

IEEE 802.15.4 HRP UWB PHY Waveform Creation

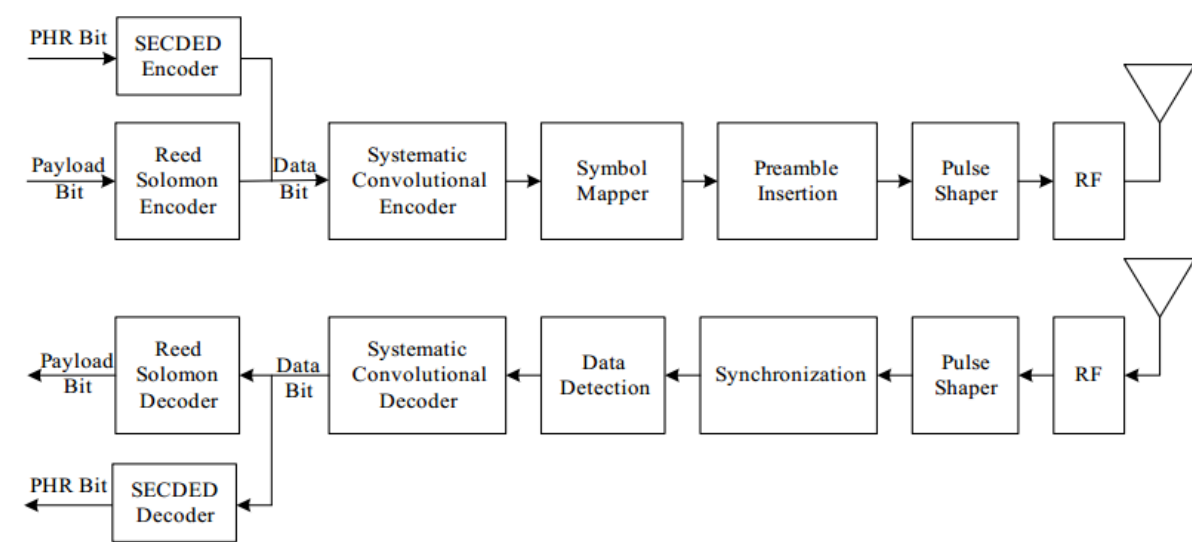
1. Overview



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.

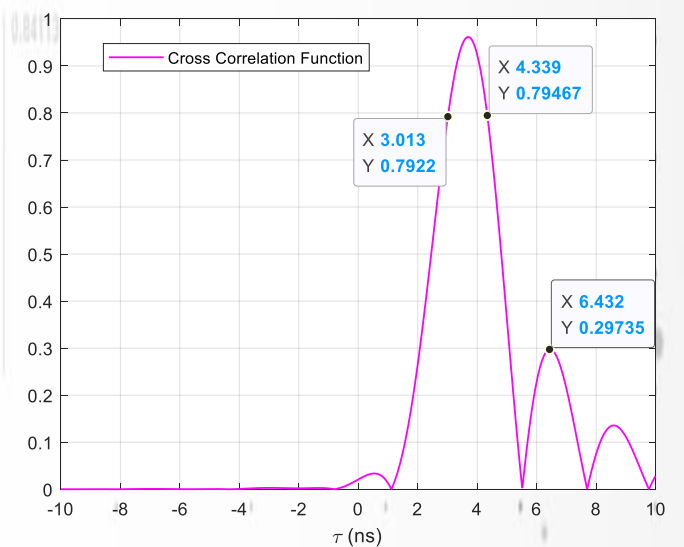
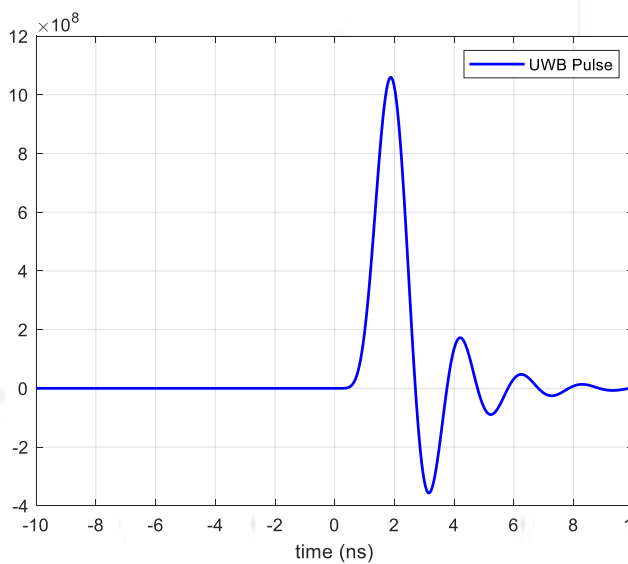
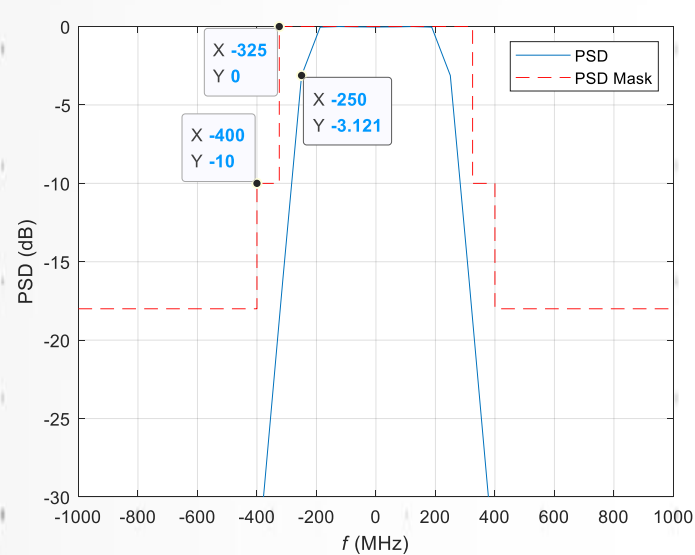
2. Signal Flow and Pulse Shape Design



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).

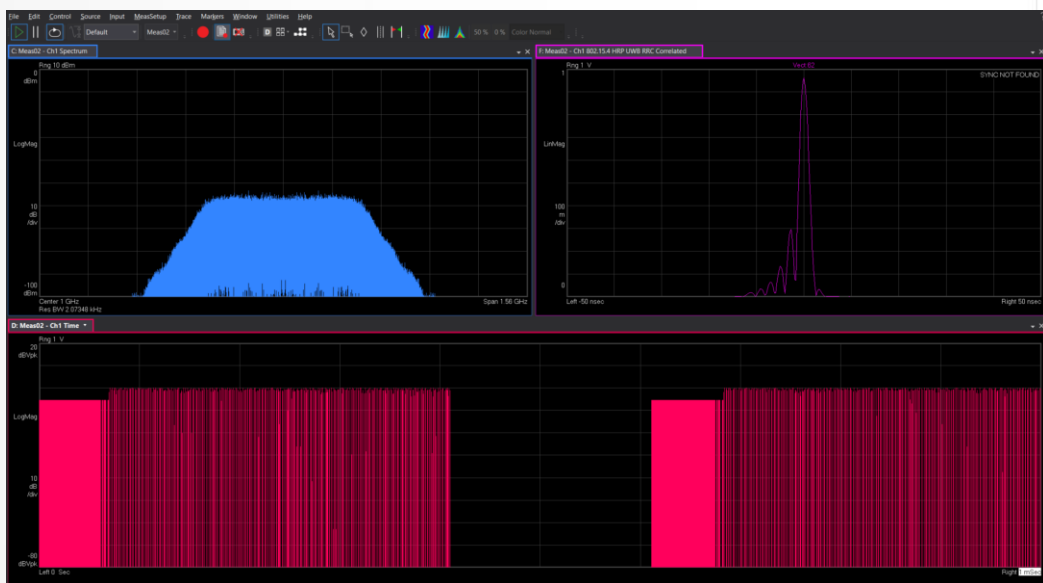
But the design of **the pulse shape** is open to developers. To meet the **PSD (Power Spectral Density) mask** and **Cross-correlation mask**, the **8 order Butterworth pulse** is designed as follows.



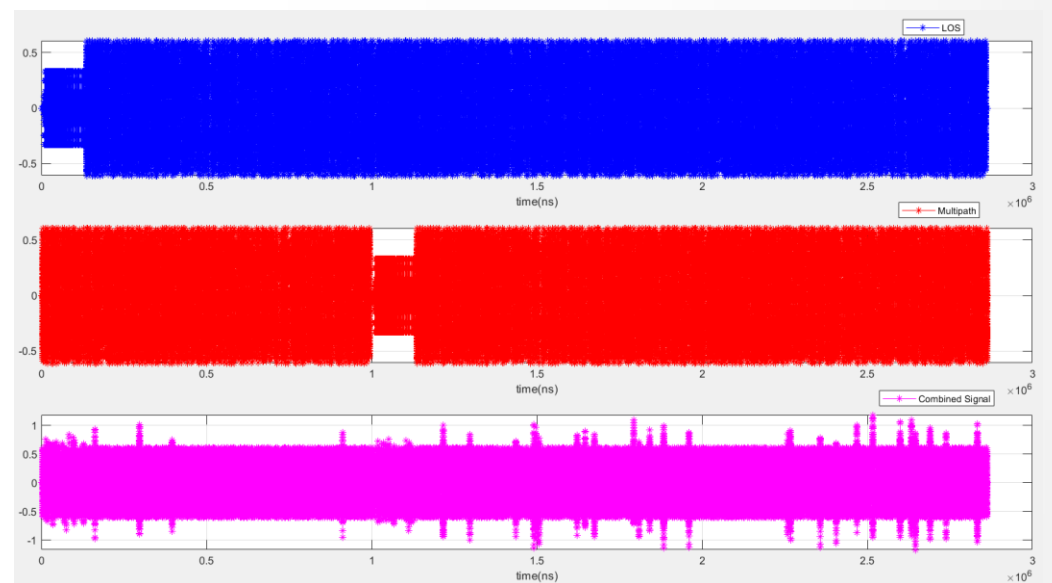
8 order Butterworth pulse with the cutoff frequency of 500MHz

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

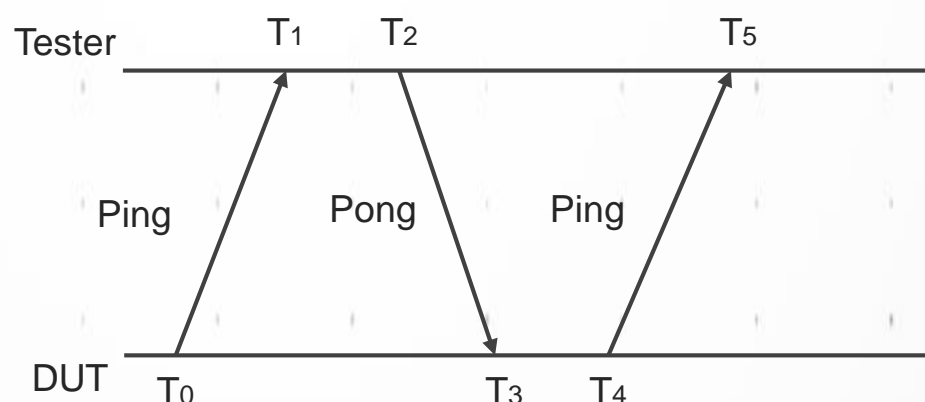
3. UWB Test Solutions



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)