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FSK Demodulation in Wireless Charging Technology

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ABSTRACT

Wireless charging is a technology that eliminates the need for physical wire connections to charge portable electronics like cell phones, earbuds, and accessories. The Wireless Power Consortium is an international group that supports wireless charging. In-band communication is used by the transmitter and receiver in wireless charging. AM modulation will be used by the receiver to communicate with the transmitter, and FSK modulation will be used by the transmitter to communicate with the receiver. Communication in wireless charging technology is half-duplex type.

To decode the data that the transmitter transmits, the receiver must implement FSK Demodulation. Due to the extremely small time difference between the carrier and modulator signals, standard FSK demodulation techniques using PPL-based or Filter-based methods will not work. In the document, FSK demodulation method is developed which can decode the data. It uses a sampler to output a sampled signal that has been through a low pass filter after sampling the FSK signal. This is sent to a device that can detect frequency shifts, the frequency shift detector.

Keywords: FSK Demodulation, AM modulation, Xilinx ISE tool, Wireless Charging Technology

I. INTRODUCTION

The technology of wireless charging will be covered in this chapter. The first wireless charging standard in the world, known as Qi (pronounced "chee"), can supply 5 to 15 watts of power to small personal electronics. Despite being primarily used to power smartphones, the standard can be easily and effectively used to power an increasing number of consumer goods. Today's market has over 3,700 products that are Qi-Certified, and Qi offers a positive and secure wireless charging experience. The wireless power consortium is a company that promotes wireless charging technology on a global scale.

Since the invention of the technology, the adoption of QI Standard has significantly increased. The demand for wireless charging products has grown recently, and all low power consumer electronics now use them. The two main benefits of wireless charging are durability and the ability to charge consumer electronics without having to physically insert a wire. More comfort and superiority

II. LITERATURE SURVEY

Roland Hessler, T. Lehmann, G. J. Suaning, L. H. Jung, P. Byrnes-Preston, and Nigel Lovell a novel digital frequency-shift keying (FSK) demodulator and a dual-link coil arrangement are presented in "A Dual Band Wireless Power and FSK Data Telemetry for Biomedical Implants ". This system is primarily used for inductively powered biomedical implants. Data and power are sent to the implant through two different links. In a configuration that minimizes magnetic interference between the two pairs; two sets of coils are used.

The presented demodulator circuitry solely relies on delaying components, sampling the initial digital FSK signal with a delayed digital FSK signal. Although the FSK signals can be used to create a synchronized clock on their own, using the power signal to do so allows for higher data rates and less complicated receiver circuitry. Receiving a 4.17/6.25 MHz FSK carrier signal synchronized with 2.083 MHz clock derived from the power carrier, the system was implemented on the bench and experimentally tested at a data rate of 2.083 Mbps with zero bit error rates. The power link was programmed to output 58mW.

FSK-Based Frequency Splitting-Based Simultaneous Wireless Information and Power Transfer in Inductively Coupled Resonant Circuits. At short distances, the so-called frequency splitting phenomenon has an impact on inductively coupled resonant circuits. In the area of power electronics, tracking one of the peak frequencies is state of-the-art. The frequency splitting effect, however, is frequently disregarded in the data transmission community. Modulation strategies in particular have not yet been modified to account for the bifurcation phenomenon.

In contrast to most other modulation schemes, we contend that binary frequency shift keying (2-ary FSK) is a low-cost modulation scheme that closely matches the double-peak voltage transfer function H(s), especially when the quality factor Q is high. In addition, we demonstrate that the rectified 2-ary FSK (RFSK) is even more appealing from the standpoints of output power and implementation. The bit error performance, the impulse response, and the efficiency factor are among the analytical and numerical contributions. It is suggested to use a low-cost non-coherent receiver. An experimental prototype serves as support for the theoretical analyses.

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III. FSK DEMODULATION USED IN WIRELESS CHARGING SYSTEM

The suggested technique for FSK Demodulation used in wireless charging systems is described in the chapter below. Power receiver module's coil voltage is fed to the FSK demodulator logic, which includes Zero Cross detector, Sampling, Ref Clock, Filter, Frequency shift Decoder and Packet Decoder blocks.

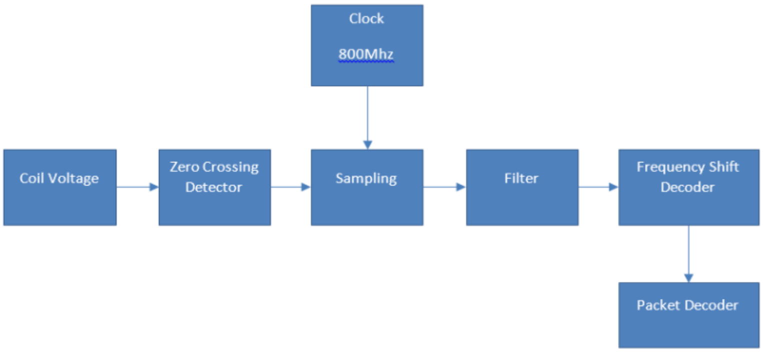

Figure 1: FSK Demodulation block diagram

Zero Cross Detector: Through a voltage divider, the coil voltage is fed to a zero crossing detector, which produces a square wave based on the input coil voltage.

Sampling: The sampling circuit takes a sample of each rising clock edge's square wave.

Ref Clock: The sampler module receives the ref clock and samples the date using it. The stability of the reference clock and the operation's frequency have an impact on the sampling module's accuracy. Better frequency change detection will be achieved with a higher ref clock.

Filter: The samples that do not operate within the range of wireless power transfer are filtered by the filter circuit (wireless charging devices operate between 85 KHz and 210 KHz). This filter will prevent erroneous decoding.

Frequency Shift Decoder: This module will determine how the frequency of the filter output changes. The number of samples in each clock cycle will be output by the sampler. Frequency shift is found based on the number of samples present in each cycle.

Packet Decoder: The FSK packet that comes from the frequency shift decoder will be decoded by the decoder.

Frequency Detector: This module determines the duration of each pulse using the FSK modulated signal that the transmitter transmitted to the receiver as a response or message. It travels through synchronization flip flops to the bit encoding module. Due to the fact that the frequency detection module operates at frequencies of 100MHz or higher, it has the

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resolution to detect deviations of 30ns between the operating frequency and the modulated frequency. Below is a description of the frequency detector flow chart.

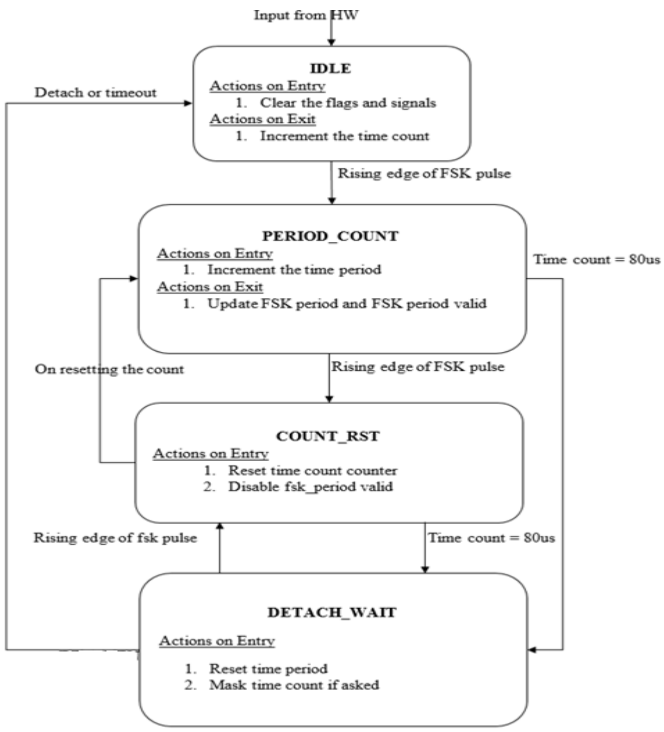

Figure2: FSK Demodulation Flow Chart

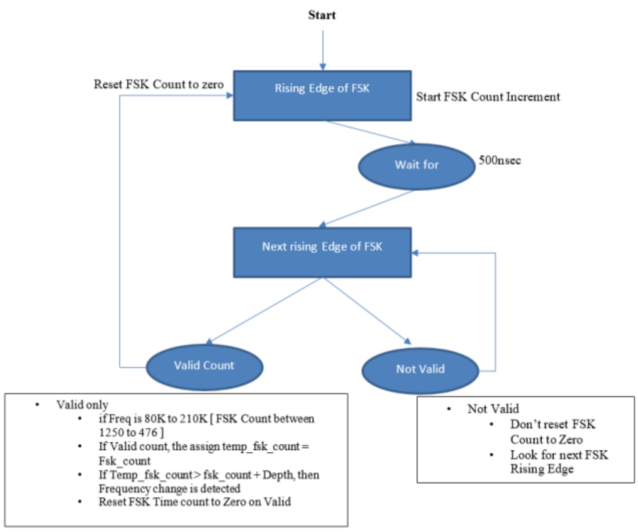

Figure3: FSK Demodulation Filter flow chart

IV. RESULTS

The FSK demodulated output between a wireless transmitter and wireless receiver is practically captured below using a frequency finder and packet decoder logic. The maximum output frequency for FSK modulation should be 2 kHz. Here, the marked data indicates unexpected data. It goes beyond 2 KHz. This is because the wireless charging coil voltage

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varies, which causes the hardware comparator to provide the FPGA with false data. To prevent this, we've added a filter that can get rid of the erroneous information coming from Comparator.

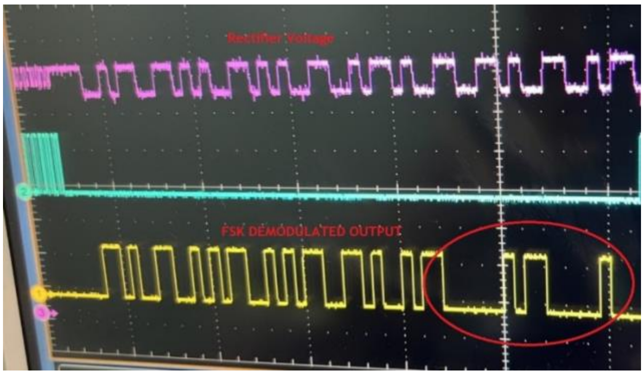

Figure 4: FSK Demodulation Result

FSK Filter

Considerations for MINIMUM_FSK_FREQUENCY = 80 KHZ
MAXIMUM_FSK_FREQUENCY = 220 KHZ

The FSK Filter module is added to the design to eliminate the frequency hiccups that were resulting in errors when identifying the bits. This module's purpose is to compare the current frequency to the next frequency in order to determine the frequency range.

Ideal Working Coil voltage waveform

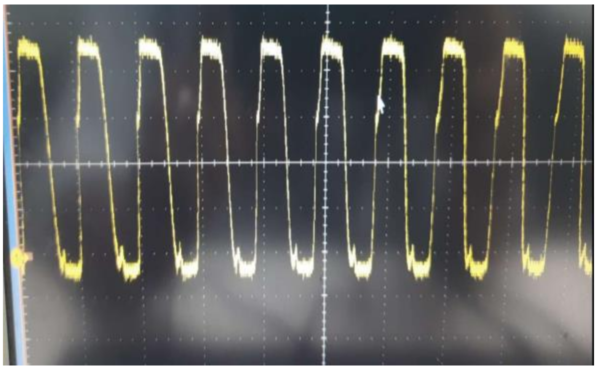

Figure 5: Ideal Coil voltage

Coil voltage waveform with Glitches due to Receiver load variations

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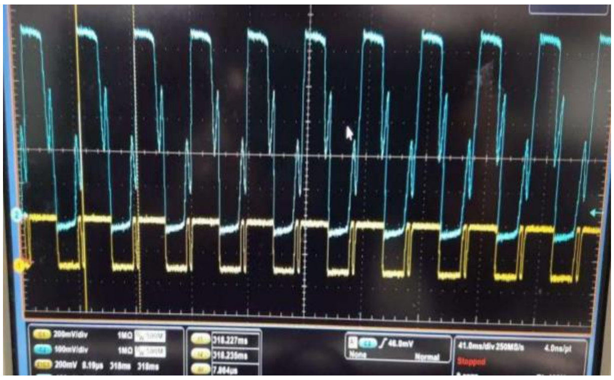

Figure 6: Coil voltage due to Load variations

Using a frequency finder, a frequency filter, and packet decoder logic, the data below was obtained between a wireless charger transmitter and a wireless charger receiver.

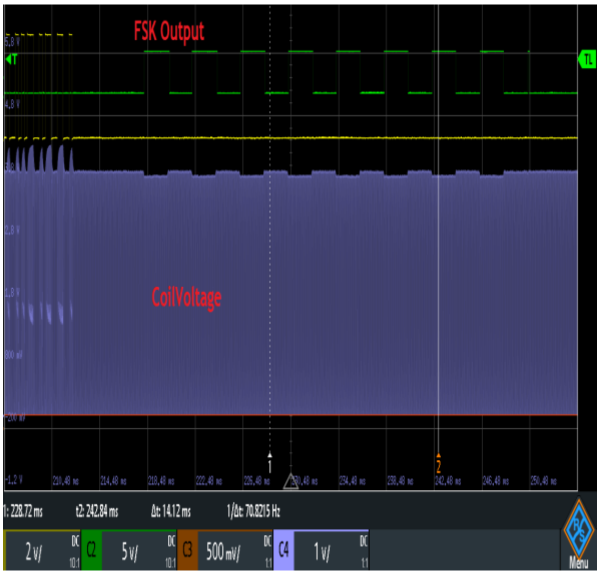

Figure 7: FSK Demodulation Results

V. CONCLUSION

There is a frequency finder, a frequency filter, and a packet decoder built into the FSK Demodulation logic. The wireless charger transmitter and receiver modules have been tested using the same logic. The output of the FSK Demodulation logic has been confirmed, and it has been compared to the wireless charging specification. The data packets produced by the FSK Demodulation logic arrived as anticipated. With the help of the Xilinx ISE tool and Xilinx 7000 Series FPGA hardware, the overall design is successfully completed. The proposed design will function under typical circumstances, in which the wireless charging signal (coil voltage) has proper cycles and experiences few variations. Future efforts will be made to enhance the FSK Filter, which will eliminate coil voltage variations.

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