The following table summarizes the identified core specifications, including typical or inferred values where direct data for DMR50 was not explicitly available:

| Item | Value | Conditions / Comments | Source |
| --- | --- | --- | --- |
| Core Type | PQ27/20 | Inferred from external dimensions and typical core sizes | 6 |
| Material | Mn-Zn Ferrite DMR50 | Specified in BOM | 1 |
| Length (approx.) | 27.5 mm | Typical for PQ27/20 | 6 |
| Height (approx.) | 19.0 mm | Typical for PQ27/20 | 6 |
| Effective Magnetic Path Length (le) | 44.4 mm | Typical for PQ26/20 (similar size) | 13 |
| Effective Cross-sectional Area (Ae) | 122.6 mm² | Typical for PQ26/20 (similar size) | 13 |
| Effective Volume (Ve) | 5440 mm³ | Typical for PQ26/20 (similar size) | 13 |
| Initial Permeability (µi) | ~2300 (±25%) | Typical for PQ27\*20 PC40/PC44 (similar Mn-Zn ferrite) | 11 |
| Saturation Flux Density (Bsat) | 4000-5300 Gauss (typical) | Range for power-grade Mn-Zn ferrites | 12 |
| Curie Temperature (Tc) | >200°C (e.g., >230°C for PC40/PC44, MN80) | Ensures stable magnetic properties at operating temperatures | 11 |
| Core Loss (at 3 MHz) | ~200 kW/m³ | Indicates excellent high-frequency performance | 10 |

## 4. Bobbin Details and Physical Characteristics

### Bobbin Material: Phenolic

The Bill of Materials (BOM) for the resonant transformer explicitly specifies the bobbin material as "Phenolic".1 Phenolic resins are thermosetting plastics widely recognized and favored for transformer bobbins due to their exceptional dielectric strength, which provides robust electrical insulation between windings and from windings to the core. Additionally, phenolic materials offer high mechanical rigidity, ensuring the structural integrity of the winding assembly, and superior heat resistance, which is crucial for maintaining performance and safety in power applications where components are subjected to significant thermal and electrical stresses. These properties make phenolic an ideal choice for reliable and durable transformer construction.

### Pin Configuration and Discrepancy Analysis

A notable contradiction exists regarding the bobbin's pin count. The BOM states the bobbin is "7-pin".1 However, the user's provided image consistently depicts an 8-pin transformer. This is evident from multiple visual cues: the component's physical labeling clearly shows pins numbered 1 through 8, the recommended PCB footprint displays 8 distinct pads for soldering, and most importantly, the detailed winding schematic explicitly utilizes pins 1, 5, 6, 7, and 8 for electrical connections.

When faced with conflicting information in technical documentation, it is essential to prioritize the most functionally descriptive and visually consistent data. In this context, the winding schematic in the user's image provides a functional representation of the transformer's electrical connectivity, showing pin 5 as an active terminal for the primary winding (connected between pins 1 and 5). The primary inductance is also specified as being measured between pins 1 and 5 1, which further confirms pin 5's active role. The "NC" (No Connection) label on pin 5 in the simple top-view diagram of the component is likely a simplification or an error, as it directly contradicts the functional winding diagram and the inductance measurement. Given the overwhelming evidence from the visual data (component image, PCB pattern, and winding schematic) consistently indicating an 8-pin configuration with active use of pin 5, it is highly probable that the "7-pin" specification in the BOM 1 is a typographical error. This situation highlights a common challenge in component analysis where documentation may contain minor inconsistencies, necessitating a critical evaluation of all available data to arrive at an accurate conclusion.

The recommended PCB pattern in the user's image implies a standard pin pitch of 2.5mm (0.1 inches) between adjacent pins. This is a common industry standard for Through-Hole Technology (THT) components, with 14 also mentioning 2.5mm pin spacing for PQ20 bobbins. The winding diagram clearly illustrates a primary winding with 32 turns connected between pins 1 and 5. The secondary side features two windings, each with 2 turns: one connected between pins 6 and 7, and another between pins 7 and 8. This configuration suggests either a center-tapped secondary winding where pin 7 serves as the center tap, or two separate secondary windings sharing a common reference at pin 7.

### Bobbin Style and Mounting (THT, Vertical vs. Horizontal)

The BOM describes the bobbin as "THT, horizontal version".1 However, the visual evidence from the user's image and the provided recommended PCB pattern clearly indicate that the component is designed for

**vertical mounting** on the printed circuit board, with its pins extending downwards for insertion into through-holes.

The term "horizontal" in the context of a transformer bobbin can be ambiguous and lead to misinterpretation. It is plausible that this description refers to the orientation of the winding axis relative to the core's main dimension, or to the internal structure of the bobbin, rather than its external mounting orientation on the PCB. For instance, a "horizontal" bobbin might imply that the winding former is oriented horizontally when the core halves are assembled, even if the completed transformer package is designed for vertical insertion into a PCB. Sunlord's own catalog uses distinct "Style" codes such as "A. Horizontal & Pin" and "C. Vertical & Pin".15 Since the image clearly shows a "Pin" type (THT) and a vertical PCB mounting, the "Horizontal" part of the BOM's description (or Sunlord's style "A") likely pertains to an internal characteristic of the bobbin or winding, such as the winding plane being parallel to the longest dimension of the core, rather than the overall component's orientation when mounted on the PCB. The PCB pattern provided in the user's image serves as the definitive guide for the intended mounting orientation.

### Physical Dimensions and Compatibility

The bobbin's dimensions are precisely engineered to be compatible with the PQ27/20 core and must fit within the overall external dimensions of the transformer package (A=28.0 Max, B=31.5 Max, C=29.5 Max). While specific bobbin dimensions for a Sunlord PQ27/20 are not explicitly detailed in the provided snippets, information for slightly smaller PQ20 bobbins offers a valuable reference. For example, PQ20 bobbins are noted with sizes such as 23.3mm x 23.2mm x 18.5mm 16 or 23.5mm x 23.5mm x 22mm.14 These dimensions are consistent with the bobbin fitting within the A2005016 package, which has overall dimensions around 28mm x 31.5mm x 29.5mm. The bobbin's design provides the necessary structural support for the windings, ensuring precise winding geometry, maintaining critical insulation distances between turns and windings, and providing robust electrical isolation between the primary and secondary circuits and the core.

The following table provides the identified bobbin specifications:

| Item | Value | Conditions / Comments | Source |
| --- | --- | --- | --- |
| Material | Phenolic | Specified in BOM | 1 |
| Pin Count | 8 pins | (Note: BOM states 7-pin, but visual evidence from component image, PCB pattern, and winding schematic clearly shows 8 pins with pin 5 actively used for primary winding) | User Image1 |
| Pin Pitch | 2.5 mm (0.1 inches) | Inferred from recommended PCB pattern and typical standards | User Image14 |
| Mounting Style | Through-Hole Technology (THT), Vertical | (Note: BOM states "horizontal version," but PCB pattern and component shape indicate vertical mounting) | User Image1 |
| Winding Configuration | Primary: 32 turns (pins 1-5); Secondary 1: 2 turns (pins 6-7); Secondary 2: 2 turns (pins 7-8) | Based on winding schematic in user image | User Image |
| Approximate External Dimensions | Compatible with transformer package (28mm x 31.5mm x 29.5mm), similar to PQ20 bobbin sizes (e.g., 23.5mm x 23.5mm x 22mm) | Inferred from overall transformer dimensions and typical PQ bobbin sizes | User Image14 |

## 5. Conclusion

The resonant transformer utilized in the Infineon EVAL-2ED2101-HB-LLC 200W converter board, identified by the Sunlord part number ATWPPQ273230A300P-02 (and marked A2005016), is precisely constructed around a **PQ27/20 ferrite core** and a **Phenolic bobbin**.

The core material, **Mn-Zn Ferrite DMR50**, is a strategic choice, specifically optimized for its low core losses and stable magnetic characteristics when operating at the high switching frequencies (up to 500 kHz) characteristic of the LLC converter.1 This material selection directly contributes to the board's compact form factor, high efficiency, and effective thermal management capabilities. The bobbin, an

**8-pin, Through-Hole Technology (THT)** component, is designed for vertical mounting on the PCB. It is important to acknowledge the discrepancy with the Bill of Materials' "7-pin" description, which is contradicted by the clear visual evidence and functional winding schematic, and the "horizontal version" style description which likely pertains to an internal winding orientation rather than the external mounting.

The selection of a PQ-type Mn-Zn ferrite core is highly appropriate for the 200W power output and the demanding high-frequency operation of the LLC converter. This choice directly contributes to the board's compact form factor, high efficiency, and effective thermal management. The phenolic bobbin provides robust electrical insulation and mechanical support for the precisely wound primary (32 turns between pins 1 and 5) and secondary (two 2-turn windings, one between pins 6 and 7, and another between pins 7 and 8) coils. This structural integrity and insulation performance are paramount for ensuring long-term reliability and safety under the operational voltages and temperatures. The specific winding configuration and the specified primary inductance of 168 μH are integral to establishing the resonant characteristics required for the efficient Zero Voltage Switching (ZVS) operation of the LLC converter within its intended frequency range. This detailed component analysis underscores the meticulous engineering considerations involved in selecting and integrating specialized magnetic components to achieve high performance, efficiency, and compactness in advanced power electronics designs.

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