Usage of pulse-edge transformer in secondary-controlled flyback applications

For EZ-PD™ PAGxS/PAGxP-based Type-C power adapter applications

Abstract

The pulse-edge transformer (PET) is used as a medium to transmit PWM pulses from a secondary-side controller, such as EZ-PD™ PAGxS, to a primary-side controller, such as EZ-PD™ PAGxP, for AC/DC applications targeting the power adapter segment.

This article explains the advantages of PET over the conventional opto-coupler based approach.

by

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1 Introduction

PAGxP works with a secondary-side controller, PAGxS. Figure 1 shows the application diagram of a USB Power Delivery (PD) Power Adapter solution with 'PAG2P +PAG2S'. In this system, once the start-up phase is complete, the primary FET control is completely synchronized to the PWM pulses received from the secondary side. The PWM pulses are transmitted over an isolation barrier using the pulse edge transformer (PET).

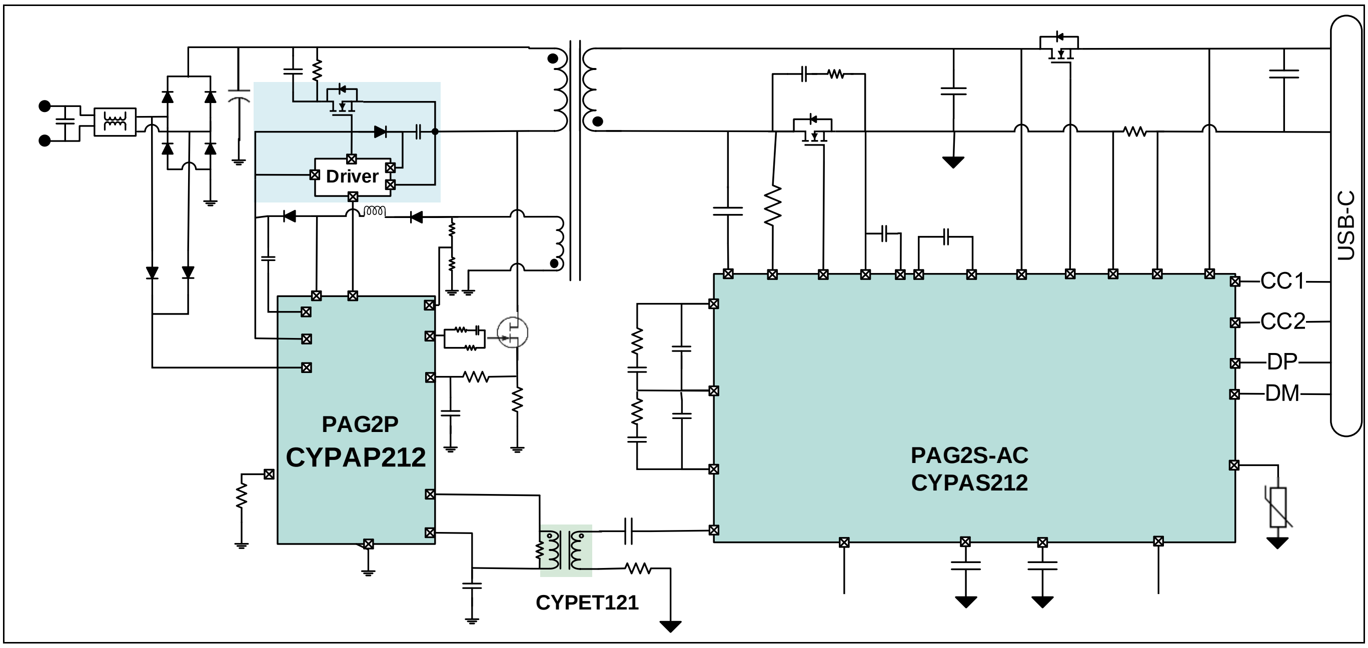

Figure 1 PAG2P +PAG2S USB Power Delivery (PD) power adapter solution application diagram

Using a PET in this secondary-controlled flyback helps to transmit high-frequency signals to primary. In the above scenario, PAG2S CYPAS212 uses time division multiplexing (TDM) to differentiate between PWM (low-side) and ACF (high-side) gate signals. A complimentary primary-side controller, CYPAP212, decodes these signals accordingly.

This white paper describes the merits of using PET in this architecture. It also compares the advantages of PET over the conventional optocoupler-based approach for passing the PWM over an isolation barrier.

2 Ease of construction and building a PET

The design of a PET mainly depends on different parameters such as inductance, power rating, impedance, low to high voltage level, size, operating frequency, frequency response, winding capacitance, and packaging.

The pulse transformers used for PAGx-based designs are smaller in size (R 4 mm x H 2.15 mm) due to the high frequency operation and lower value of inductance. The lower value of inductance results in fairly fewer turns, which in turn results in low leakage inductance and interwinding capacitance of this transformer.

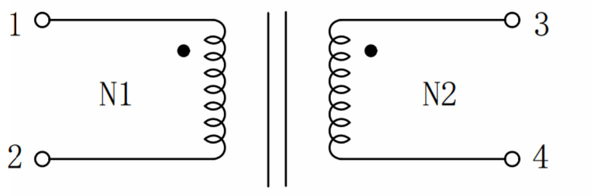

Figure 2 Circuit diagram

Infineon has two PET variants: CYPET121 and CYPET131. Refer to the following table to select the appropriate PET part number based on the system.

System	Turns-ratio (N1:N2)	Part number
PAG1P-PAG1S	1:3	CYPET131
PAG2P-PAG1S		
PAG2P-PAG2S	1:2	CYPET121

More details can be found in the EZ-PD™ PAGxP - PAGxS pulse edge transformer (PET) datasheet.

3 System benefits using PET

As the demand for smaller form factors and higher energy efficiency for charger/adapter grows, the wide bandgap (WBG) device technology is gaining popularity. To use the potential of WBG and thus improve the power density and efficiency, the switching frequency levels of converters are in the order of 300 kHz to 400 kHz. The higher switching frequency also requires faster control or response time and thus higher system bandwidth. The PAGx architecture uses a secondary side control, which eliminates the dependency on the galvanic isolator component for system bandwidth. The galvanic isolator is required in PAGx designs to provide the PWM signal from the secondary control PAGxS to the primary side controller PAGxP.

A PET is used for this purpose, as against the conventional approach of using optocouplers because the PET offers several benefits over an optocoupler for designing a reliable system. The following sections highlight the benefits of PET with respect to few key design parameters:

Response time: The PET offers a very predictable response time, which can be controlled or designed by transformer inductance and other passive elements such as resistors and capacitors in the circuit. The response time of the PET is immune to aging, temperature, input drive current, and other external factors. The optocoupler response time is a function of many factors such as aging [3], temperature, forward current (IF), and load resistance on the secondary side (transistor side [2]). The optocoupler response time variation is mainly attributed to its current transfer ratio (CTR) variation due to these factors.

Non-linear CTR variation of optocoupler w.r.t. forward current (IF): The CTR of the optocoupler varies with IF nonlinearly [2]; that is, CTR continues to improve/increase with IF up to a certain value and then it starts reducing. Therefore, ensure you select the optocoupler IF carefully.

Common-mode transient immunity (CMTI): The higher switching frequency and higher power density designs are also prone to noisy environments for the circuit to operate. Thus, the CMTI becomes imperative for reliable operation. Optocouplers require additional/external components at the input and output circuit to improve the CMTI [4]. Input and output circuit modifications that help to increase optocoupler performance include an external (instead of internal) pull-up resistor, reverse biasing, or shorting the LED and an external RC to filter momentary output glitches. In case of PET, the CMTI design parameter depends on and can be controlled by the winding method. The PET does not require any external components for higher CMTI.

External power supply: The PET eliminates the need for isolated power supply that is a must for optocoupler based systems. This, in turn, saves power because PET consumes power only when it is driven; else, it is just a passive device. However, the optocoupler is an active device which requires a separate isolated power supply.

PWM and communication signals: The PET gives the flexibility of transmitting the high-frequency PWM signal, and is not limited to the feedback signal as in the case of the optocoupler. This high-frequency PWM signal helps in secondary control. In addition to the PWM signal, PET also enables a high-bandwidth communication between the secondary and primary-side controller. This, in turn, gives us an opportunity to significantly improve system bandwidth and enable certain protections swiftly. Additionally, PAG2x implements time division multiplexing (TDM) using PET to differentiate between low-side PWM and high-side ACF signals.

4 Value proposition and advantages of a PET

This white paper presents the PAGx architecture-based secondary-side control using PET. It compares the PET with the optocoupler over several key design parameters, which are important for designing high-frequency and high power density designs using WBG devices. The PET is clearly the more predictable and controllable galvanic isolator component. In addition, the PET provides the flexibility of transmitting PWM and communication signals over the same link without changing the bias circuitry. Therefore, the PET is a clear choice of a modern converter, which operates with several hundreds of kHz switching frequency and eliminates design constraints on space.

References

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Glossary

ACF

Active Clamp Flyback

CTR

Current transfer ratio

IF

Forward current

PAG2P

Power Adapter Generation 2 Primary

PAG2S

Power Adapter Generation 2 Secondary

PET

Pulse edge transformer

WBG

Wide Bandgap

Revision history

Document revision	Date	Description of changes
**	2023-09-01	New white paper

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