Solving The 6-24 GHZ Backhaul Congestion Challenge.

Analog Devices' Highly Integrated, High Performance Microwave Radio IC Chipsets cover 6 - 42 GHz Bands for Microwave Point-to-Point ODUs (Outdoor Units)

By Jon Firth, senior marketing engineer, Analog Devices

Introduction

Today's mobile devices deliver more communications power than ever before. The newest Smartphones use roughly 30 times more data than the cellphones they replaced, which means that the demand for mobile data is doubling every year. Industry analysts predict mobile data traffic will quadruple by 2015 as the number of mobile users and use of multimedia services continues to rise. As a result, cell sizes are shrinking, microwave backhaul networks are getting denser, new sites are getting smaller and established sites are becoming more densely populated.

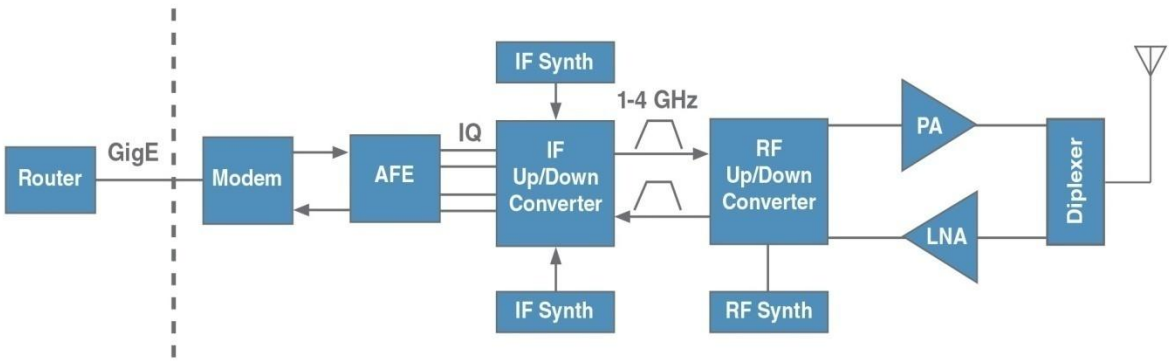

Figure 1: Full ODUBlock Diagram

Full outdoor microwave radios (or FODUs) are emerging because space for equipment such as indoor units (IDUs) is at a premium and the costs of upgrading sites with bigger equipment shelters is often not viable or possible due to site constraints (Figure 1). As a result, more network terminals are being repackaged for deployment outdoors on supporting structures such as towers, walls or masts. Full outdoor microwave radios are self-contained systems which incorporate the traffic interfaces, switching/multiplexing elements, radio modem and radio transceiver—all packaged in a weatherproof outdoor housing. Full ODUs also eliminate cabling and the inherent cable losses, and with Analog Devices' highly integrated IF transmitter and receiver chips and baseband modem chips, can ultimately offer the designer a less complex radio with reduced footprint.

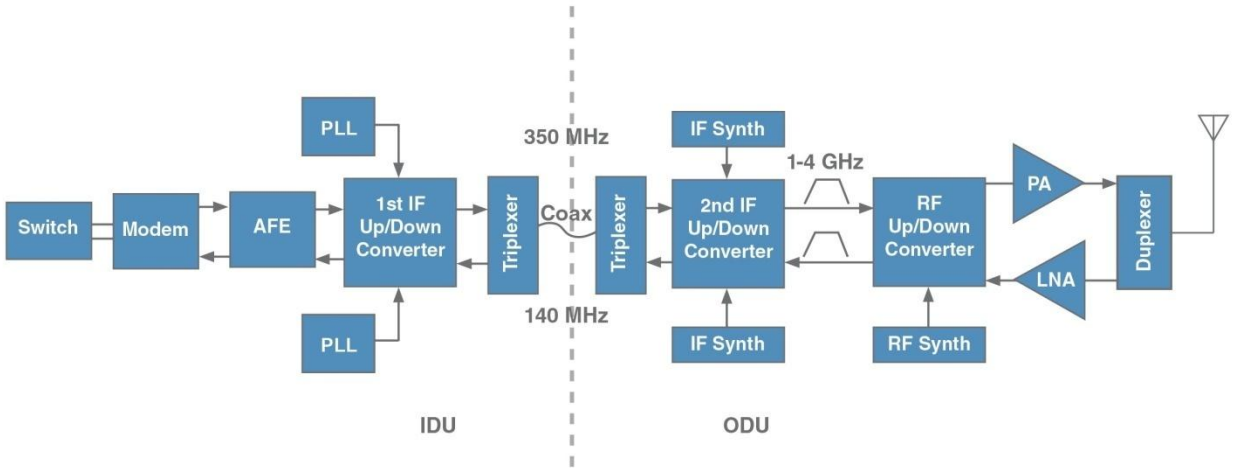

Figure 2: Split-Mount ODU Block Diagram

By contrast, the outdoor unit (ODU) used in traditional split-mount systems only contains the microwave radio, which connects to a radio modem embedded in an indoor unit (IDU) (Figure 2) over a coaxial cable. In a split-mount radio system, the IDU also provides the traffic interfaces and switching/multiplexing elements.

In recognition of these industry developments, Analog Devices has developed a series of microwave radio IC chipsets which cover the 6 to 42 GHz frequency bands while dramatically reducing the size, complexity, production cost and power consumption of microwave radios. The chipsets offer complete upconversion and downconversion solutions which are designed to address the need for higher bandwidth and faster time-to-market in microwave split-mount ODUs, and are equally applicable to full outdoor units (FODU). The chipset solutions simplify system manufacturing, deployment, and inventory management, as the chipsets are highly integrated such that fewer individual ICs are required. Analog Devices' new chipsets also support high order modulation, providing 7 to 112 MHz channels of up to 4096-QAM modulation and delivering a significant improvement in spectrum utilization and capacity.

Complete 18 GHz Microwave Radio Chipset Solution for Point-to-Point ODU

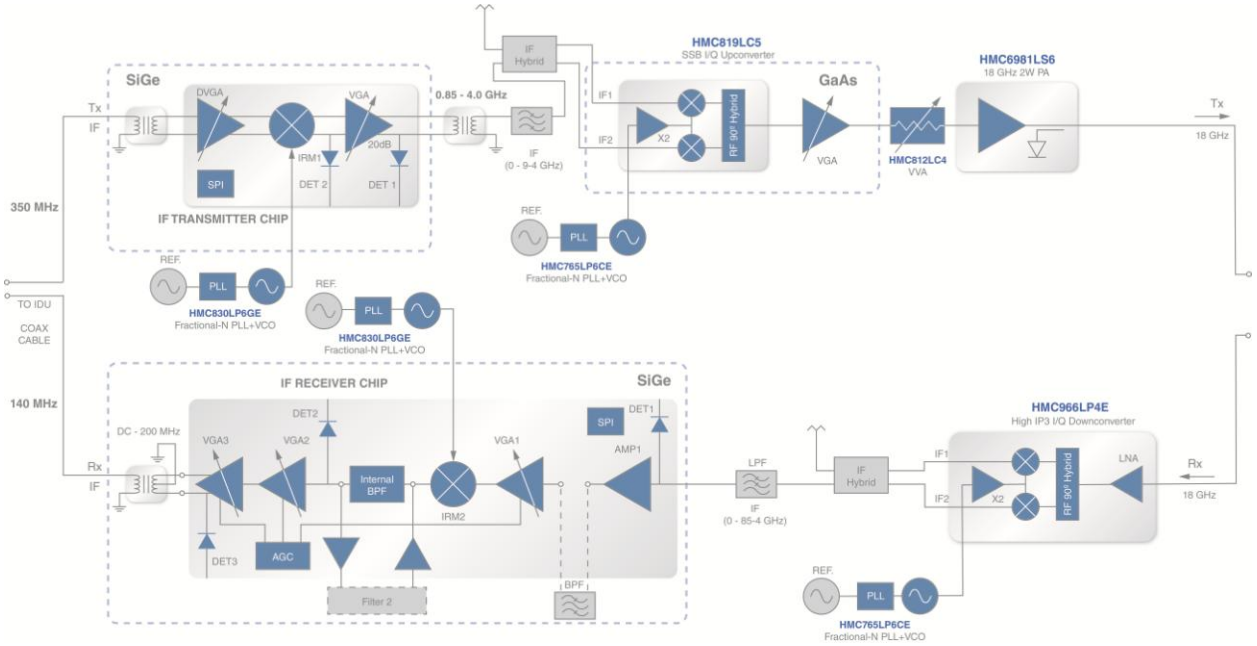

Figure 3: Complete Microwave Radio Chipset Solution for the 18 GHz Radio Band

The functional diagram shown above in Figure 3 is an example of how Analog Devices' upconversion and downconversion chipsets can be used to realize a microwave radio transceiver solution for the licensed 18 GHz point-to-point radio band (17.7 to 19.7 GHz).

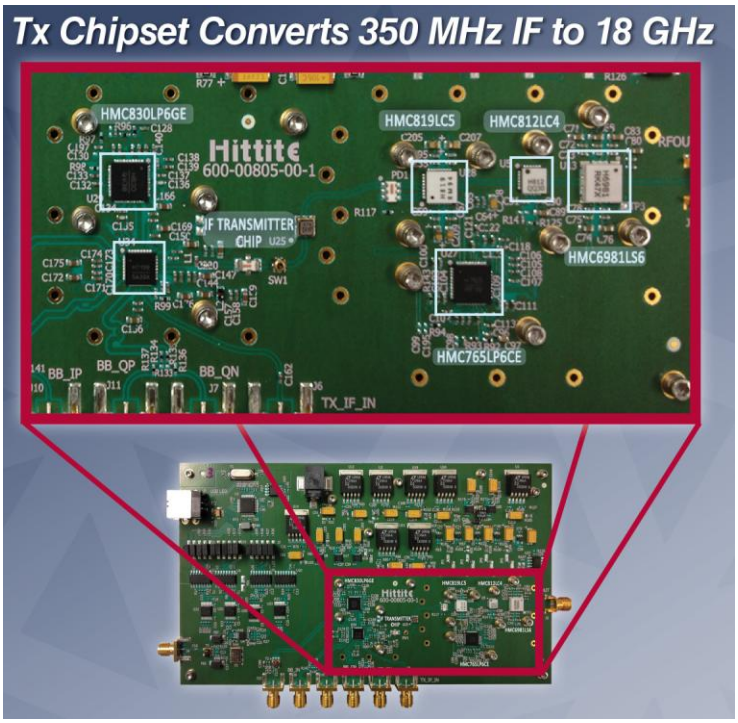

Figure 4: The 18 GHz Transmit Chipset Reference Design

The 18 GHz Transmit Chipset coverts the 350 MHz IF frequency from the IDU to an 18 GHz transmit signal at the antenna.

At the heart of the Transmit chipset is a highly integrated IF Transmitter chip, HMC7437LP5ME. HMC7437LP5ME is designed for high linearity operation, supports modulations up to 4096-QAM and is housed in a compact, 32-pin 5 x 5 mm standard QFN package.

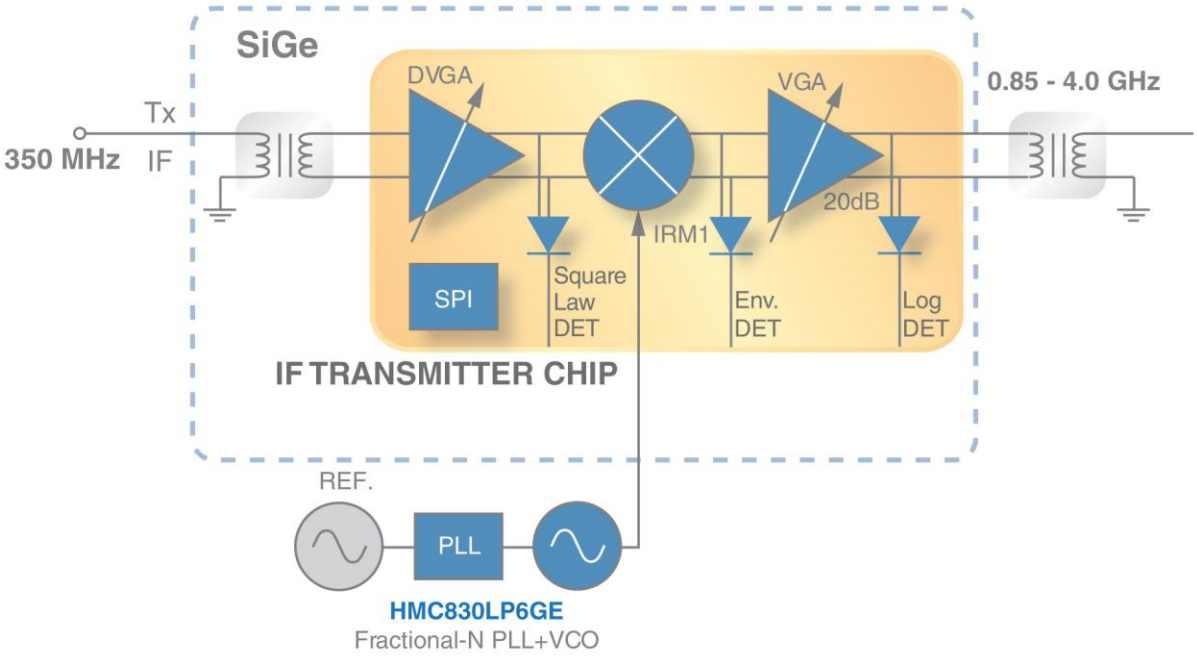

Figure 5:HMC7437LP5ME IF Transmitter Chip Block Diagram

The HMC7437LP5ME IF Transmitter chip, shown in Figure 5 above, takes the industry standard 300 to 400 MHz IF input signal and converts it to a 0.85 to 4 GHz single-ended RF signal at its output. The IF input power range is from -28 dBm to +3 dBm. To equalize for input signal cable losses, the HMC7437LP5ME provides 32 dB of digital gain control in 1 dB steps, while an analog VGA controls the transmit output power continuously from -20 dBm to 0 dBm.

The HMC7437LP5ME also features three integrated power detectors. A square law detector after the DVGA is used to set the power level into the mixer, the envelope detector after the mixer can be used for calibration, and the log detector is for fine output power adjustment through the analog VGA. Analog baseband IQ interfaces (not shown) are also provided to

support full ODU configurations. The IF Transmitter chip is configured via a 3-wire SPI interface.

The LO for the IF Transmitter chip can be taken from the HMC830LP6GE wideband fractional synthesizer which covers 25 to 3000 MHz, or the HMC833LP6GE which covers up to 6000 MHz.

The HMC819LC5 in the transmit chain is a sub-harmonically pumped I/Q transmitter which incorporates a frequency doubler in the LO path, a pair of double balanced mixer cells, and a single-ended driver output amplifier. This high linearity I/Q transmitter is rated for microwave frequencies from 17.7 to 23.6 GHz, and provides 15 dB conversion gain and 35 dB of sideband rejection. The upconverter is followed by the HMC812LC4 voltage variable attenuator (VVA) which is used to set the output power level of the transmit chain. The HMC812LC4 is rated from 5 to 30 GHz and provides a continuously variable attenuation range from 0 to 30 dB. Implementing a VVA in this section enables the radio to dynamically adjust its output power depending upon the environmental conditions. Following the VVA, the HMC6981LS6 power amplifier delivers 2W of output power, representing one of Analog Devices' best-in-class microwave radio linear power amplifiers.The HMC6981LS6 covers the 15 to 20 GHz frequency band and delivers 26 dB of gain,+33.5 dBm output P1dB and +43.5 dBm output IP3. The amplifier also features an integrated, temperature-compensated power detector which may be used in a closed loop circuit to maintain constant output power over temperature variations.

The LO for the upconverter is provided by the HMC765LP6CE fractional PLL/VCO which covers 7.8 to 8.8 GHz with closed loop phase noise of -101 dBc/Hz at 10 kHz offset.Analog Devices offers the widest portfolio of fully integrated PLL-based microwave frequency synthesizers and VCOs with best-in-class phase noise and spurious performance.

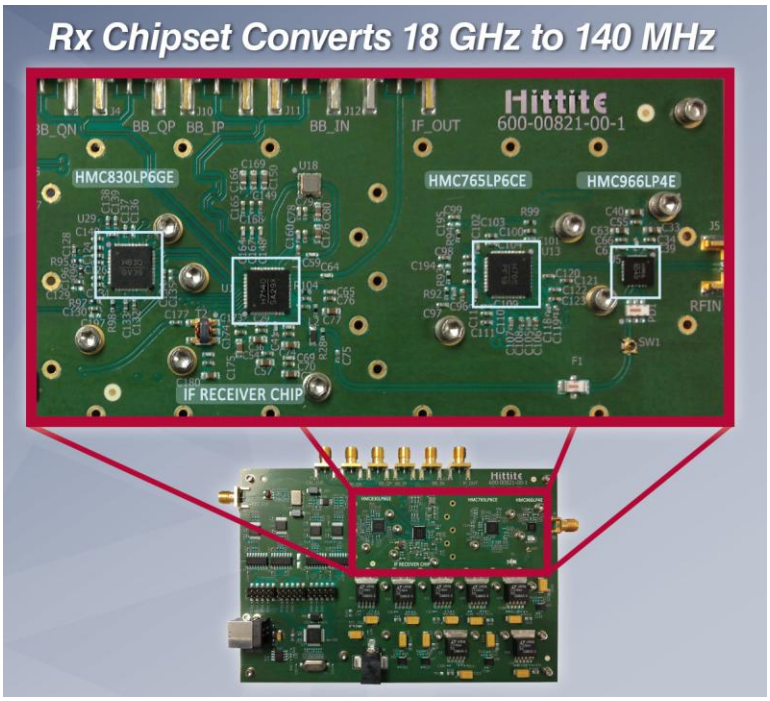

Figure 6: The 18 GHz Receive Chipset Reference Design

The 18 GHz Receive Chipset converts 18 GHz RF signals from the antenna down to a 140 MHz IF which travels via coaxial cable back to the IDU.

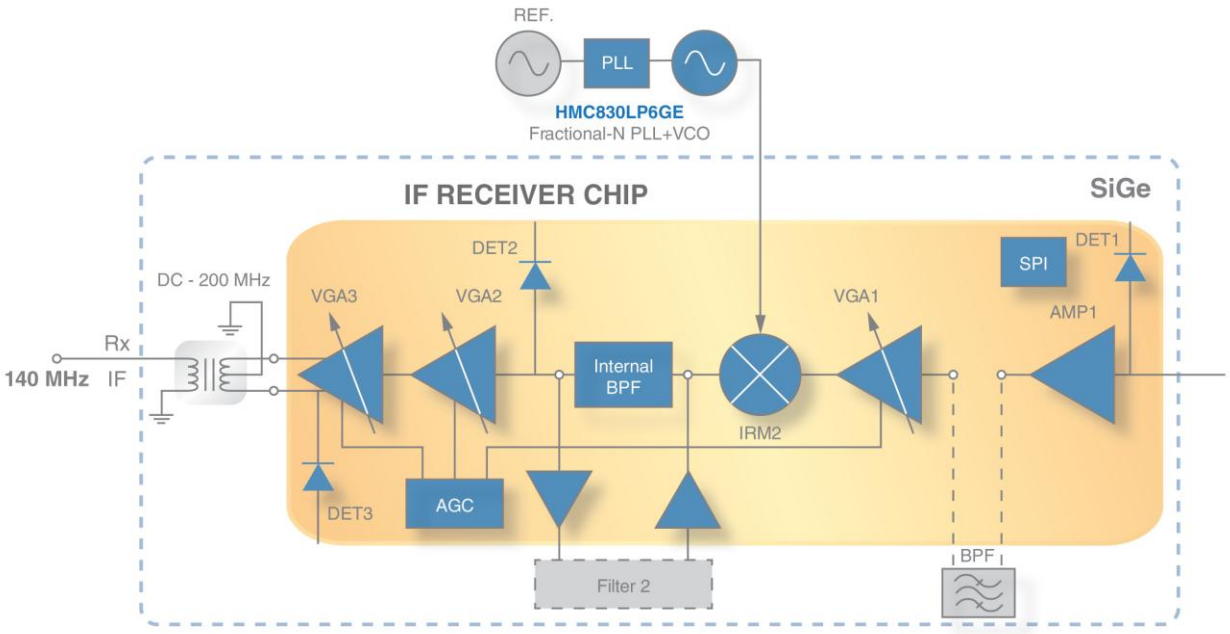

Figure 7: HMC7744LP6JE IF Receiver Chip Block Diagram

In the receiver section, the HMC966LP4E shown in Figure 6 is a sub-harmonically-pumped low noise downconverter (LNC) which is rated for input frequencies from 17 to 20 GHz, and incorporates a frequency doubler in the LO path, with a pair of double balanced mixer cells. The HMC966LP4E accepts a sub-harmonic LO input between 7.5 and 11.75 GHz, supports an IF of DC to 3.5 GHz, and achieves 40 dBc image rejection and a low 2.5 dB noise figure.

Following the LNC is the highly integrated IF Receiver chip, HMC7744LP6JE which converts the downconverted receive signal to a 140 MHz IF which is fed back to the IDU. As shown in Figure 7, it includes three VGAs to achieve 80 dB of analog gain control, three power detectors, a programmable AGC block, as well as selectable integrated bandpass filters (14, 28 or 56 MHz bandwidth). The filters can also be bypassed to allow for off-chip filtering of other user-defined bandwidths.

The HMC7744LP6JE IF Receiver chip is designed for high linearity operation, supporting modulations of up to 4096-QAM and bandwidths up to 112 MHz. It supports an RF input range from 0.8 to 4 GHz and is housed in a compact, 40-pin 6 x 6 mm standard QFN package.

The HMC7744LP6JE also supports baseband IQ interfaces after the mixer so that the chips can be used in the full ODU configuration.

For all other microwave radio bands, designers can select chipsets to realize all of the licensed microwave radio bands from 6 to 42 GHz. The part numbers shown in Table 1 represent a small selection of the components available from Analog Devices for microwave radio applications. The IF Transmitter and Receiver chips support all of the standard microwave frequency bands from 6 to 42 GHz. No other supplier offers a broader array of chipset solutions for the microwave radio market.

Hittite Transceiver Chipsets for Standard Microwave Radio Bands							
	7/8 GHz	11 GHz	13/15 GHz	18/23 GHz	26 GHz	28/32 GHz	38/42 GHz
	7.1-8.5 GHz	10.7-11.7 GHz	12.7-15.35 GHz	17.7-23.6 GHz	24.5-26.5 GHz	27.5-33.4 GHz	37-43.5 GHz
IF Transceivers-Tx Section	IF Transmitter Chip	IF Transmitter Chip	IF Transmitter Chip	IF Transmitter Chip	IF Transmitter Chip	IF Transmitter Chip	IF Transmitter Chip
I/Q Upconverters/Transmitters	HMC925LC5	HMC924LC5	HMC709LC5	HMC710LC5	HMC815LC5	HMC1042LC4	HMC6787ALC5A
				HMC819LC5			HMC6146BLC5A
VGAs and VVAs	HMC996LP4E	HMC996LP4E	HMC694LP4E	HMC997LC4	HMC997LC4	HMC985LP4KE	HMC985
	HMC712LP3CE	HMC712LP3CE	HMC712LP3CE	HMC812LC4	HMC812LC4		
			HMC812LC4				
Driver Amplifiers	HMC441LP3	HMC441LP3	HMC490LP5E	HMC757LP4E	HMC863LP4E	HMC499LC4	HMC1016
	HMC451LC3	HMC451LC3	HMC451LC3	HMC498LC4	HMC504LC4B	HMC566LP4E	HMC-ALH310
				HMC504LC4B			
Power Amplifiers	HMC591LP5E	HMC952LP5GE	HMC995LP5GE	HMC756	HMC943LP5E	HMC943LP5E	HMC1016
	HMC486LP5E	HMC592	HMC949	HMC757LP4E	HMC863LP4E	HMC906	HMC969
			HMC950	HMC6981LS6			
			HMC965LP5E				
IF Transceivers-Rx Section	IF Receiver Chip	IF Receiver Chip	IF Receiver Chip	IF Receiver Chip	IF Receiver Chip	IF Receiver Chip	IF Receiver Chip
Low Noise Amplifiers	HMC903LP3E	HMC903LP3E	HMC903LP3E	HMC751LC4	HMC752LC4	HMC519LC4	HMC1040LP3CE
	HMC902LP3E	HMC963LC4	HMC963LC4	HMC963LC4	HMC962LC5	HMC566LP4E	HMC-ALH376
I/Q Downconverters/Receivers	HMC951LP4E	HMC908LC5	HMC869LC5	HMC967LP4E	HMC977LP4E	HMC1065LP4E	HMC6147ALC5A
				HMC966LP4E			
PLL w/ Integrated VCO *requires x2 or x4	HMC764LP6CE	HMC778LP6CE	HMC807LP6CE	HMC778LP6CE*	HMC783LP6CE*	HMC764LP6CE*	HMC769LP6CE*
			HMC765LP6CE*	HMC765LP6CE*			
Wideband IF PLL w/ Integrated VCO	HMC830LP6GE	HMC830LP6GE	HMC830LP6GE	HMC830LP6GE	HMC830LP6GE	HMC830LP6GE	HMC830LP6GE
	HMC833LP6GE	HMC833LP6GE	HMC833LP6GE	HMC833LP6GE	HMC833LP6GE	HMC833LP6GE	HMC833LP6GE

Table 1: Analog Devices' Chipset offering for 6 to 42 GHz Radio Bands

18 GHz Point-to-Point Microwave 1024-QAM Link Demonstration

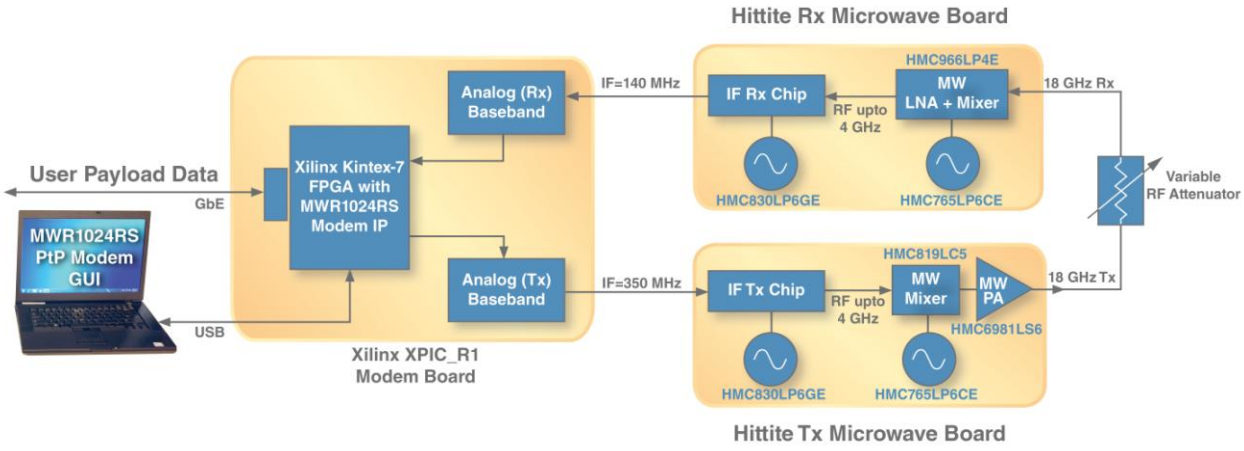

Figure 8a: 18 GHz Microwave Link Bench Demonstration Setup

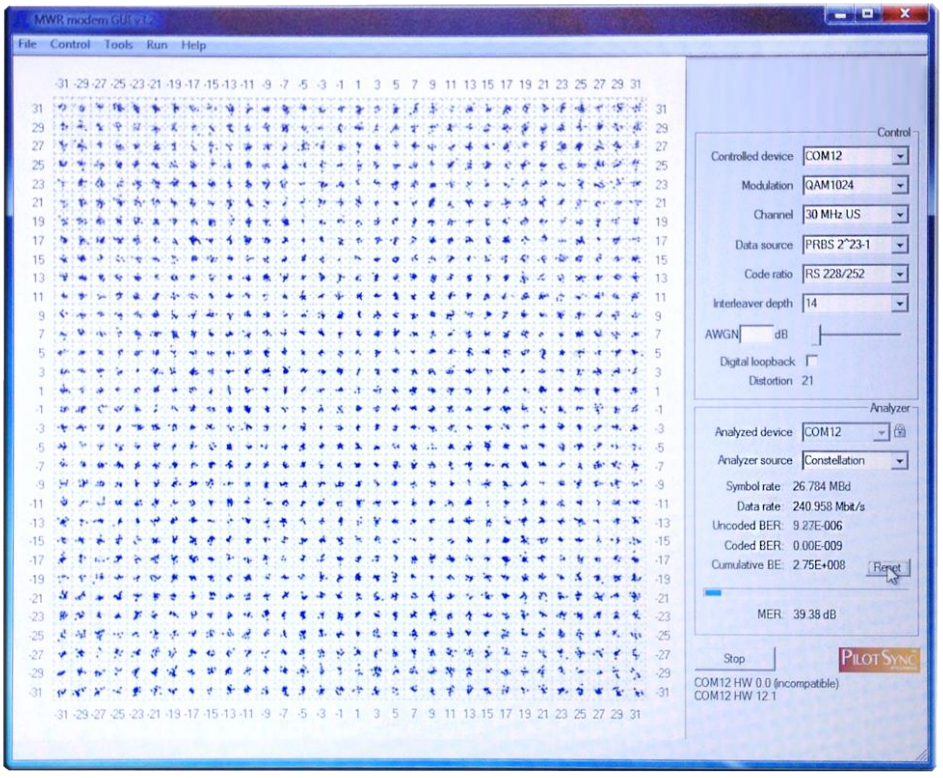

Figure 8b: Detailed Constellation View

To validate the performance of the Tx and Rx chipsets, an 18 GHz Point-to-Point microwave demonstration link was set up. Analog Devices and Xilinx Corp. worked together to develop the

demonstration setup shown in Figure 8a. The demonstration setup combines the Xilinx XPIC_R1 modem boards with a pair of transmit and receive microwave front-end boards from Analog Devices. The connections between the Xilinx and Analog Devices boards are the conventional 140 MHz Rx IF and 350 MHz Tx IF. The Xilinx XPIC_R1 is running the complete PtP modem IP, named MWR1024RS, on a Kintex-7 FPGA. This full-featured, high-performance modem IP from Xilinx is capable of up to 1.0 Gbps raw data throughput with QAM-1024 modulation. The user data payload is streamed over a Gigabit Ethernet link in the end system. The demonstration platform relied on the Xilinx MWR1024RS PtP Modem GUI to control the boards and display the received signal constellation and key link statistics (see Figure 8b).

The Analog Devices synthesizer and IF chips were programmed using a 3-wire SPI port. The synthesizers were programmed for an IF frequency of 1740 MHz for Tx and 1840 MHz for Rx, while the IF chips were programmed for channel bandwidth, gain and interface type (IF). The Tx modem was configured to transmit a 1024-QAM modulated signal in a 30 MHz channel, and the transmitter chip gains were set to achieve +20 dBm RF signal output power. A variable RF attenuator was connected between the transmit and receive RF ports to simulate the link path loss that would be realized in a deployed microwave radio link. As the RF attenuator was varied, the AGC in the Rx IF chip maintained the appropriate IF output power to the modem to maintain optimal link performance.

The modem was able to measure a BER (Bit Error Rate) of better than 10^{-9}over a wide range of attenuation settings. Even lower signal levels could have been demodulated if the modem were allowed to reduce the modulation order down to QPSK.

Summary

Analog Devices continues to provide innovative, high performance end-to-end microwave component solutions covering all bands from 6 to 42 GHz, while supporting both split-mount and full ODU style microwave radios.

The IF Transmitter and IF Receiver chips provide a very high level of integration, support all of the standard microwave frequency bands from 6 to 42 GHz, and form the core of these compact, high performance upconversion and downconversion chipsets.

Analog Devices has successfully demonstrated 1024-QAM modulation in a 30 MHz channel over an 18 GHz microwave link. The BER (Bit Error Rate) was better than 10^{-9} over a wide range of attenuation settings. The IF Transmitter and IF Receiver chips are also capable of supporting modulations of 2048 and 4096-QAM, but with reduced link distances.

Designers should consult Analog Devices directly to discuss specific custom microwave radio requirements. For IF Transmitter and Receiver product inquiries please contact rfmg-txrx@analog.com. All released data sheets are available at www.analog.com/hittitemw. For more information on Xilinx solutions, visit www.xilinx.com.