D-TA SYSTEMS INC.

TECH NOTE

SENSOR INTERFACE & PROCESSING COMPANY

TN-01

From Ether to Ethernet: Common Radio Platform for Demanding Multi-Antenna Applications

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A Simple Solution for a Complex Problem

Demanding multi-channel applications like software radio, phased array radars, smart antenna, sonobuoy, Arbitrary waveform generation including simulation and stimulation, SIGINT, tactical communications, MIMO, ECM, EW etc. require sub-system level products that can be readily integrated. The conventional approach so far has been to integrate a large number of bus-based (e.g., PCI, VME, etc.) functional level boards (commonly referred to as COTS boards). The problems commonly encountered include technical risk of integrating multiple hardware cards from various vendors and making them work synchronously, expensive and elaborate software development exercise and time-consuming system integration, test and characterization. These problems lead to engineering frustrations and huge cost overruns.

D-TA's approach to this problem is to shield the application developer (e.g., the radar expert or the modem expert) from the sensor interfacing details so that they can concentrate on developing the applications on their PC / Workstation. The pre-processed (e.g., digital down converted) sensor signals are provided to the user via industry standard 1 or 10 Gbit networks. This provides a true "plug and play", OS and platform agnostic interface for data transfer in and out of the application. The D-TA products offer a common platform that is an ideal solution for a wide variety of applications. The common platform approach also offers an enormous cost savings for the user.

SYSTEM INTEGRATION MADE EASY. JUST ADD THE COMPUTER AND WRITE THE APPLICATION CODE. D-TA PRODUCTS TAKE CARE OF THE SENSOR INTERFACING.

The current D-TA Radio platform comprises of the following sub-systems:

- DTA-3200: Up to 16 channel tunable RF up and downconverter (20 MHz to 6 GHz)
- DTA-2300: Up to 16 channel (antenna) Digital IF Transceiver
- DTA-2210: Single channel (antenna) Digital IF Transceiver

The D-TA Radio Platform allows the user to directly connect to the antenna for HF, VHF and UHF applications. The DTA-3200 tunable RF front provides up to 16 input and output channels up to 6 GHz. Unlike other RF downconverters products available in the market, the output IF power is amplified to account for the full scale input power for high speed ADCs. The DTA-2300 Digital IF transceiver offers up to 16 ADC and DAC input channels, high performance FPGA processing and four 10 Gbit network ports for high speed real time data transfer. Digital I/O lines from the DTA-2300 can be used to directly control the gain settings of the DTA-3200 RF front end.

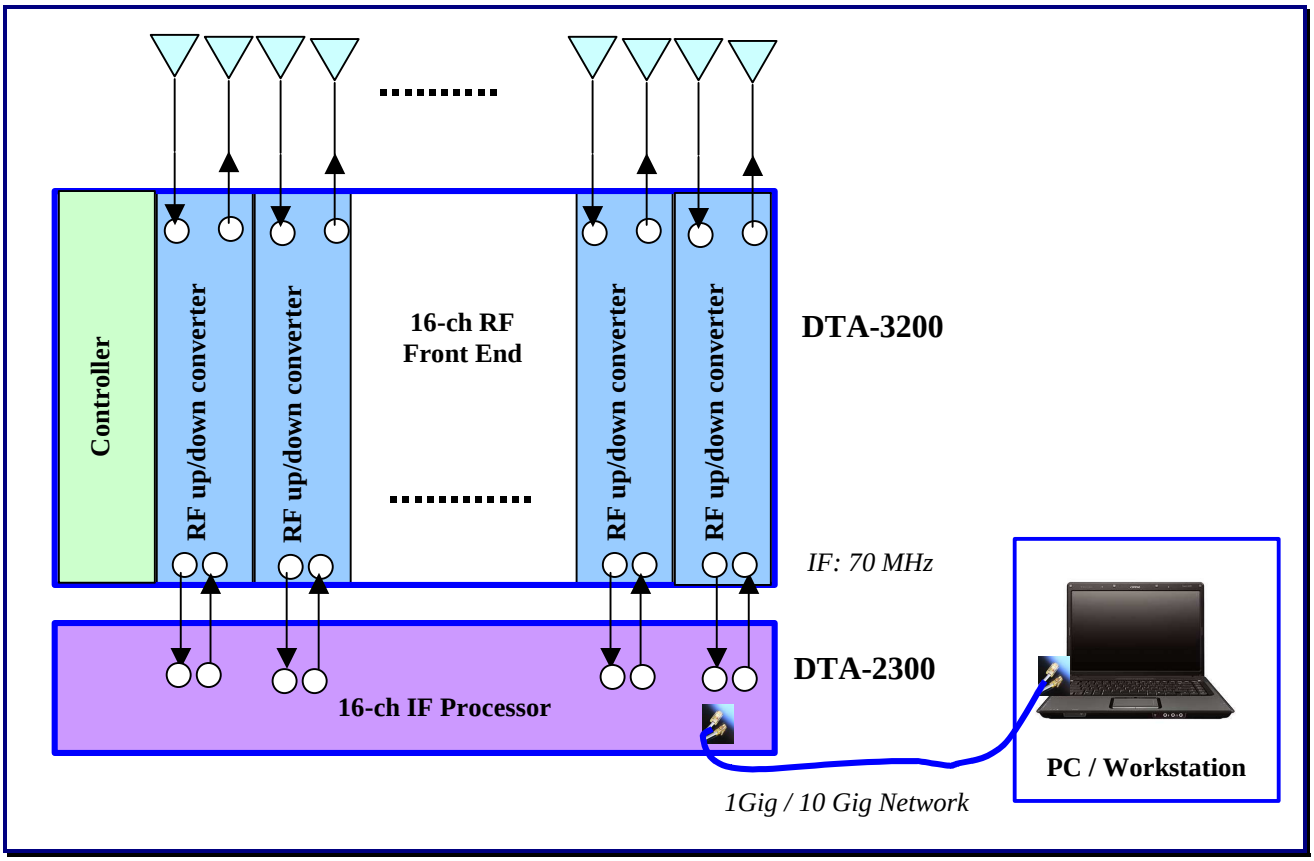

Figure 1: DEVELOPING COMPLEX APPLICATIONS WITH D-TA RADIO PLATFORM IS EASY

DTA-3200 RF Front End

The DTA-3200 RF front end is a 19” rackmountable unit that is architected in a modular fashion and allows an easily scalable solution from one-channel to 16-channel requirement. The down converter can handle input signal up to 6 GHz and provides an output IF of 70 MHz (other IFs available as factory option). The output bandwidth is 40 MHz (other bandwidths are available as factory option). The upconverter accepts a signal up to 200 MHz and up-convert it to anywhere in the 20 MHz to 6GHz frequency range.

The modular architecture produces high dynamic range, low noise figure and can be easily customized for specific applications.

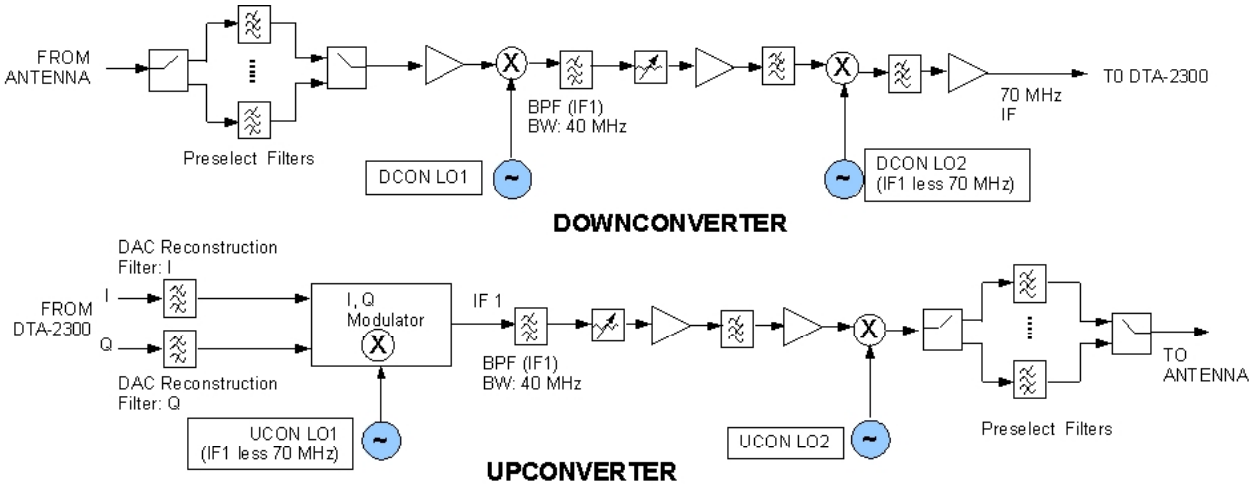

Figure 2: SINGLE CHANNEL RF UP / DOWN CONVERTER MODULE. DTA-3200 INCLUDES UP TO 16 MODULES THAT CAN BE PHASE AND FREQUENCY SYNCHRONIZED TO A COMMON SYNTHESIZER MODULE

DTA-2300 Multi Channel Digital IF Transceiver

The DTA-2300 is architected in a modular fashion and comprises of three modules: Digital Network Interface Module, Analog I/O Module and High Precision Clock Module.

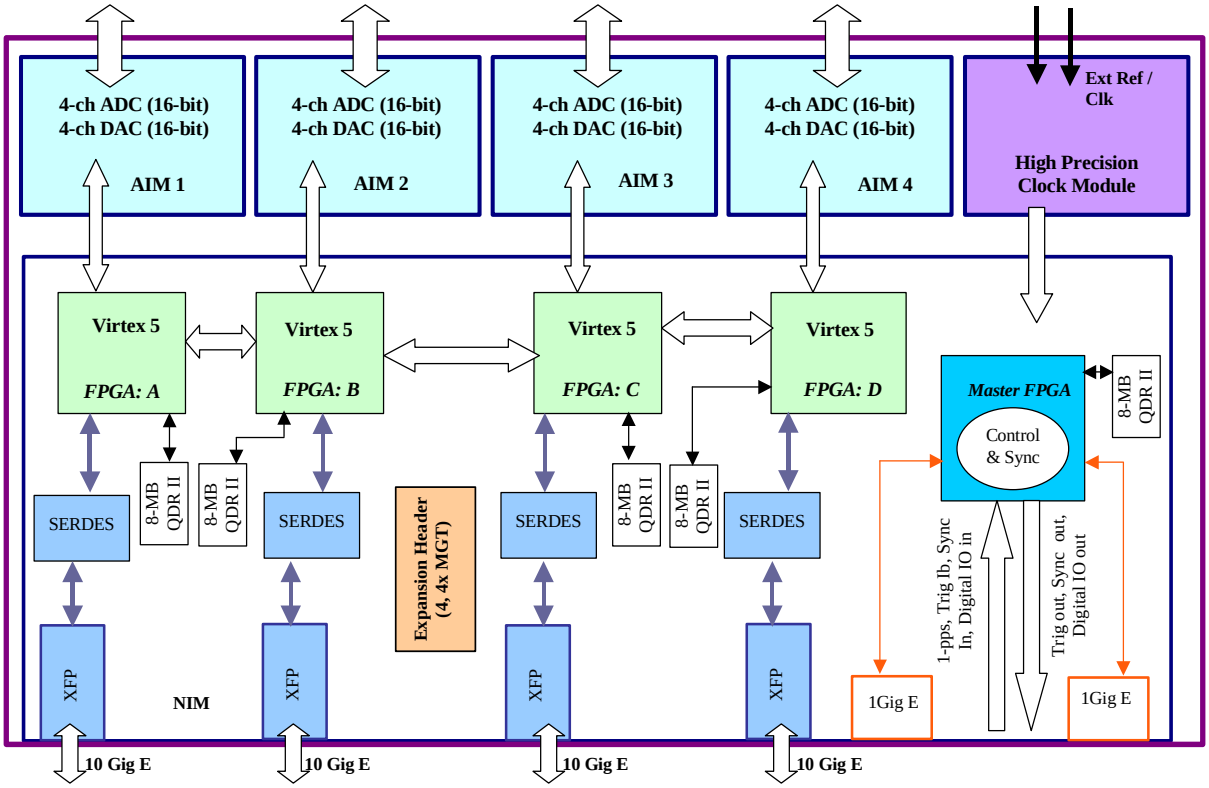

Figure 3: DTA-2300 DIGITALIF PROCESSING

The Network Interface Module (NIM) contains 4 data FPGA and one control FPGA and provides support for four XFP modules to implement four 10 Gbit interfaces. The data FPGA implements the 10Gbit Ethernet MAC and the UDP protocol stack. The NIM is a flexible module and can support a variety of I/O modules. The NIM is a standalone module can also serve as a high performance FPGA based processing module. Four large data FPGAs (Virtex 5 SX95T available as an option) each with its own separate 10 Gbit interface allow fully duplex data transfer in and out of the module. These interfaces allow multiple NIMs to be connected via the industry standard XFP connector.

DIFFERENT I/O MODULES CAN BE INTERFACED WITH THE DIGITAL NETWORK INTERFACE MODULE ENABLING A WIDE FLEXIBILITY OF I/O OPTIONS.

Each Analog I/O module currently supports four, 16-bit 130 MSPS ADC and two dual output 16-bit, 500 MSPS DACs. Each transmit and receive channel can support in excess of 50 MHz bandwidth. The Analog I/O module has programmable delays on the

sampling clock for precise calibration in 10 ps steps. Figure 4 shows a functional block diagram of the analog I/O Module.

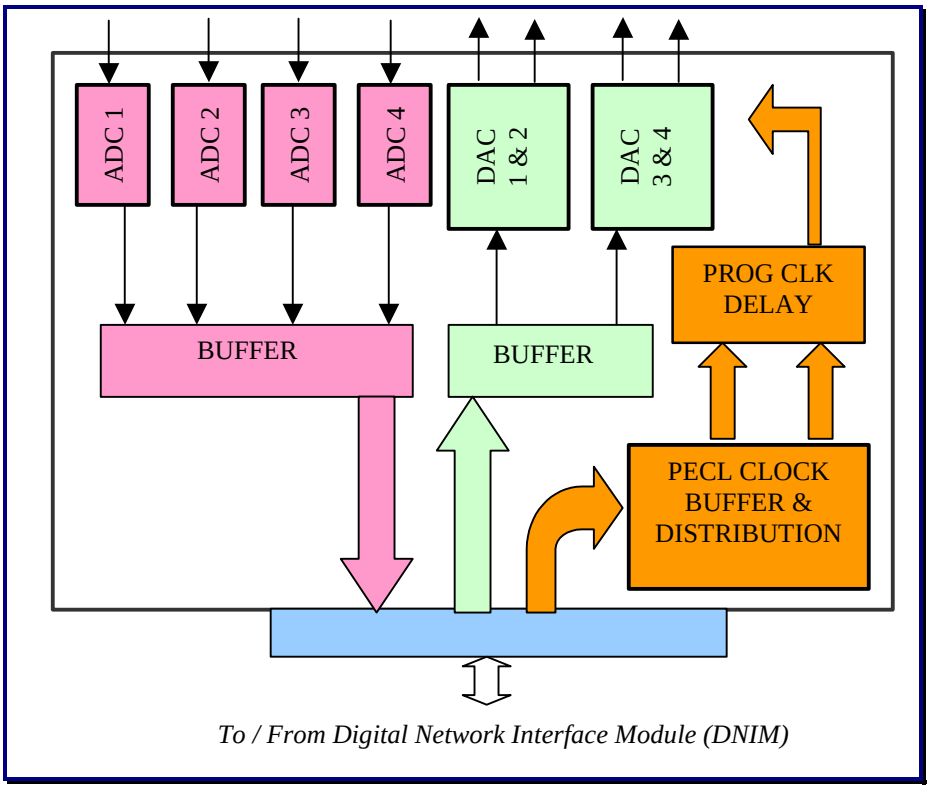

Figure 4: DTA-2300 Analog IO Module

The Clock Module provides the sampling / conversion clocks to the Analog I/O modules. It has a 100 MHz TCXO and a very high speed PLL for synchronized operation across multiple channels and multiple boxes. The clock module can accept an external reference signal or up to two separate external clocks and creates the ADC and DAC sampling clocks. These clocks are distributed to the analog modules via the NIM. The clock module also outputs these ADC and DAC clocks. The following clocking schemes are supported:

- Using the 100 MHz TCXO as a ADC / DAC clock
- All ADC / DAC clocks locked to an external reference clock (10 MHz to 100 MHz). ADC / DAC clocks are generated by an integer division of the VCO frequency.
- All ADC / DAC clocks locked to an internal TCXO based reference clock (100 MHz). ADC / DAC clocks are generated by an integer division of the VCO frequency.
- Separate external ADC and DAC clocks

- Common external ADC and DAC clocks

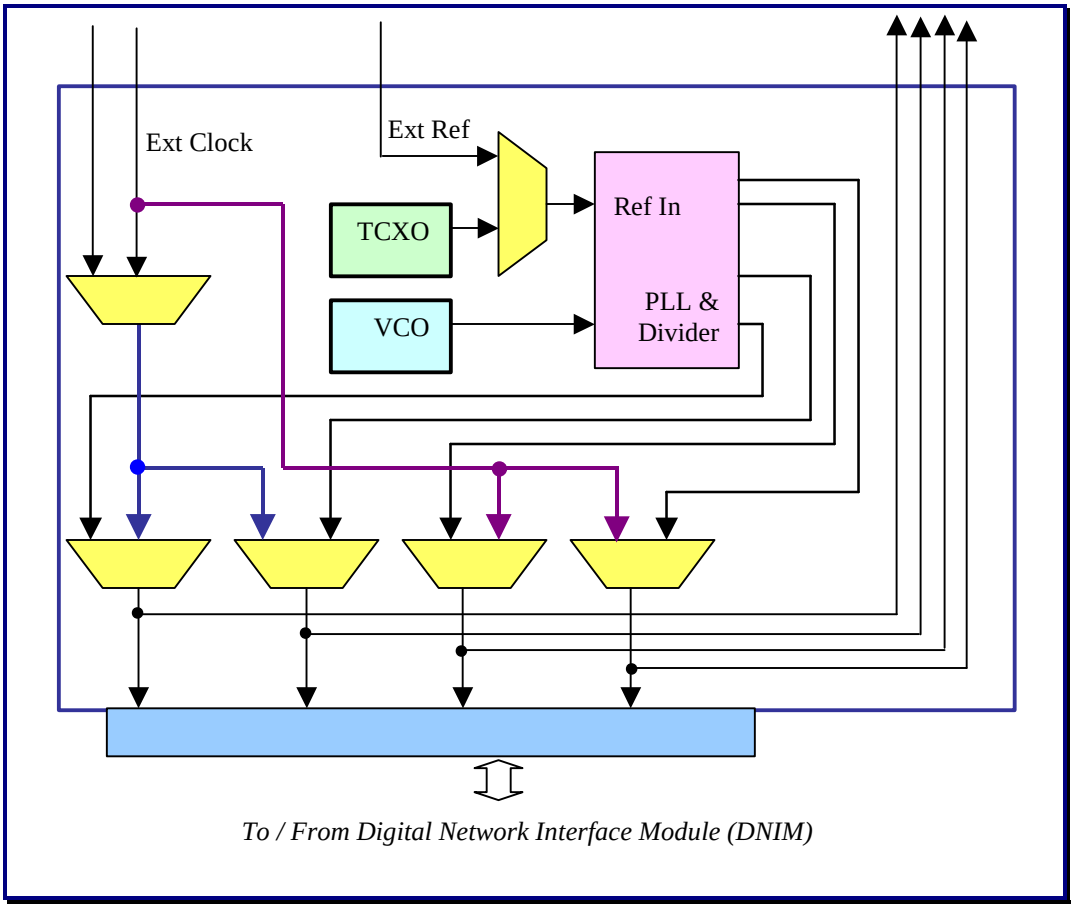

Figure 5: DTA-2300 Clock Module

DTA-2210 Single Channel Digital IF Transceiver

The DTA-2210 is a single channel digital IF transceiver that is very similar to the DTA-2300. It provides one 16-bit ADC at a maximum sampling rate of 160 MSPS and a 16-bit DAC at 50 MSPS. The DAC may be operated as a complex DAC or a real DAC. In the real mode, two independent channels may be generated. It also offers a large User FPGA (Virtex 5, SX50T as standard, SX95T as a upgrade option).

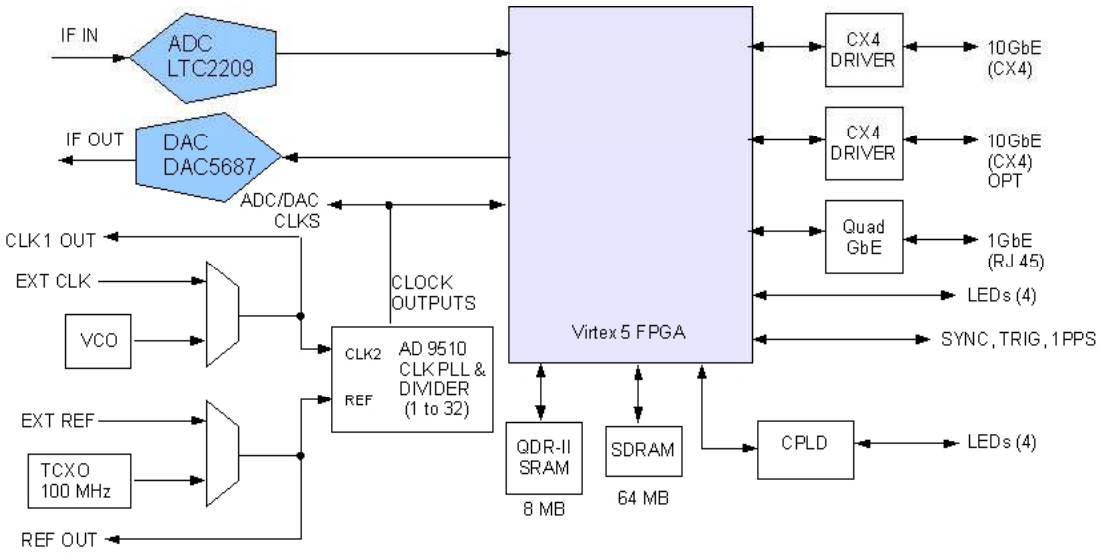

Figure 6: DTA-2210 SINGLE CHANNEL DIGITALIF PROCESSING

The architecture of the DTA-2210 is very similar to the multi channel DTA-2300 and thus offers an easy upgrade path from the single channel configuration to the multi-channel configuration.

Multiple DTA-2210 units may be locked to a GPS synchronized reference signal and thus can implement distributed TDOA application.

Network Advantage

One of the issues with high channel count, high performance system is the ability to handle large data rate in true real time. The DTA-2300 solves this by implementing four 10 Gigabit network interfaces directly from the four processing FPGAs. The FPGAs also include 10 GbE MAC and logic for implementing UDP protocol. At 125 MSPS the raw data rate for four channels is 1,000 Mbytes/sec, well within the payload capacity of the 10GbE. The DTA-2210 implements two 10 GbE copper interfaces (CX4).

The availability of 10 Gigabit network interfaces in today's high-end computers, allow direct connectivity to the D-TA Radio platform. The inherent full duplex capability of the 10Gbit interface and the inherent scalability allows multiple boxes to be connected for a higher channel count system.

Custom FPGA Development

The standard FPGA implements the 10 GbE MAC core and data packetization functionality for transmission over the 10 GbE interface. Users can implement their own custom DSP functionality. D-TA Systems offers custom FPGA development services to help users speed up their system deployment. D-TA Systems can offer extensive FPGA

application capability including DDC/DUCs, FFTs and a whole range of communication functions (like modulators, demodulators, FEC etc.).

Please contact factory to discuss specific requirements.

Multi Unit Synchronization

The D-TA radio platforms are designed to allow ease of synchronization for multi-unit operation. A variety of options are provided that allow co-located or distributed units to be synchronized. For co-located units, the user can provide a common sampling clock or a common reference signal. Alternately, one of the units may act as a master unit and distribute the common sampling clock (or the reference signal) and the trigger signal to the multiple units. For distributed units (e.g., HF direction finding over a wide area), the radio platform allows for very precise (around 2.5 ns) time stamping of the data. The multiple units are then synchronized via a GPS reference clock. The platforms also have the ability to accept a 1 pps signal and synchronize all the fine timers.

High Speed 10Gbit Ethernet Recorder/Playback

D-TA Systems offers a 10Gbit Ethernet recorder/playback solution that works seamlessly with DTA-2300 & DTA-2210. The 19 rackmountable, 3U high recorder/playback unit can record /playback at a sustained and continuous rate in excess of 800 Mbytes/sec and offers a storage of 18 TB. This allows users to record 4 channels (antenna inputs) of RF signals with a bandwidth of 40 MHz for over 6 hours. The playback functionality can be used for analog playback of previously recorded signal or simulated signal and allows the user to easily build a simulator for complex applications.

The recorder/playback is fully scalable and higher record/playback rates and storage is obtained by combining multiple units. D-TA Systems will also work with the user to customize the recorder/playback to meet specific user requirements.

Applications

The flexible architectures of the D-TA Systems platforms allow them to be used in a variety of high-end multi-channel applications. A few examples are shown here.

Phased Array Radar

Phased array radar applications require large number of channels that are phase coherent and synchronously sampled. Some advanced phased array radars are being designed with large number of elements. The DTA-2300 platform is ideally suited for these high-end radar applications. A 16-channel beamformer can be implemented with a single DTA-2300 Digital IF Processor in a 1U chassis! Higher channel count systems can be easily integrated by combining multiple DTA-2300 units. Thus four boxes may be combined for a 64-channel requirement. The 10 Gbit interfaces allow a simple way for connecting

multiple boxes at extremely high data rate. The features of the radio platform that are critical for phased array radar application are:

- Clock delay for individual ADC and DAC sampling clock (10 ps steps) enable easy calibration of the entire analog chain (including the RF front end)
- The four processing FPGAs are interconnected with MGTs that allow for passing intermediate results back and forth (e.g., partial beams)
- Four 10 Gbit network access for real time data transfer. Separate dual Gigabit Ethernet interface for control function
- Multiple boxes may be connected via the industry standard XFP connectors for full duplex data link
- Multi-channel programmable RF front end that directly connects to the IF box without any external filters or amplifiers.

Smart Antenna

Smart antenna systems are very similar to phased array radar systems. However, the number of antenna elements is usually much smaller. A traditional cellular base station has three sectors and a two antenna diversity receiver. With the addition of two more antennas per sector, a robust smart antenna system may be implemented that significantly improves the Carrier to Interference (C/I) ratio and leads to significant capacity improvement. With the DTA-2300 a three sectored smart antenna system with four elements each can be easily implemented in a 5U space with channels to spare!

Sonobuoy

The DTA Radio Platform is an extremely powerful platform for implementing a cost reduced sonobuoy platform. Sonobuoys are traditionally implemented as an analog radio receiver that output the acoustic signal. A backend acoustic ADC digitizes the signal and an acoustic processor processes the signal. The DTA radio platform combines the radio receiver and the acoustic receiver functionality, thereby reducing size, weight and power of the equipment.

- Fast tuning 16-channel programmable RF front end can easily handle the 1 MHz bandwidth of the newer digital buoys
- Double Mixing architecture, individual gain control, enables high dynamic range and protection from desensitization caused by out of band high power interferers (e.g., TV channels).
- Four large processing FPGAs in the DTA-2300 can implement digital down conversion, FM / FSK demodulation. This eliminates the need for a separate acoustic digitizer.
- Acoustic processing may also be implemented in the FPGA thereby eliminating bulky acoustic processing hardware.

- Digital channelization (i.e., multi-channel DDC) allows the user to handle more than 16 sonobuoy channels.
- Spectrum monitoring (FFT) function to determine clear channels can be implemented in the FPGA. This can be used to implement a radio map which can be used to program the channels to be used by the sonobuoys

Arbitrary Waveform Generation and Simulator/Stimulator Applications

The multi-channel synchronized transmit capability of the D-TA Radio Platform makes it an ideal candidate for multi-channel Arbitrary Wave form generation and other simulator/stimulator applications.

- The RF upconverter module has three antenna outputs (per channel) for seamless switching of antenna. This allows a wideband signal generation without the need to manually change antennas.
- DTA-3200 RF upconverter allows direct connection to the DTA-2300 Digital IF processing sub-system without the need for external amplifiers and filters.
- Digital IO lines from the DTA-2300 IF processor can directly control the DTA-3200 RF front end.
- The 10 Gigabit real-time Ethernet data playback system can playback previously recorded or generated data.
- On board QDR-II SRAM memory allow continuous looping without the need for any real-time high-speed network link from the host. About 4ms (512k samples at 125 MSPS) worth of data per channel can be stored in the on-board memory.
- Synchronized conversion of multiple channels (16-channels in a single box) allows complex system modeling like transmit beamforming, C/I reduction in smart antenna systems, etc.
- Switchable multi-output ports allow simulation of a rotating antenna without any mechanical servos.
- Maximum output power of 0 dBm allow direct connection to antenna for a large number of low to medium power applications like wireless applications and simulation. For other applications, external power amplifiers are needed.

Spectrum Monitoring

The D-TA Radio Platform is an ideal platform for wideband spectral monitoring. The availability of 16 simultaneous channels allows the user to deploy a massive parallel monitoring scheme in a small footprint. At a 20 MHz bandwidth a total of 300 MHz can be easily covered using all the 16 channels.

- The RF downconverter module has three antenna inputs (for each channel) for seamless switching of antenna. This allows a wideband spectrum monitoring without the need to manually change antennas. A separate test/calibration port is also provided.

- Unlike other RF downconverter products available in the market, the output IF signal power is amplified to account for the full scale input range for the ADCs. This means that the DTA-3200 RF front end can be directly connected to the DTA-2300 IUF processor without the need for any external amplifiers or filters.
- The data FPGA can run a real time FFT and output the spectral map to a computer for display.
- Digital I/O lines from the DTA-2300 IF processor can directly control the DTA-3200 RF front end.
- A 10 Gigabit real-time Ethernet data recorder (DTA-5000) can record the raw data for detailed post processing.

Signal Intelligence (SIGINT) and Direction Finding (DF)

Signal Intelligence applications are diverse and varied. Some include the spectrum monitoring as described earlier, others include direction finding and multiple drop receivers.

- The DTA-3200 RF front end design ensures very high dynamic range ideally suited for SIGINT applications: detection of a low level signal
- Direct control of the attenuators for flexible gain control
- Real time FFT to determine signals of interest and directly tune the drop receivers.
- A large number of (in excess of 128) of narrow band drop receivers may be implemented in the FPGAs (optional: SX95T).
- High speed interconnection of processing FPGAs allow ADC data to be distributed to all four processing FPGAs
- Expansion headers connected to the processing FPGAs allow custom expansion modules to implement additional drop receivers or large delay memory.

Electronic Counter Measure (ECM) and Electronic Warfare (EW)

ECM and EW methods are extremely important tools for security and to counter IEDs. A high performance, synchronized transceiver is an extremely important requirement for these applications.

- Handling excess of 40 MHz transmit and receive bandwidth
- A fully synchronized transceiver with multiple large FPGAs (XC5VSX95T or bigger devices as option) allow for fast on-board processing of received signal and generating countermeasure signal
- A transceiver on a single module allows for ease of transmit and receive synchronization without complicated multi-board synchronization hassles.

- A high throughput 10 Gig interface allows for real time recording of the received signal for signature analysis: either real time or at a later date.
- Programmable delay lines on the ADC and DAC sampling clocks allow for precise calibration of phase delay.

Conclusion

The brief discussions presented above demonstrate that the same D-TA Systems Radio platform can be used for a wide range of complex and demanding applications like phased array radars, smart antenna, sonobuoy, SIGINT, tactical communications, MIMO, ECM, EW etc. We presented the DTA-2210, a single channel digital IF transceiver, DTA-2300, 16-channel Digital IF Processor and the DTA-3200, 16-channel RF up and downconverter products for these applications. The D-TA Systems radio platform offers plug and play advantage and greatly simplifies system integration.

D-TA Systems has achieved the feat of creating a common platform by using the absolute state of the art technology and painstakingly optimizing the performance of each sub-module. The common platform approach offers the advantage of volume production and the ability to pass on the cost savings to the customer.

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