

# **TB042**

# Interfacing a KEELOQ® Encoder to a PLL Circuit

Author: Lucio Di Jasio Microchip Technology Inc.

## **OVERVIEW**

Most of the recently introduced advanced KEELOQ Encoders, like the HCS362, HCS365, HCS370 and HCS412, have provisions for controlling a multiple stage RF transmitter or a Phase Locked Loop (PLL) circuit.

This Technical Brief will provide a few hints on how to interface advanced KEELOQ Encoders to widely adopted PLL ICs, namely Infineon TDA5100 and Temic U2741B.

# WHY USE A PLL

Traditionally in the consumer remote control market a PLL circuit was considered an expensive alternative to the standard single stage transmitter, which are typically SAW filter based or LC (free oscillator) based. With international regulations restricting their requirements in terms of allowed bandwidths, harmonics and emission power limitations, this alternative is becoming more and more a necessity. Further, the current market trends dictate the use of lower voltages and smaller batteries, like 3V lithium cells, while operating at higher frequencies (868 MHz vs. 300-434 MHz). For all of these cases, the PLL circuit is probably the only solution to comply with the new regulations while maintaining a reasonable efficiency and operating range.

# INTERFACING TO PLLS

The objective of this Technical Brief is not that of proposing any complete RF PLL application, but instead that of clarifying some of the details of the encoder configuration (programming) and the (logic) interface between the encoders and the RF stage. It is recommended that the reader refer directly to the corresponding Application Notes from the PLL ICs manufacturers (see References) for the actual design of the RF stage, proper dimensioning of all the components and PCB layout.

## THE RF ENABLE OUTPUT

HCS362, HCS365, HCS370 and HCS412 all offer the user a new output function. This function called RF Enable (or RFEN) is always multiplexed on a button input pin, but the actual pin chosen can vary with the encoder model for compatibility reasons.

The RF stage, whatever its nature, is assumed to be power hungry (as is the case of PLL circuits and/or more sophisticated multiple stage transmitters). Therefore, it is supposed to be powered off most of the time, in order to save energy and ensure the required battery life. The RFEN output has been designed to be used to activate the RF stage only a few milliseconds before the actual stream of data is output for transmission and deactivate it immediately after the data stream is completed.

Both the Temic and Infineon PLL ICs offer the ability to operate in the ASK and FSK modulation modes. The two modes are exclusive and pose different requirements in terms of timing for the signals to reach the PLL: RFEN or data first. In the following chapters, we will analyze the options available for each encoder.

# **HCS362 INTERFACE**

The HCS362 RFEN output offers only basic ASK functionality. The output goes high immediately after button debouncing is resolved and stays high until the output data stream is completed plus one extra elementary time unit (TE). Refer to the HCS362 data sheet [DS40189] Power-up and Transmit Timing Figure 8-1, Table 8-3, and parameter TRFON.

RFEN output can be used as an ASK enable signal by connecting it to the Infineon TD5100 PLL circuit enable input (pin 7), or for the Temic U2741B enable input (pin 2), while connecting the encoder DATA output to the corresponding PLLs ASK data input.

FSK modulation is not possible due to the fixed timing sequence of the RFEN output.

# HCS365/HCS370 INTERFACE

The HCS365/370 RFEN outputs offer both ASK and FSK functionality. The output timing can be programmed to produce the appropriate sequence for both modes of operation depending on the PLL bit in the configuration word of the encoders. Refer to HCS365 data sheet [DS41109] and HCS370 data sheet [DS41111], RF Enable and PLL Interface Chapter 3.5 (Figure 3-10).

In ASK mode, RFEN output can be used as an ASK enable signal, connecting to the Infineon TD5100 PLL circuit enable input (pin 7), or Temic U2741B enable input (pin 2), while connecting the encoders DATA output to the corresponding PLL ASK data input.

In FSK mode, RFEN output can be used as an FSK enable signal, connecting to the Infineon TD5100 PLL circuit enable input (pin 6), or Temic U2741B enable input (pin 1), while connecting the encoders DATA output to the corresponding PLL FSK data input.

Looking at the schematics presented in the appendixes, this results in a direct or swapped connection of the RFEN and DATA outputs of the encoder depending on the modulation method selected.

# HCS412 INTERFACE

The HCS412 RFEN outputs offer both ASK and FSK functionality as well. The output timing can be programmed to produce the appropriate sequence for both modes of operation depending on the AFSK bit in the encoder configuration word. Refer to HCS412 data sheet [DS41099], ASK/FSK Option (AFSK), Chapter 2.3.13.

In ASK mode, RFEN output can be used as an ASK enable signal, connecting to the Infineon TD5100 PLL circuit enable input (pin 7), or Temic U2741B enable input (pin 2), while connecting the encoder DATA output to the corresponding PLL ASK data input.

In FSK mode, RFEN output can be used as an FSK enable signal, connecting to the Infineon TD5100 PLL circuit enable input (pin 6), or Temic U2741B enable input (pin 1), while connecting the encoder DATA output to the corresponding PLL FSK data input.

Looking at the schematics presented in the appendixes, this results in a direct or swapped connection of the RFEN and DATA outputs of the encoder depending on the modulation method selected.

# **S3 AND RFEN MULTIPLEXING**

The HCS362, HCS365 and HCS412 multiplex the RFEN output function and the S3 button input function (S2 for the HCS412) on the same pin.

When the RFEN function is enabled (setting the corresponding RFEN bit in the configuration word), the button input functionality is still available but with certain limitations. The input button status is in fact tested only at the start of the first transmission and updated only 2 seconds after the last button is released. This results in a different transmission sequence when the multiplexed S3/ RFEN button input is used alone. The transmission is practically intermittent with a 2 second period. Queueing functionality is also not available in this specific case.

For these reasons it is recommended to always use the multiplexed button input in combination with other button inputs by using a couple of diodes and only if strictly necessary (see data sheet for typical circuits).

Note: The HCS412 is further multiplexing the same S3/RFEN (pin 3) with the LC1 input of the transponder resonant circuit. Therefore, the PLL control interface is NOT available in applications where the HCS412 transponder functionality is required or if it is fully used as a transcoder, like in Passive Entry or Proximity Activation applications.

# REFERENCES

Microchip Technology Inc.:

- HCS362 Data Sheet [DS40189]
- HCS365 Data Sheet [DS41109]
- HCS370 Data Sheet [DS41111]
- HCS412 Data Sheet [DS41099]

Infineon Technologies:

• TDA5100 ASK/FSK Transmitter Data Sheet and Application Note. (http://www.infineon.com/products/ics/pdf/tda5100.pdf)

Temic:

 U2741B UHF ASK/FSK Transmitter Data Sheet and Application Note. (http://www.temicsemi.com/products)

# **KEYWORDS**

KEELOQ, Encoder, PLL, ASK, FSK

# APPENDIX A: HCS362/365 INTERFACE TO TDA5100



APPENDIX B: HCS412 INTERFACE TO TDA5100



# APPENDIX C: HCS362/365 INTERFACE TO U2741B



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# APPENDIX D: HCS412 INTERFACE TO U2741B



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