Current-Steering Digital-to-Analog Converter based Pulse Generation Techniques for Ultra-Wideband Pulse Radio Transmitter

We propose a UWB pulse synthesis architecture using on-chip memory and high-speed Digital-to-Analog Converters as a means to generate broadband pulses at high repetition rates and to control the pulse spectral characteristics like pulse duration, center frequency and side-lobe spectral leakages. Challenges specific to UWB pulse radio design, e.g. group-delay constancy requirements, fast channel-hopping, transceiver synchronization, have been studied and new architecture based solutions have been proposed. A frequency plan has been devised which utilizes one fixed clock frequency and generates different 500 MHz wide pulses in the 3.1-10.6 GHz FCC band. Next we have proposed techniques to remove broadband sampling images appearing as a result of DAC based pulse synthesis. The theory behind the image cancellation has been derived and circuits have been developed to demonstrate these principles.

We describe first a quadrature-DAC architecture (working at a sampling speed f_s of 800 MHz) to remove the sampling image specifically in the second Nyquist band ($0.5f_s$ - f_s). We then extend the technique to get an effective 2x increase in the sampling speed. We next describe how a conventional Zero-order Hold DAC followed by a windowed-integration based filter (WIBF) results in a novel Partial-order Hold (POH) DAC architecture with the ability of broadband image reduction in between $1.5f_s$-$2f_s$ while also providing a flat group-delay. Interleaving two such POH-DACs results in a DAC with an excellent output signal reconstruction whereby the broadband sampling images below $2f_s$ in the output signal spectrum are strongly reduced. Implementation techniques have been proposed and the effect of implementation non-idealities has been evaluated. We have presented measurement results from a dual conversion, 3-7 GHz UWB pulse radio transmitter using interleaved, IF DACs (working at 2 GSPS) followed by a POH reconstruction filters and an RF up-converter. Eight different channels have been covered and on-the-fly channel-hopping has been demonstrated without the need to change clock speeds. 1.25 nJ is spent per pulse for a Pulse Repetition Rate of 100 MHz while achieving a broadband image cancellation of 42 dBc.