ISSN: 1863-5598

ZKZ 64717
04-15

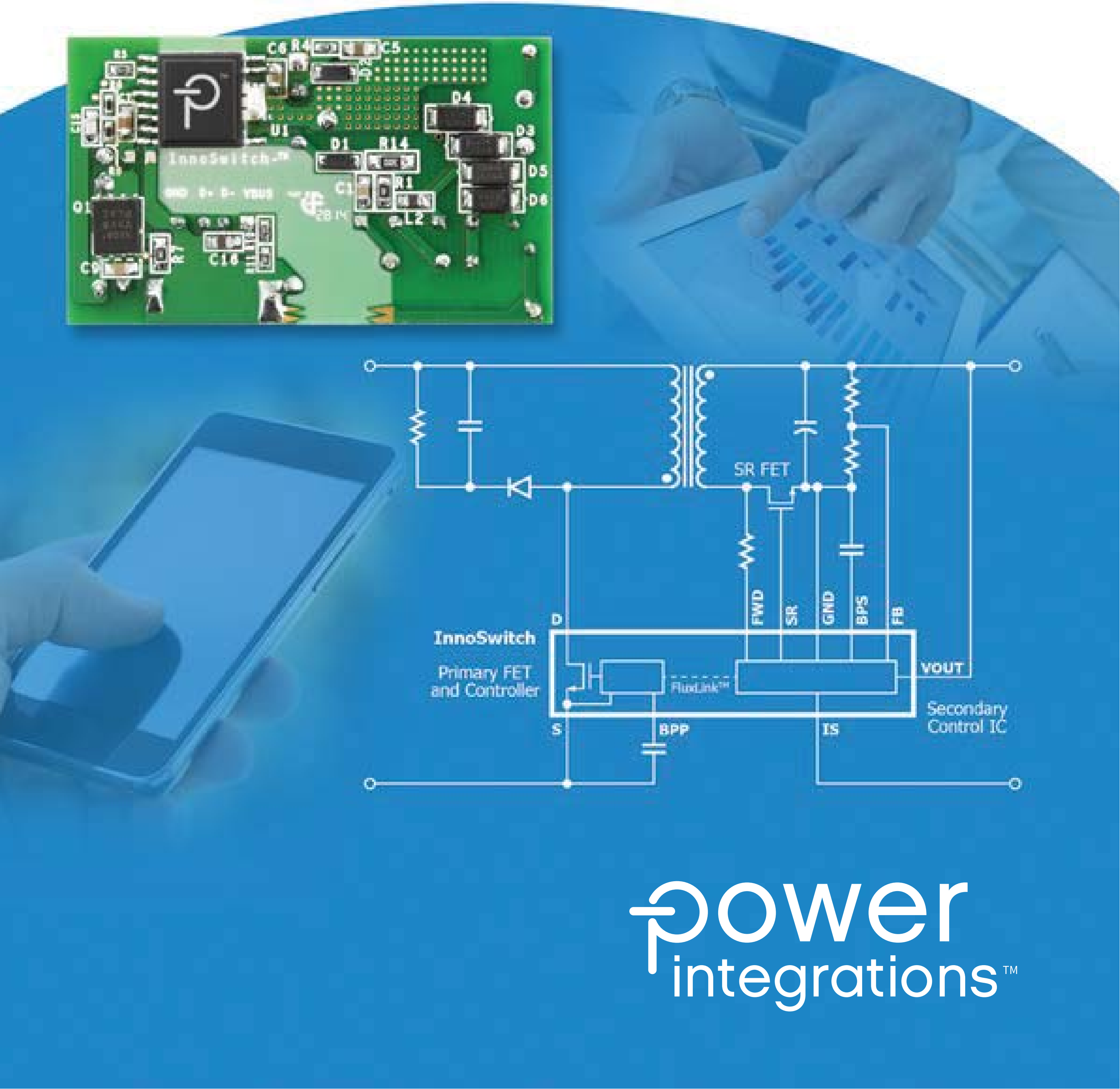
Bodo´s Power Systems®

Electronics in Motion and Conversion

April 2015

Simplifying Synchronous Rectification in Flyback Power Supply Design

Page 22



Read online and search for key subjects from all articles in Bodo's Power Systems by going to Powerguru: www.powerguru.org

CONTENT

Wireless Power Transmission with High Efficiency and Wide Dynamic Range for Extensive Applications

Wireless power transmission has been known for many years, with inductive near field proximity coupling being the most commonly used technology.

By Markus Rehm, Ingenieurbuero Rehm, Villingen-Schwenningen, Germany

The demand for wireless power supplies is huge: Mobile devices, charged without wire or contact, are robust, splash proof, reliable, simple to protect against humidity, sea water, dust, vibrations and explosion and are easy to sterilize. Mobile robots or operation terminals, medical equipment, implanted sensors, amplifiers, pumps and transceivers and e-mobility are some of the predestined applications.

After an enthusiastic start the industry has realized that there are some technical challenges regarding loose coupling, efficiency and EMI.

The „universal Wireless Power" („uniWP") presented here represents a new solution to overcome the existing technology barriers.

Traditionally, wireless power transmission uses coupled resonance circuits, where the power transmission reaches its maximum, when the resonance frequency of the two circuits are identical and the transmitter operates at this resonance frequency. Unfortunately the resonance frequency of this coupled arrangement changes due to variations or drifts in the components (tolerances, aging and temperature) and in the coupling (mispositioning- or geometric changes between transmitter and receiver). Even load changes on the receiver side cause the resonance frequency to change as well.

The solution adopted by WPC´s QI [1] and others senses the resulting resonance frequency, when a receiver becomes coupled with a transmitter. Power can be transmitted only, if the system works in resonance. That means transmitter frequency and resonance frequency have to be equal. The resonance frequency depends on several factors, such as the load, the rectification, components in the primary and secondary resonance circuits and of course the coupling. If one of these factors change, for example the load, the distance or a capacitor gets a bit warmer, the resonance frequency changes as well. In normal applications some of these factors change permanently, so the resonance frequency is dynamic, it changes continuously. There is no power transfer at all, if the transmitter frequency does not correspond exactly to the resonance frequency. Additionally, the tight standardization down to circuitry- and component level severely limits adaptability to future evolutions.

Unfortunately, there is no possibility to determine the resonance frequency actively. In fact, the generator is the slave of the various parameters of the resonant circuit.

Can coupled resonant circuits be equivalent to a wired connection?

Wireless power supplies operate with inductive near field transmission. You can imagine that like a transformer. Primary and secondary winding are close together, there is almost no leakage inductance and the coupling factor is almost equal to 1. Conventional wireless power supplies work similarly. They need constant and tight coupling like in the electric toothbrush. But that´s not what the user wants! Normal applications have some distance between transmitter and receiver, perhaps a shifted position, maybe vibrations. So in reality we have a coupling factor much smaller than one, and a leakage inductance much larger than zero, which is even dynamic.

Actually, the large leakage inductance is not a problem, because it can be compensated with a resonance network via its quality factor Q. A low coupling factor k can be compensated with a high quality factor Q

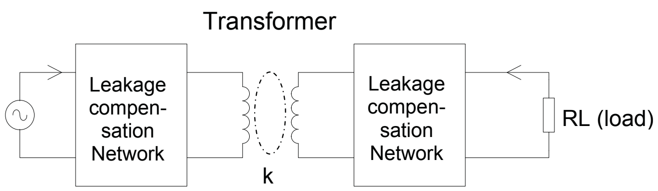


Figure 1: Inductively coupled wireless power transmission link using leakage compensation networks

One defines: Undercritical coupling, critical coupling and overcritical coupling (see Figure 2).

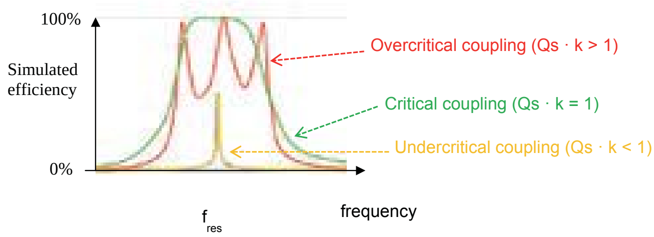


Figure 2: Theoretical efficiency in different coupling conditions

The critical coupling (green curve) is the equivalent of a wired connection. A further increase in Qs moves the system into an over coupled condition state (bifurcation), wherein there is no stable resonance frequency any longer (red). Over coupling must be avoided, because it increases losses and the semiconductor break down due to overstress. To avoid overcritical operation, common systems work in under critical coupling condition (yellow), which results in very low efficiency and very small bandwidth.

Summary: Conventional wireless power supply fail because of the dynamic resonance frequency, the low efficiency and the high electromagnetic emissions.

The new technology „uniWP“ has two main innovations. One is a large signal VCO, which guarantees independent, fast and stable resonance tracking. Thus, the system is not dependent on the given resonance frequency, because it can determine it itself. The new system uniWP has the ability to adjust the resonance frequency. Second innovation is the guaranteed linear operation with limitation to its physical limit, by avoiding over critical coupling. uniWP detects over coupling condition and takes measures against it. The system can work in critical coupling state, (green curve) which means 100% efficiency in theory.

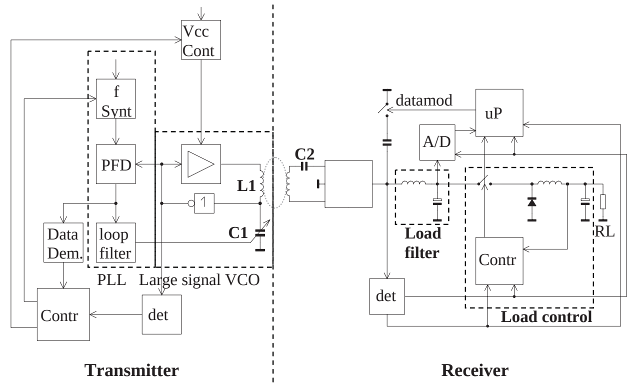


Figure 3: Block diagram of a wireless „uniWP“- transmission link example

New solution „uniWP“ with high efficiency

If the resonant circuit is driven precisely at its resonance frequency, the wireless transmission link behaves like a real transformer. This automatically results in the optimum matched condition since the real load is directly transformed to the transmitter side. This is exactly what occurs in „uniWP“ technology.

The maximum efficiency is achieved under the critical coupling condition as explained above.

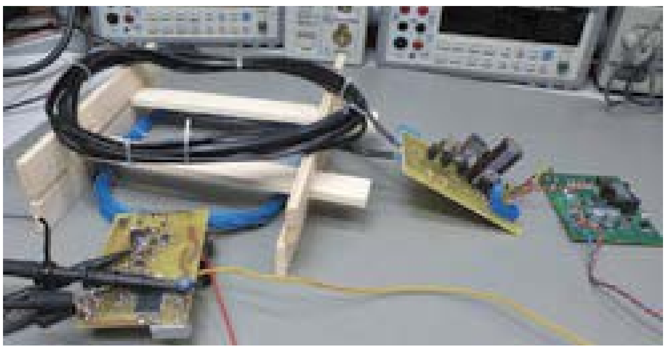


Figure 4: One example of „uniWP“: Transmitter with blue loop antenna, receiver with black loop antenna, synchronous rectification board and buck-boost-converter for a controlled output, here 24 Volt.

The „uniWP“ concept was verified with a regulated output voltage on the secondary side.

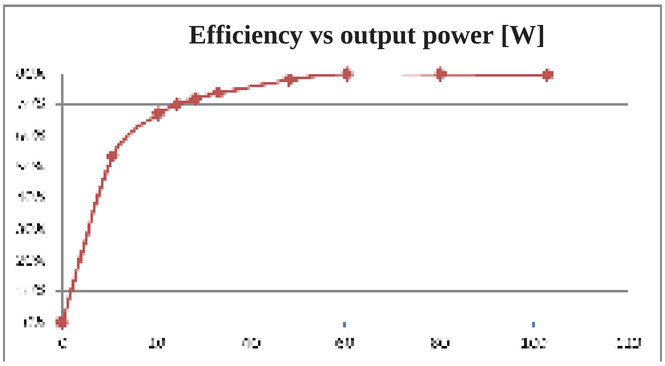


Figure 5: Efficiency of the example as shown in figure 4. There is no auxiliary supply! The distance between transmitter and receiver is approx. 4cm. The output voltage is a controlled 24 Volt.

New solution „uniWP“ improves EMI

Thanks to the high dynamic in the new „uniWP“ large signal resonance frequency control loop, arbitrary frequency spectrums can be generated through software (frequency synthesizer).

Figure 6a depicts a discrete output transmission frequency peak (134 kHz) and Figure 6b shows sweep operation (120 … 134 kHz).

The „uniWP“ frequency spreading feature allows a reduction in the spectral density of 10 dB for the same transmitted power!

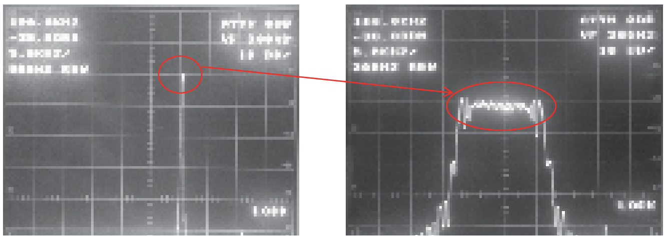


Figure 6a): Transmitter output spectrum in discrete frequency operation

Figure 6b): Transmitter output spectrum in sweep frequency operation

In this manner federal frequency standard EN300330 (Figure 7) can easier be achieved by software without any hardware change (synthesizer frequency data). Thus, frequency notches can be generated at excluded frequencies in the swept frequency hopping mechanism in order to comply with additional national regulations.

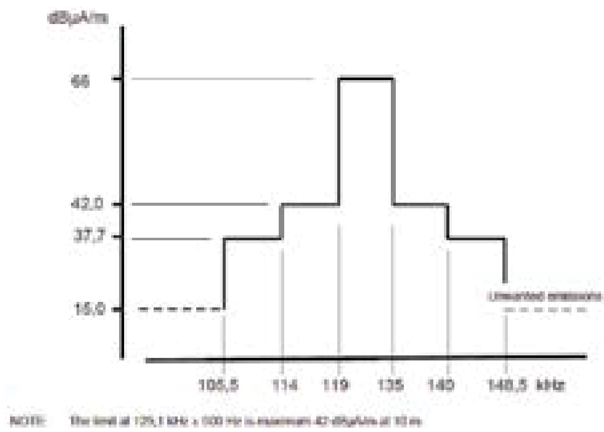


Figure 7: Excerpt from EN300330

EN300330 and others specify the maximum levels in the specific frequency range. Consequently, thanks to the frequency spreading feature, „uniWP“ can transmit higher power levels than all other wireless transmission solutions.

	Known arts	*uniWP*
Resonant frequency is not inside the allowed band	No power transfer	maximum power transfer, because of large signal VCO
Dynamic load and coupling condition	No power transfer	maximum power transfer, due to fast resonance tracking
Efficiency	Low	High, due to critical coupling
Power	A few watts	Up to 200W (1kW planned)
Area of application	Different for each region	Wordwide (frequency management sw.)
Range	Small range	Long range due to high quality factor
Number of receiver	One	Several
Coupling	Tight	Tight or loose
EMI performance	Low	High
Flexibility	No (standard)	High
Data transfer included	Yes	Yes
Cost	High, small tolerance components	Low, only standard components

Table 1: Comparison

Summary

The concept to transmit power over a wireless link according to „uniWP“ allows multiple new applications and features. The advantageously insensitive operation even in harsh and dynamic coupling environments allows the system to be operated at the maximum physical limit. The simple power scalability far outperforms existing solutions. The research activities driven by cost, reliability and practical constraints demonstrate uniWP is a good solution for future product implementations and is well suited for future evolution.

References

[1] WPC: http://www.wirelesspowerconsortium.com/
[2] A4WP: http://www.a4wp.org/index.html
[3] PMA: http://www.powermatters.org/
[4] Si, Hu, etc: A Frequency Control Method for Regulating Wireless Power to Implantable Devices, IEEE 1.3.2008
[5] S. Chopra, P. Bauer: Analysis and Design Considerations for a Contactless Power Transfer System, IEEE 2011

Contact:

Ingenieurbuero Rehm, Tiroler Strasse 10,
D 78052 Villingen-Schwenningen, Germany
Tel.: +49 (0) 7721 / 73717,
Email: rehm@ib-rehm.de.

www.uniwp.de

www.ib-rehm.de