Keywords: direct RF, RF modulator, RF transmitter, converged cable access platform, CCAP, quadrature amplitude modulation, QAM, cable modem termination system, CMTS, cable TV, CATV, video-on-demand, VoD, switched digital video, SDV, digital upconverter, DOCSIS

APPLICATION NOTE 5394

Digital RF Modulators Provide the High Density, Agility, and Cost Benefits for a Converged Cable Access Platform (CCAP)

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Abstract: A digital RF modulator, an integrated solution that satisfies stringent DOCSIS RF-performance requirements, takes advantage of modern technologies like high-performance wideband digital-to-analog conversion and CMOS technology scaling. This application note describes the concept and advantages of a digital quadrature amplitude modulation (QAM) modulator that uses the direct-RF architecture to enable a cable access platform (CCAP) system.

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Introduction

The demand for cable broadband digital services like video and data is increasing downstream data rates at 30% to 40% per year. Meanwhile, consumers expect to spend about the same for an increasing number of connected devices at home. The current generation of downstream modulators that uses analog technology has proven to be costly in the long term. And service providers find it too expensive to meet the growing demand for bandwidth by using incremental upgrades to existing access platforms.

Ultimately the issue for users and providers is the same: supplying the demand for bandwidth. Analog transmitters are no longer the answer. Instead, a new generation of digital RF modulators provides high-density and low-cost solutions to meet future bandwidth requirements. Using the direct-RF architecture, digital RF modulators enable a converged cable access platform (CCAP) for full-spectrum quadrature amplitude modulation (QAM) transmissions. These digital RF modulators also have 32x the capacity of analog modulators at one-twentieth of the power dissipated per transmitted QAM channel.

This application note describes the concept and advantages of a digital QAM modulator that uses the direct-RF architecture to enable a CCAP system.

Why a Direct-RF Transmitter Is Replacing an Analog Transmitter

The CCAP for cable TV (CATV) (**Figure 1**) combines the downstream services transmitted by edge QAM equipment for video and by cable modem terminations systems (CMTS) for high-speed Internet access. The transmitted QAM-modulated digital carriers include broadcast TV and narrowcast services like video-on-demand (VoD), switched digital video (SDV), and high-speed Internet. These carriers fill the downstream CATV spectrum in the 50MHz to 1000MHz bandwidth. Up to 158 (6MHz wide) QAM carriers (channels) occupy the entire spectrum from a single RF port in a CCAP headend. Up to 8 to 12 RF ports are present in a single linecard, and more than five downstream linecards can be present in a single 13RU CCAP chassis.

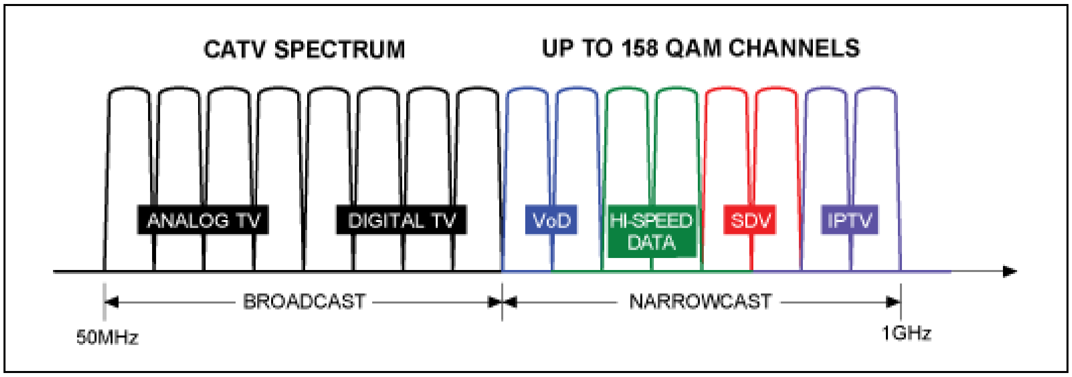

Figure 1. CATV spectrum includes broadcast and narrowcast services.

The downstream CCAP physical layer (PHY) requires highly dense RF modulators. These QAM modulators, in turn, must have low-power dissipation, scalability, and QAM carrier agility. In the older-generation headends, QAM carriers from multiple superheterodyne analog transmitters were combined to fully populate the CATV spectrum (**Figure 2**). However, that methodology would potentially require more than 300W for a single CCAP RF port. A direct-RF transmitter (**Figure 3**), however, easily performs digital upconversion (DUC) and modulation of QAM carriers in the digital domain, and it can be implemented in an ASIC or a field-programmable gate array (FPGA). This type of digital architecture is enabled only by a wideband RF digital-to-analog converter (RF DAC) as the entire spectrum of QAM carriers is transmitted by a single RF chain.

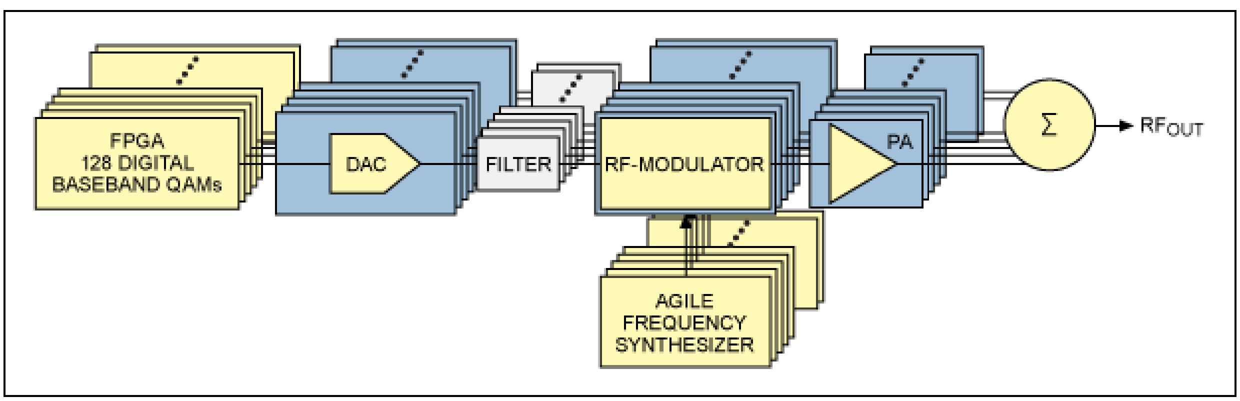

Figure 2. An older-generation analog upconverter combines multiple analog transmitters.

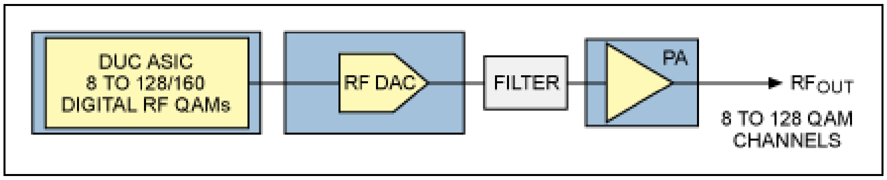

Figure 3. A direct RF transmitter is a single signal chain.

There is a significant advantage of the direct-RF transmitter in a CCAP system: the entire signal processing, now implemented in the digital domain, can benefit from CMOS process geometry. CMOS processes allow much higher channel densities in a small footprint and at low-power dissipation. The benefits of this approach are easily seen with an example.

The MAX5880 is a 128-channel DUC and QAM modulator that drives an RF DAC (**Figure 4**). It accepts forward-error-correction (FEC) encoded symbols from an FPGA, performs QAM modulation, pulse shaping, and resampling of each QAM channel. It then combines, interpolates, and modulates up to 128 QAM channels to drive an RF DAC. The sample rate for the RF DAC must be more than 2Gsps to synthesize the entire CATV band; it must also satisfy the stringent DOCSIS® RF-performance requirements. This design uses the 14-bit 4.6Gsps MAX5882 RF DAC.

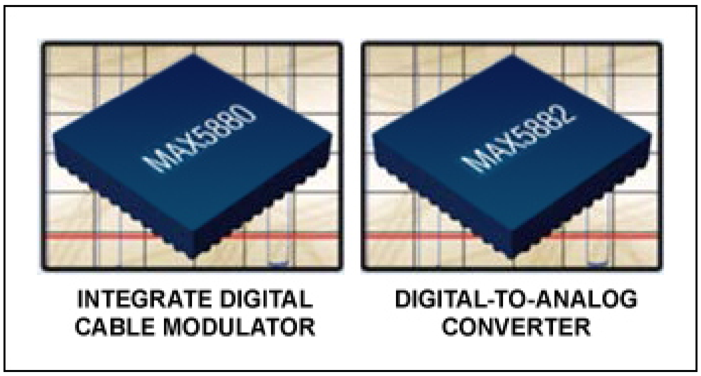

Figure 4. The MAX5880 is a 128-channel DUC and QAM modulator that drives the MAX5882 RF DAC.

The MAX5882 oversamples the 1GHz band at an update rate of more than 4Gsps. Note that according to the Nyquist theorem, slightly more than a 2GHz sample rate is required to synthesize the 1GHz band. However, if a 2.5Gsps DAC is used, the dominant harmonic distortion products like the second harmonic (HD2) and third harmonic (HD3) can fold back into the 1GHz cable spectrum due to aliasing (**Figure 5A**). These distortion products can violate the in-band RF performance requirements for DOCSIS® transmitters. However, if a 4Gsps DAC is used (**Figure 5B**), the HD2 and HD3 can never fold back into the CATV band.

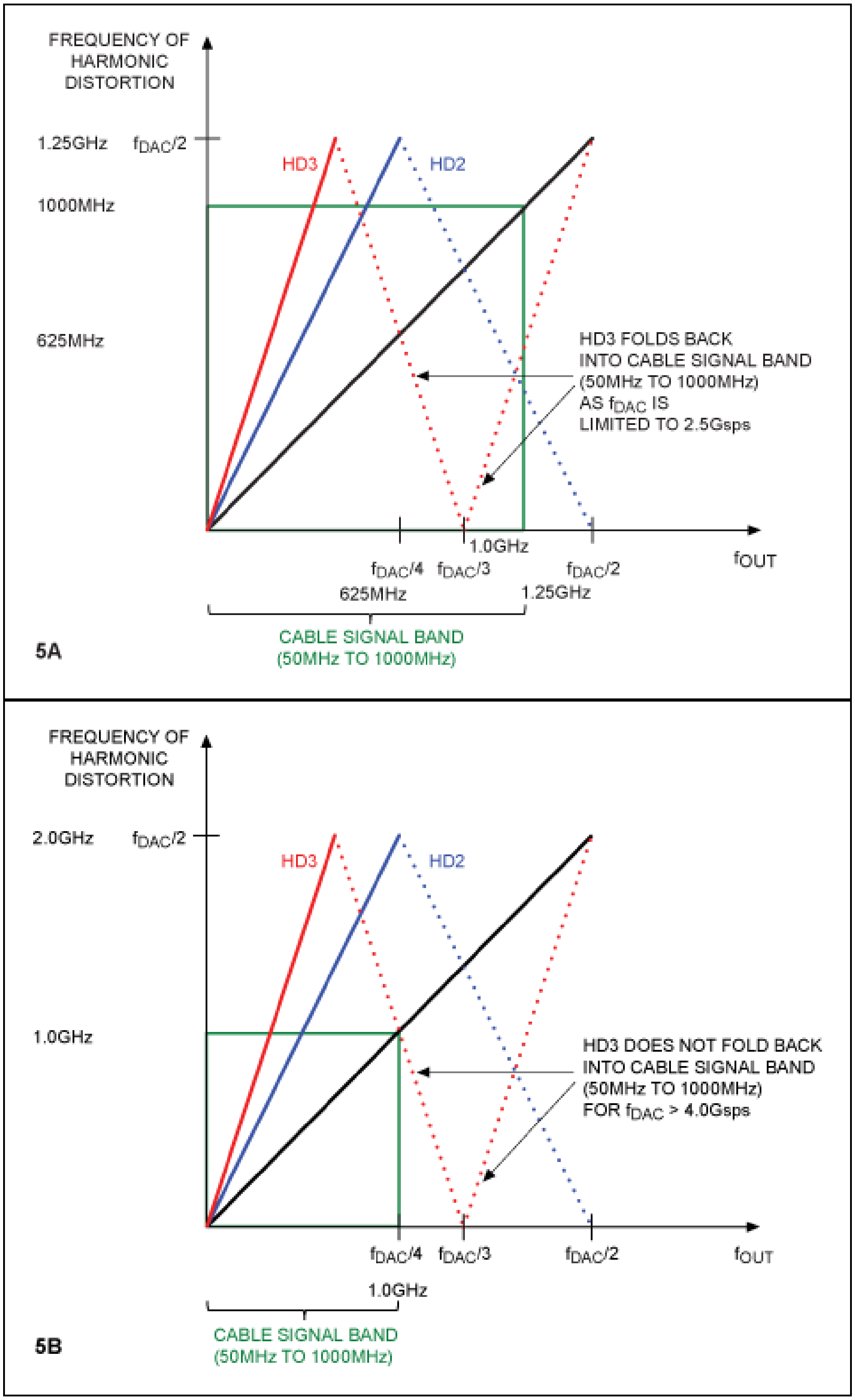

Figure 5. Synthesizing the cable band using a 2.5Gsps DAC (5A) and a 4Gsps DAC (5B).

The RF output of the digital RF QAM modulator chipset is shown in **Figure 6** for 128 channels that are

6MHz wide in a 1GHz span. The RF performance is fully compliant with DOCSIS RF requirements. The DUP and DAC dissipate a total of about 6W for transmitting 128 QAM channels. That translates to about a 95% savings in power dissipated per QAM channel compared to traditional analog RF modulators. Each of the chips is 17mm x 17mm in a 256-ball CSBGA package, thus enabling the RF port density required by downstream CCAP linecards.

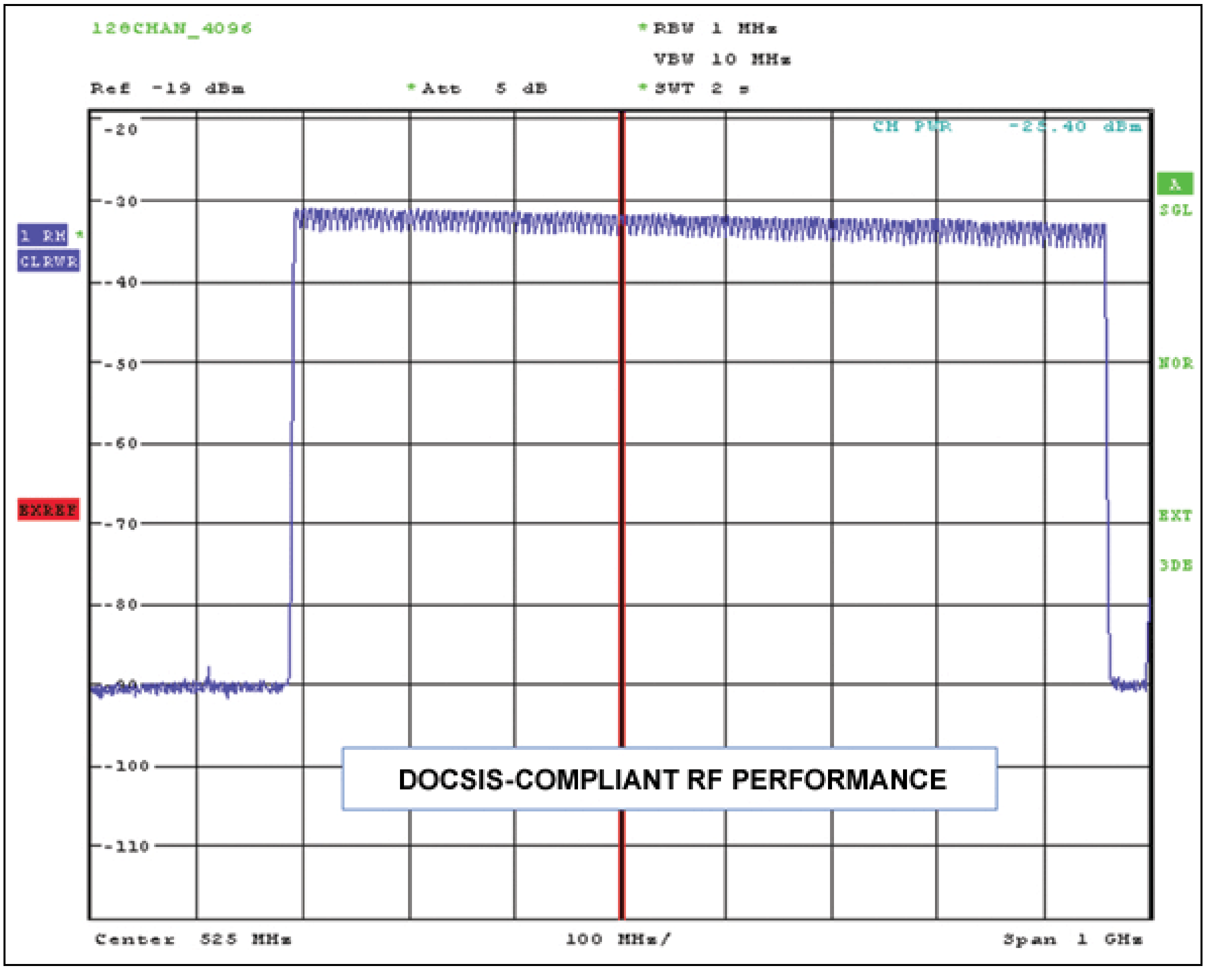

Figure 6. Cable RF spectrum of 128 QAM channels using the DUC (MAX5880) and RF DAC (MAX5882) chipset.

Summary

The new digital RF modulator takes advantage of modern technologies like high-performance wideband digital-to-analog conversion and CMOS technology scaling. The digital RF modulator is a highly integrated solution that also satisfies stringent DOCSIS RF performance requirements. Telecommunications companies now have the opportunity to supply cable service providers with the technology to meet the broadband requirements of tomorrow, cost effectively, today.

Related Parts	
MAX5880	High-Density Downstream Cable QAM Modulator and Digital Upconverter
MAX5882	14-Bit, 4.6Gsps Cable Downstream Direct RF Synthesis DAC

More Information
For Technical Support: http://www.maximintegrated.com/support
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