

IEEE 802.15.4 HRP UWB PHY Waveform Creation

1. Overview

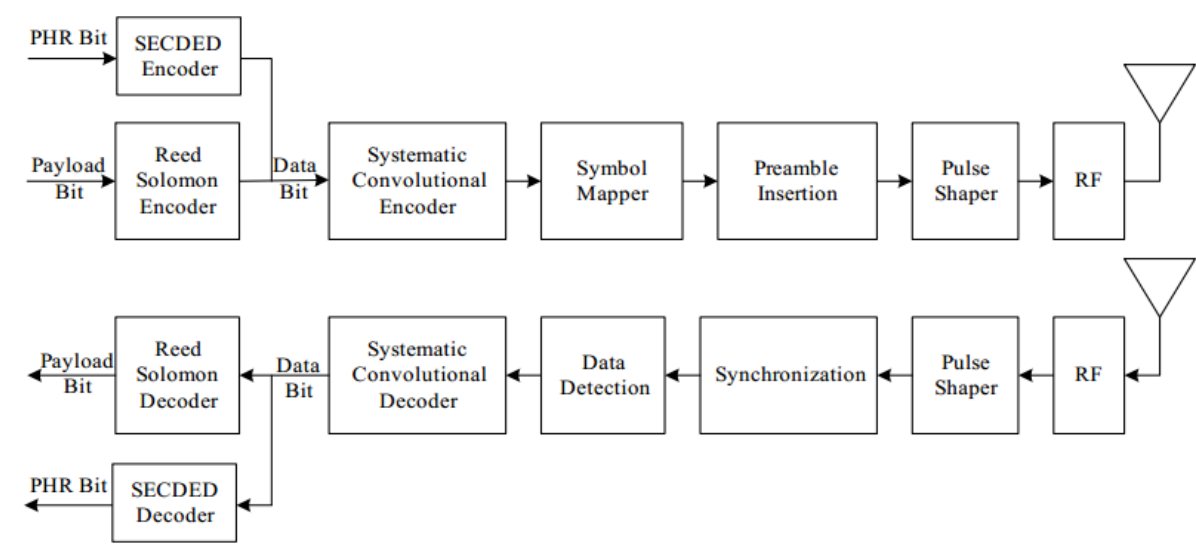


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IEEE 802.15.4-2015 defined the HRP (High Rate Pulse Repetition Frequency) UWB (Ultra-wide Band) PHY (Physical Layer) with the feature of precision ranging, which can be employed in a **low-rate wireless personal area network (LR-WPAN)**. The main objectives of a LR-WPAN are **ease of installation, reliable data transfer, extremely low cost, and a reasonable battery life**, while maintaining a **simple and flexible protocol**.

The HRP UWB PHY waveform generated from *Keysight Signal Studio for IoT* can be utilized to test UWB devices of users, such as the U1 chip in iPhone 11. The test solutions include **PER (Packet Error Rate)**, **TOF (Time of Flight)** and **AOA (Angle of Arrival)** measurement and verification.

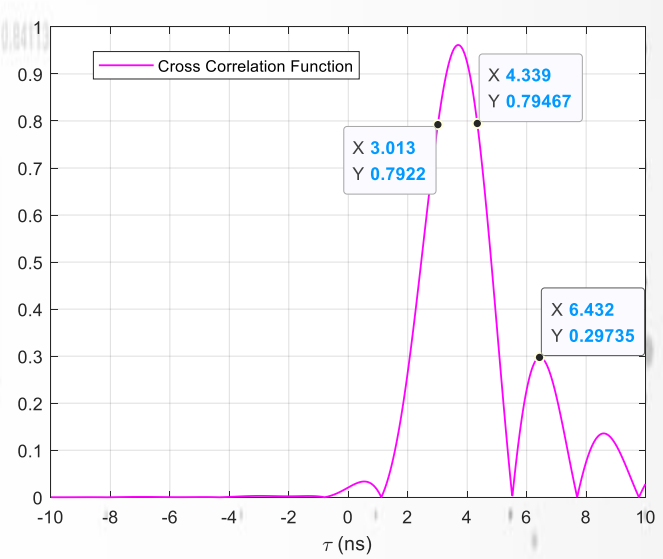
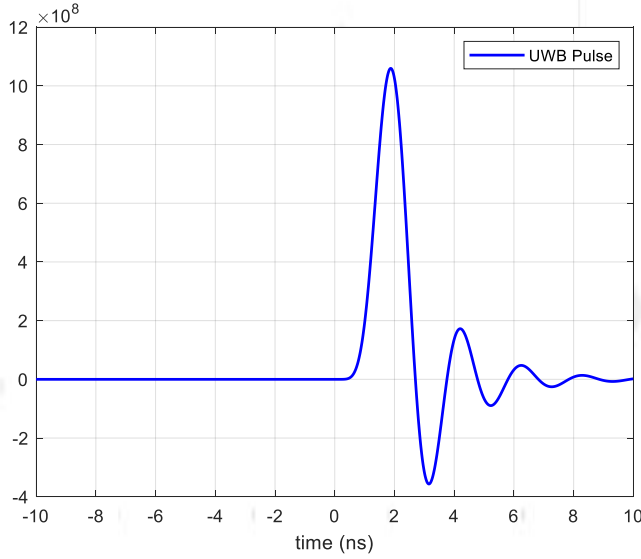
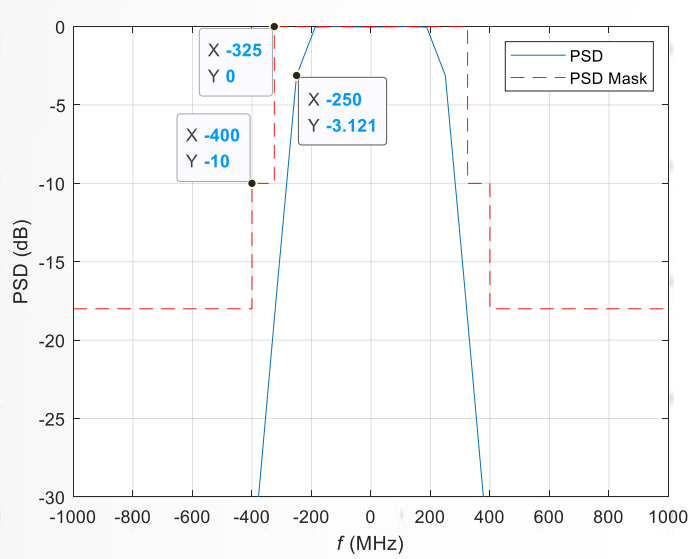
2. Signal Flow and Pulse Shape Design



HRP UWB PHY Signal Flow

The signal formats of HRP UWB PHY and HRP-ERDEV (Enhanced Ranging Device) PHY are respectively defined in IEEE 802.15.4-2015 and IEEE 802.15.4z (Draft 2019).

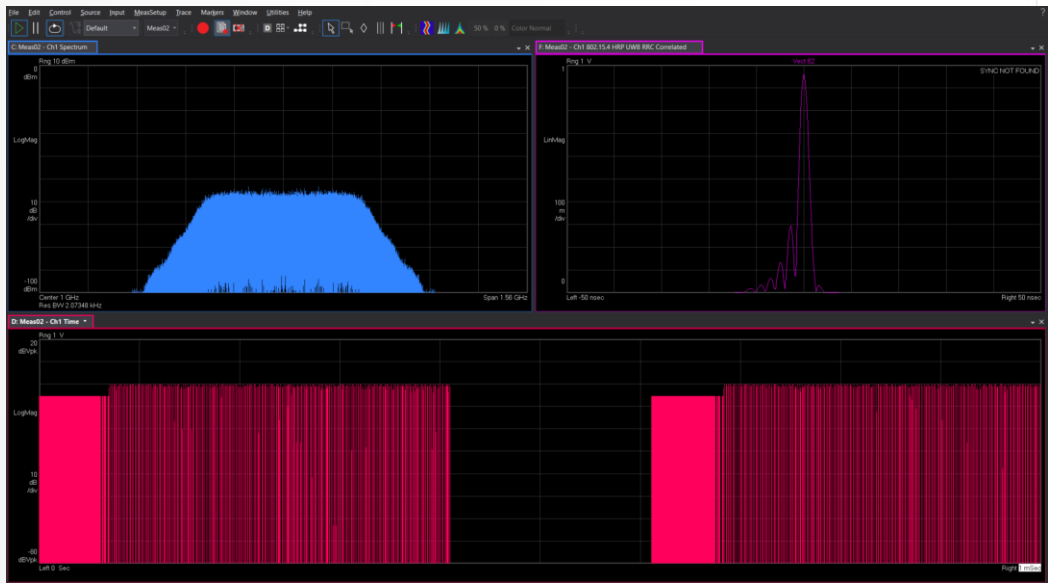
But the design of **the pulse shape** is open to developers. To meet the **PSD (Power Spectral Density) mask** and **Cross-correlation mask**, the **8 order Butterworth pulse** is designed as follows.



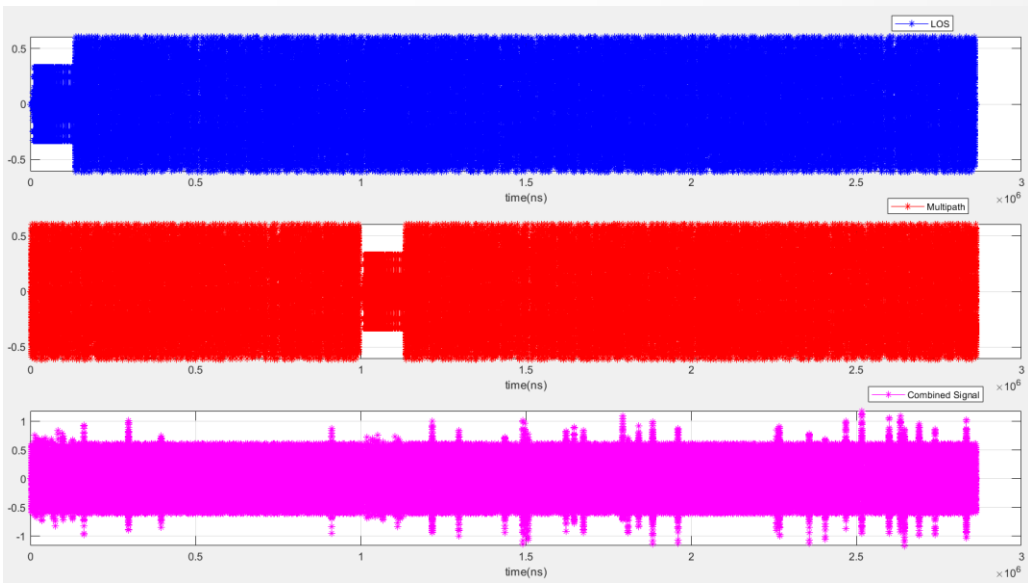
8 order Butterworth pulse with the cutoff frequency of 500MHz

$$p(x) = 2\varepsilon(t)\Omega_c \sum_{k=0}^3 e^{a_{pk}t}(a_{k_k} \cos b_{pk}t - b_{k_k} \sin b_{pk}t)$$

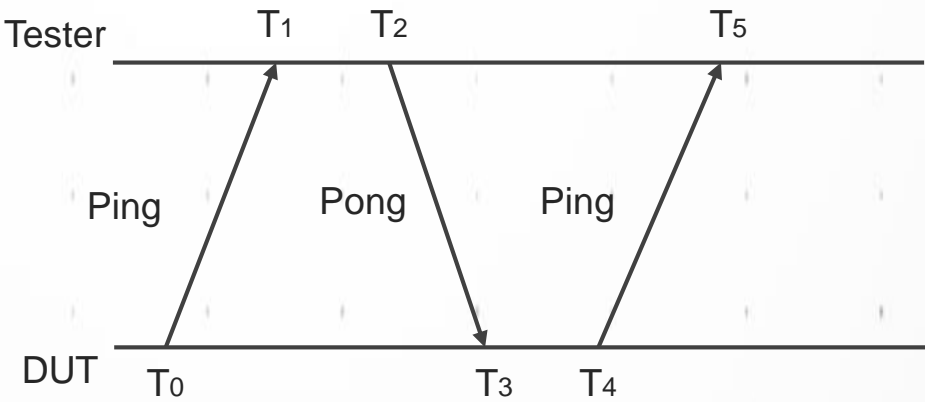
3. UWB Test Solutions



Waveform Generation and PER Measurements



Multipath Measurements



$$\frac{(T_3 - T_0)(T_5 - T_2) - (T_2 - T_1)(T_4 - T_2)}{T_4 + T_5 - T_0 - T_1}$$

TOF Measurements and Verification Combined with E7760A Wideband Transceiver (In Progress)