DT7816

**Linux Data Acquisition
Real-Time High Performance
ARM Module for Embedded Applications**

The DT7816 is a high performance, System on Module (SOM) for data acquisition, featuring an embedded Cortex-A8 1 GHz ARM processor.   For use in embedded data acquisition and control applications, this real-time module is an open-source Linux platform with extensive examples using TI's SDK Essentials package.

Offering outstanding accuracy at a high throughput rate, the DT87816 provides 8 parallel, 16-bit, 400kHz A/D converters plus two 16-bit, parallel, 400kHz DAC outputs. Additionally, it provides a tachometer input, and 16 general-purpose I/O signals that provide up to 16 DIO, one 32-bit C/T, and one Measure/Counter.

Key Features

- **High performance, simultaneous data acquisition module** with embedded ARM
- **8 simultaneous analog input channels,** 16-bit resolution, up to **400KHz /ch**, ±10V input range
- **2, 16-bit, high performance,** stimulus waveform analog outputs, up to **400kHz/ch**, ±10V output range
- **16 GPIO Signals** that provide Digital I/O, Counter/Timer, Measure Counter, External Digital (TTL) Triggers, and External Clocks
- **One tachometer** input

Figure 1. The DT7816 provides 8 analog inputs, 2 analog outputs, DIO, C/T, tachometer, and measure counter functions along with an embedded ARM processor for real-time processing and analysis of DAQ measurements.

- **TI AM335x ARM Cortex-A8 MPU** with 2GB on-board NAND Flash memory
- **Open source Linux** computing platform using the TI AM335x SDK Essentials Version 7.0
- **Micro SD-Card interface** for measurement results and raw data
- **USB-host port** for additional SSD hard disk, Wireless LAN, or GSM communication stick
- **RS232 (3.3V) serial interface** to communicate with PLC
- **Ethernet and USB client** for host communication
- **Numerous example programs included** to get users up and running quickly
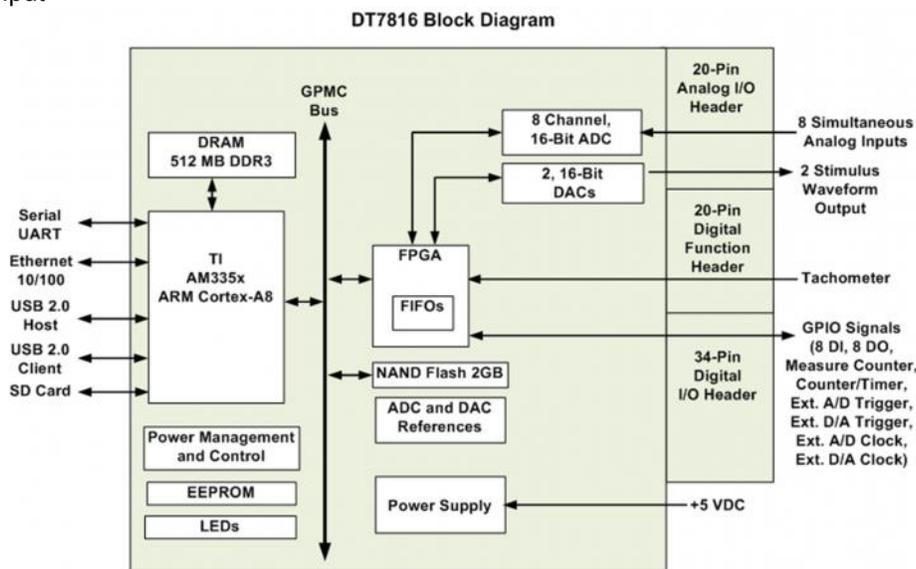

Figure 2. The DT7816 block diagram shows the board with the TI AM335x ARM Cortex-A8 processor, FPGA, memory and support peripherals as well as interfaces for a USB host and client, Ethernet, power, SD card, A/D, D/A, digital I/O, tachometer, and counters.

DATA TRANSLATION®
A MEASUREMENT COMPUTING COMPANY

5V Power Supply Input
...alternate parallel connection for maximum flexibility

SD Card Connector
...portable storage for later analysis

USB Device Connection

USB Host Port

Ethernet Port
10/100 mbps

6 Layer Board
...minimizes noise & gives pristine signal performance

Debug & Serial I/O Header
...easy access for monitoring activity

ARM A-8 Processor

512MB SDRAM

8 Separate 400kHz, 16-bit ADC Channels
...parallel simultaneous operation prevents channel to channel interaction

2GB NAND Flash
...all startup programs plus generous user space

Precision Voltage References
...high accuracy and excellent temperature stability

Digital Functions
...8 DIO, 2 counters, tachometer, ext. triggers

2 Separate 400kHz, 16-bit DAC Channels
...high speed, high accuracy

20-pin Digital Function Connector

20-pin Analog I/O Connector

34-pin Digital I/O Connector
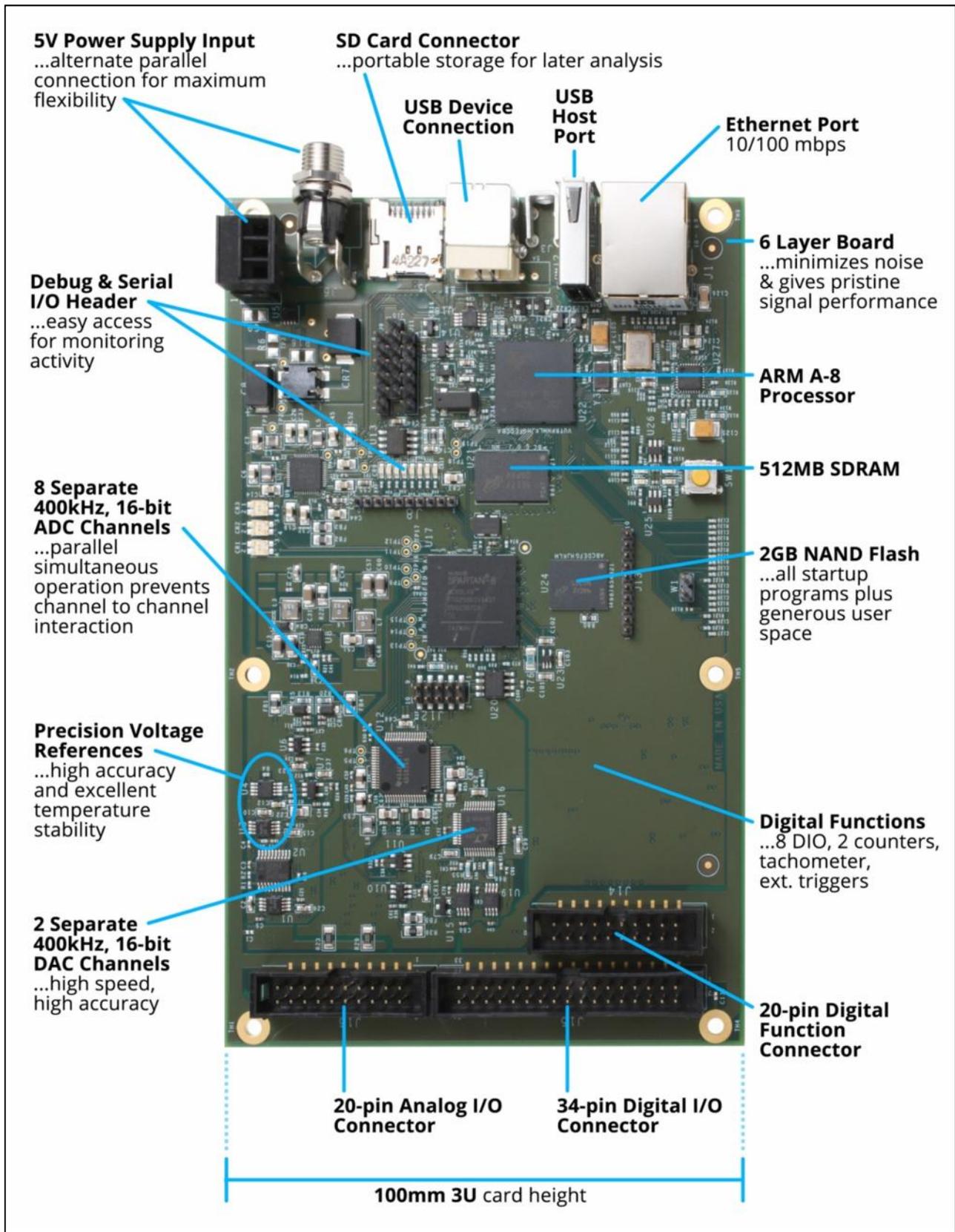
100mm 3U card height

Figure 3. The call-outs above illustrate the outstanding performance of the DT7816. It provides 8 analog inputs, 2 analog outputs, DIO, C/T, tachometer, and measure counter functions along with an embedded ARM processor. This real-time module is an open-source Linux platform for real-time processing and analysis.

DT7816 Overview

The DT7816 module is an open-source Linux computing platform offering high speed, simultaneous analog inputs and outputs. It is ideal for embedded data acquisition and control applications.

ARM Processor

The ARM processor used on the DT7816 module is the TI Sitara AM3352. This processor and its associated peripherals provide an open-source, single-board computer. The AM3352 supports many different interfaces, many of which are shared on the configurable I/O pins. In addition to the AM3352, the DT7816 module uses an embedded NAND flash and an FPGA.

Analog Input Channels

The DT7816 provides eight analog input channels with input range of ±10V. Each analog input channel uses a 16-bit analog-to-digital converter (ADC) that provides simultaneous capture. In addition to acquiring data from the analog input channels, the DT7816 supports the ability to simultaneously acquire the value of the tachometer input, measure counter, and digital input port in the analog input stream.

Input Triggers

The DT7816 module supports the following sources for starting acquisition:
- software trigger
- external digital (TTL) positive or negative trigger
- threshold trigger

Input Clock

The DT7816 module supports both an internal A/D clock, which is derived from the 48 MHz reference clocked that is generated from the onboard oscillator, and an external A/D clock, which can be connected to one of the general-purpose input signals on the I/O header.

If using the internal A/D clock, the sampling frequency can range from 100 Hz to 400 kHz. If using an external A/D clock, the maximum sampling frequency is 400 kHz; there is no minimum sampling frequency.

Tachometer Input

The DT7816 supports a tachometer input signal with a range of ±30V. The frequency or period between two edges of the tachometer input signal can be measured to calculate the rotational speed of the high level tachometer input. The value can then be returned the value in the analog input data stream. The starting edge (either rising or falling) of the tachometer signal is programmable. An internal 12MHz counter is used for the measurement.

Digital I/O Lines

The DT7816 module supports one digital input port, consisting of 8 digital input lines and one digital output port, consisting of 8 digital output lines. Users can synchronously read all 8 digital input lines or write to all 8 digital output lines. Users can also return the value of the digital input port in the analog input stream to correlate digital input and other input measurements or update the value of the digital output port in the analog output stream.

The 34-pin digital I/O header on the board provides access to the digital I/O lines through general-purpose I/O pins. Users can redefine these pins for use as the counter/timer gate, counter/timer input, counter/timer output, external clock, or external trigger signal, as required by their specific user application.

General Purpose Counter/Timer

The general-purpose counter/timer on the DT7816 module supports the following counter/timer operation modes:

- **Event Counting** – Counts the number of rising edges that occur on the counter's input signal whenever the gate is active
- **Rate Generation** – Generates a continuous pulse output signal whenever the gate is active
- **Non-repeatable one-shot** – Generates a single output pulse whenever the gate is active (after the pulse period from the previous output pulse expires). Any gate signals that occur while the pulse is being output are not detected.
- **Idle** – The counter no longer drives the clock output signal.

Users can program the gate type, C/T clock source, pulse width, pulse output period, and pulse output polarity.

Measure Counter

DT7816 module provides one measure counter. Using this counter, you can measure the frequency, period, or pulse width of a single signal or the time period between two signals and return the value in the analog input stream. This is useful for correlating the analog input data with digital positional data, measuring the frequency of a signal, or as a tachometer. An internal 48 MHz counter is used for the measurement, yielding a resolution of 20.83 ns (1/48 MHz).

Analog Output Channels

The DT7816 provides two high speed, simultaneous, 16-bit analog outputs an output ranges of ±10V. The module provides output rate up to 400kHz/channel.

Analog Output Clock

The DT7816 module supports both an internal D/A clock, which is derived from the 48 MHz reference clock that is generated from the onboard oscillator, and an external D/A clock that you can connect to one of the general-purpose input signals of the I/O header.

If using the internal D/A clock, the output frequency can range between 1 Hz and 400 kHz. If using the external D/A clock, the maximum output frequency is 400 kHz; there is no minimum frequency.

Output Triggers

To start an output operation, the following output triggers are supported:
- software trigger
- external digital (TTL) positive or negative

Simultaneous Input and Output Operations

The DT7816 supports the ability to continuously acquire data from the input stream and continuously output data from the channels in the output stream simultaneously. Since the A/D and D/A subsystems have separate clock signals, input and output functions may also be run independently.

Synchronizing Acquisition on Multiple Modules

The clocks of multiple modules can be synchronized by using an external clock source that is connected to each module. Acquisition can be started on multiple modules at the same time by connecting an external trigger to each module. Using software, you must define one of the general-purpose input pins on the 34-pin digital I/O header on each DT7816 module as the external trigger signal and another general-purpose pin as the external clock signal. When triggered, the modules start acquiring data at the same time at the clock rate of the external clock source.

Software

The DT7816 modules run Linux 3.12 (Debian distribution) with custom loadable kernel modules (LKM) or device drivers.

The DT7816 device drivers and numerous example application programs reside on the DT7816 module.

Users can power up the module and run the examples right out of the box!

The drivers are loaded when the DT7816 module is powered up. The device drivers (DT7816 driver and DT7816 USB driver), shown in the block diagram below, expose the functionality of the module to Linux user space applications using virtual file interfaces.
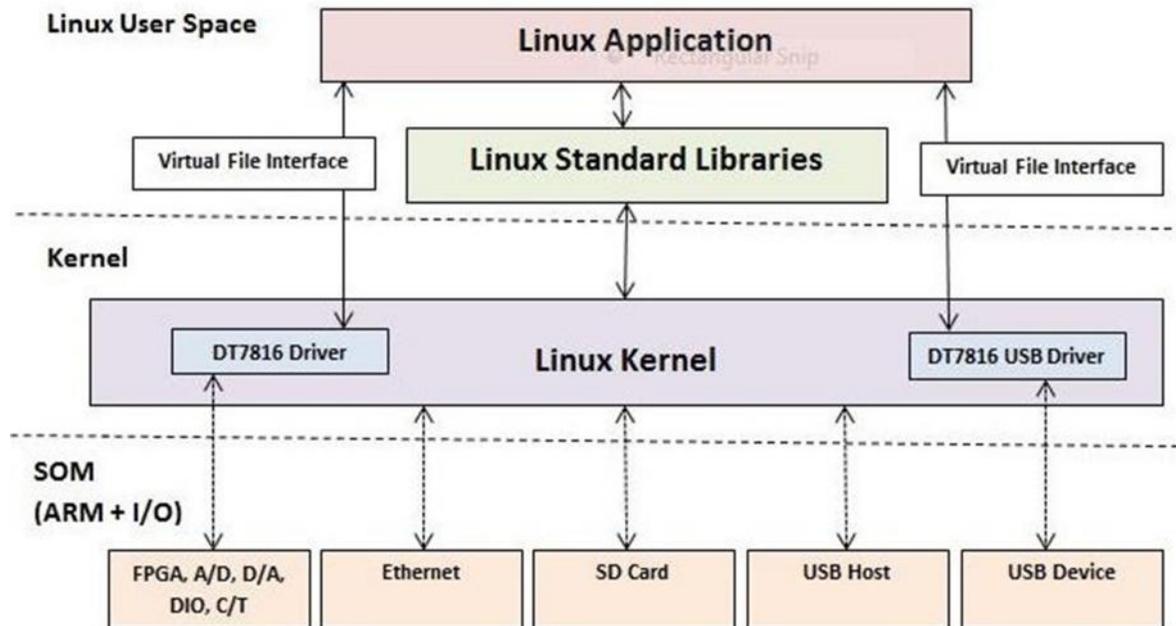

Figure 4. The DT7816 runs Linux 3.12 with custom loadable kernel modules, i.e., "device drivers" for the board hardware. These "drivers" expose the functionality of the board to Linux user space applications.

The DT7816 module uses the following virtual files to access its subsystems:

- /dev/dt7816-ain – Analog input subsystem.
- /dev/dt7816-aout – Analog output subsystem.
- /dev/dt7816-din – Digital input subsystem.
- /dev/dt7816-dout – Digital output subsystem.
- /dev/dt7816-tach – Tachometer input subsystem.
- /dev/dt7816-measure – Measure counter subsystem.
- /dev/dt7816-ctr-tmr – Counter/timer subsystem.
- /dev/dt7816-stream-in – Input stream.
- /dev/dt7816-stream-out– Output stream.

The USB device functionality of the DT7816 is accessible to user-space embedded applications using the following files:

- /dev/dt7816-ep1in - EP1 IN endpoint.
- /dev/dt7816-ep1out - EP1 OUT endpoint.
- /dev/dt7816-ep2in - EP2 IN endpoint.
- /dev/dt7816-ep2out - EP2 OUT endpoint.
- /dev/dt7816-ep3out - EP3 OUT endpoint.
- /dev/dt7816-ep4out - EP4 OUT endpoint.
- /dev/dt7816-ep5out - EP5 OUT endpoint.

User applications can perform standard file operations such as **open**, **close**, **read**, and **write** on the virtual files to access and control the hardware or to send data to the USB host through an IN endpoint and receive data from the USB host through an OUT endpoint.

For instance, to access the digital input subsystem on the DT7816 module, the application uses the virtual file handle for the digital input subsystem (/dev/dt7816-din) as follows.

1. Open the file /dev/dt7816-din, thereby allowing access to the digital input subsystem.
2. If supported, configure parameters for the digital input subsystem using IOCTL commands.
3. Read from the file, which in turn, reads the value of the digital input port and returns a value.
4. Close the file.

DT7816 Example Programs

The DT7816 ships with many example programs that demonstrate the capabilities of the hardware. They also illustrate how user programs communicate with the DT7816 drivers using file I/O commands and IOCTLs. All examples are written in ANSI C, are open source, and include make files that allow them to be built using the TI SDK tool chain and cross compilers.

Users can build these example programs, use them to test their hardware, and modify them as needed to get up and running quickly.
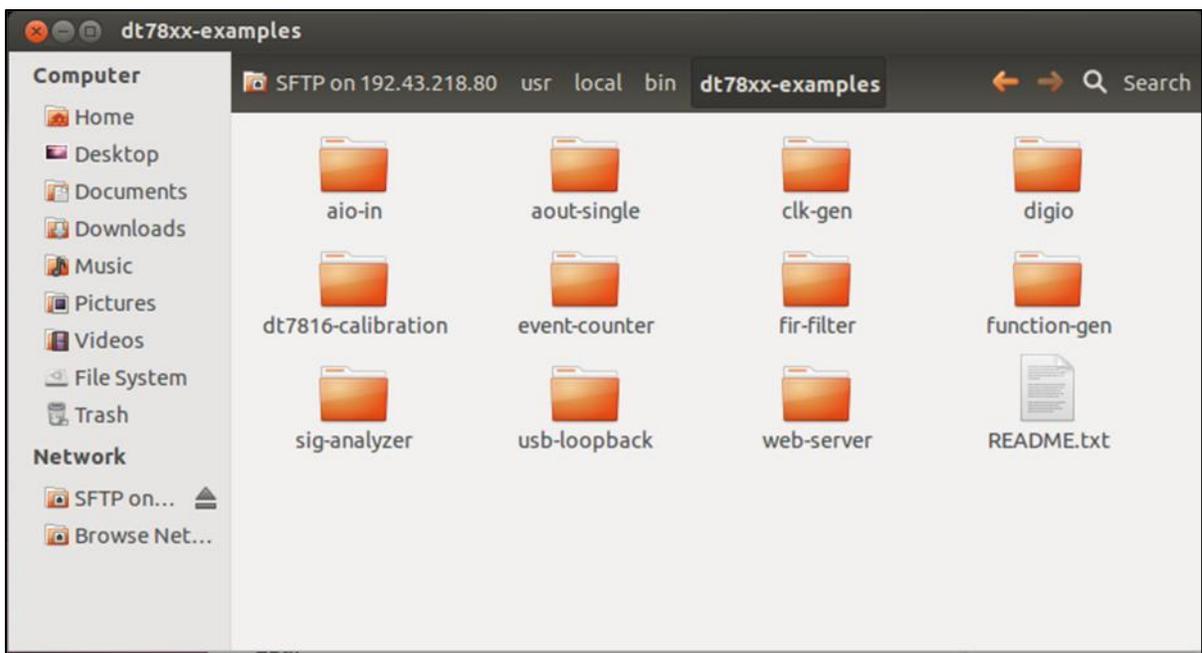

Figure 5. DT7816 example programs allow users to get up and running applications.

The following example programs are provided:
*   aio-in – Performs an asynchronous analog input operation, generating a sine wave, triangle waveform, or sawtooth waveform
*   function-gen – Performs an asynchronous analog output operation, generating a sine wave, triangle, or sawtooth waveform using Direct Digital Synthesis.
*   aout-single – Performs a synchronous write operation on the analog output channel.
*   clk-gen – Uses the counter/timer to generate an output clock.
*   common – Includes common functions used by the other example programs.

*   usb-loopback – Demonstrates use of the gadget USB driver to send data from a host application to the DT7816 using and OUT USB pipe and to receive data from the DT7816 using IN USB pipe.
*   digio – Performs a synchronous write operation on the digital output port, and then reads back the value that was output by performing a synchronous read operation on the digital input port.
*   dt7816-calibration – A command-line program that calibrates the analog input and analog output circuitry.

- sig-analyzer – An embedded web server and signal analyzer. It acquires data from two analog input channels and performs and FFT on the data. The results are displayed to a client's web browser when connected to the device.
- web-server – An embedded web server that performs most of the functions of the DT7816 module and saves the acquired data to a file.

- fir-filter - Performs an input stream and an output stream operation simultaneously and continuously. Data from the input stream is filtered and then output from the analog output channel.

Ordering Summary

- **DT7816**   8-channel, Simultaneous ARM DAQ Module

Accessories:
- **DT7816 Accessory Kit**   Includes STP781X Screw Terminal Panel, EP405 USB To Serial TTL Debug Cable, EP394 Power Supply, USB Cable, and Ethernet Cable

  Or order separately:
- **STP781X**   Screw Terminal Panel
- **EP405**   USB to Serial TTL Debug Cable
- **EP394**   +5V DC Power Supply and Cable