

# DT7816

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

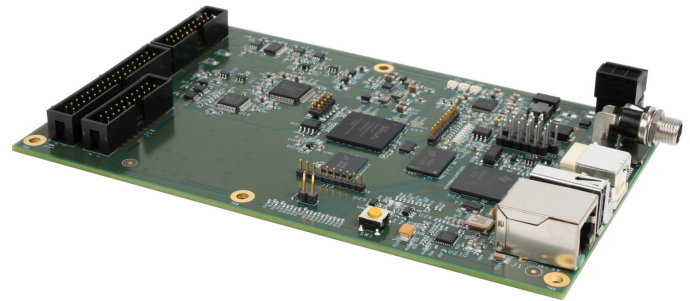
### Overview

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 DT7816 provides 8 parallel, 16-bit, 400 kS/s/ch A/D converters plus two 16-bit, parallel, 400 kS/s/ch DAC outputs. Additionally, it provides a tachometer input, and 16 general-purpose I/O signals that provide up to 16 DIO, one 32-bit counter/timer, 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 400 kS/s/ch,  $\pm 10$  V input range
- 2, 16-bit, high-performance, stimulus waveform analog outputs, up to 400 kS/s/ch,  $\pm 10$  V output range



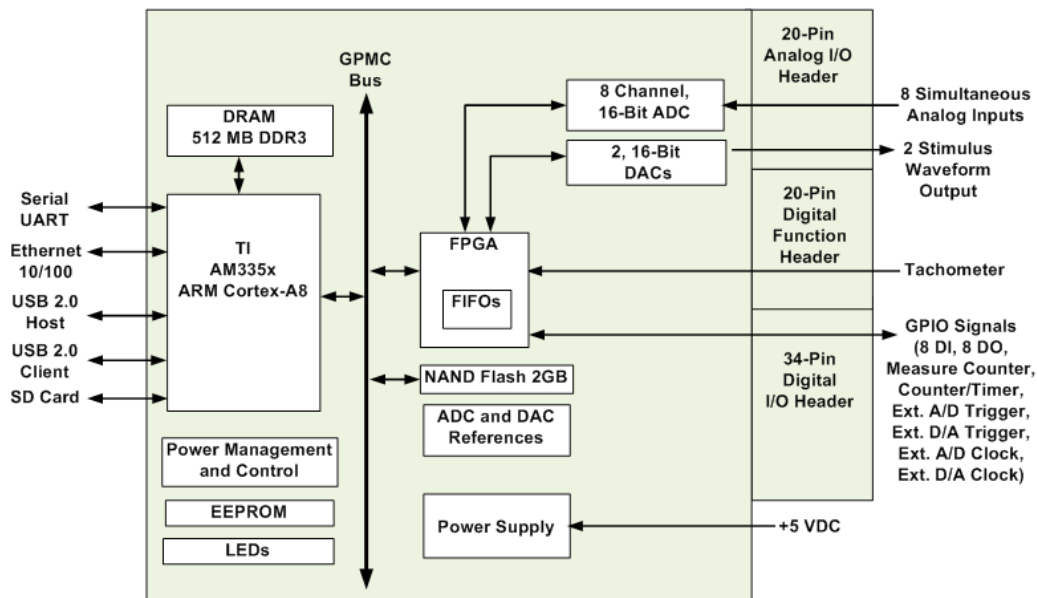
*The DT7816 provides 8 analog inputs, 2 analog outputs, DIO, counter/timer, tachometer, and measure counter functions along with an embedded ARM processor for real-time processing and analysis of DAQ measurements.*

- 16 general-purpose I/O signals that provide digital I/O, counter/timer, measure counter, external digital (TTL) triggers, and external clocks
- One tachometer input
- 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 (3.3 V) serial interface to communicate with PLC
- Ethernet and USB client for host communication
- Numerous example programs included to get users up and running quickly

### Supported Operating Systems

- Linux

DT7816 Block Diagram



*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.*

**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

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

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

**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

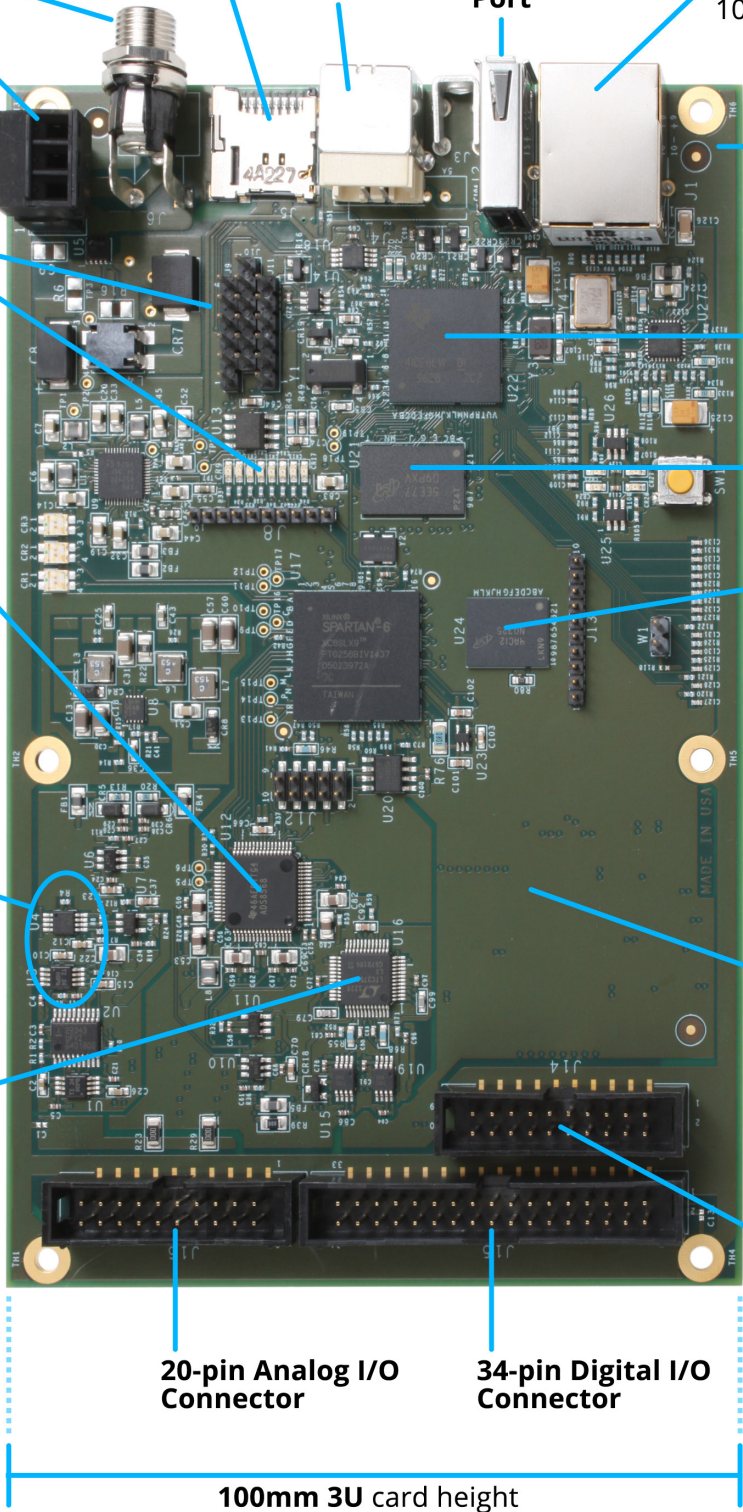
**2 Separate 400kHz, 16-bit DAC Channels**  
...high speed, high accuracy

**20-pin Digital Function Connector**

**20-pin Analog I/O Connector**

**34-pin Digital I/O Connector**

**100mm 3U card height**



The callouts above illustrate the outstanding performance of the DT7816. It provides 8 analog inputs, 2 analog outputs, DIO, counter/timer, 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 Module

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 TI Sitara AM3352 ARM processor is used on the DT7816 module. 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  $\pm 10$  V. 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  $\pm 30$  V. The frequency or period between two edges of the tachometer signal can be measured to calculate the rotational speed of the high level tachometer input. The value can then be returned to the analog input data stream. The starting edge (either rising or falling) of the tachometer signal is programmable. An internal 12 MHz 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, counter/timer 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  $\pm 10$  V. The module provides an update rate up to 400 kS/s/ch.

## 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

Use an external clock source that is connected to each module to synchronize the clocks of multiple modules. Start acquiring from 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.

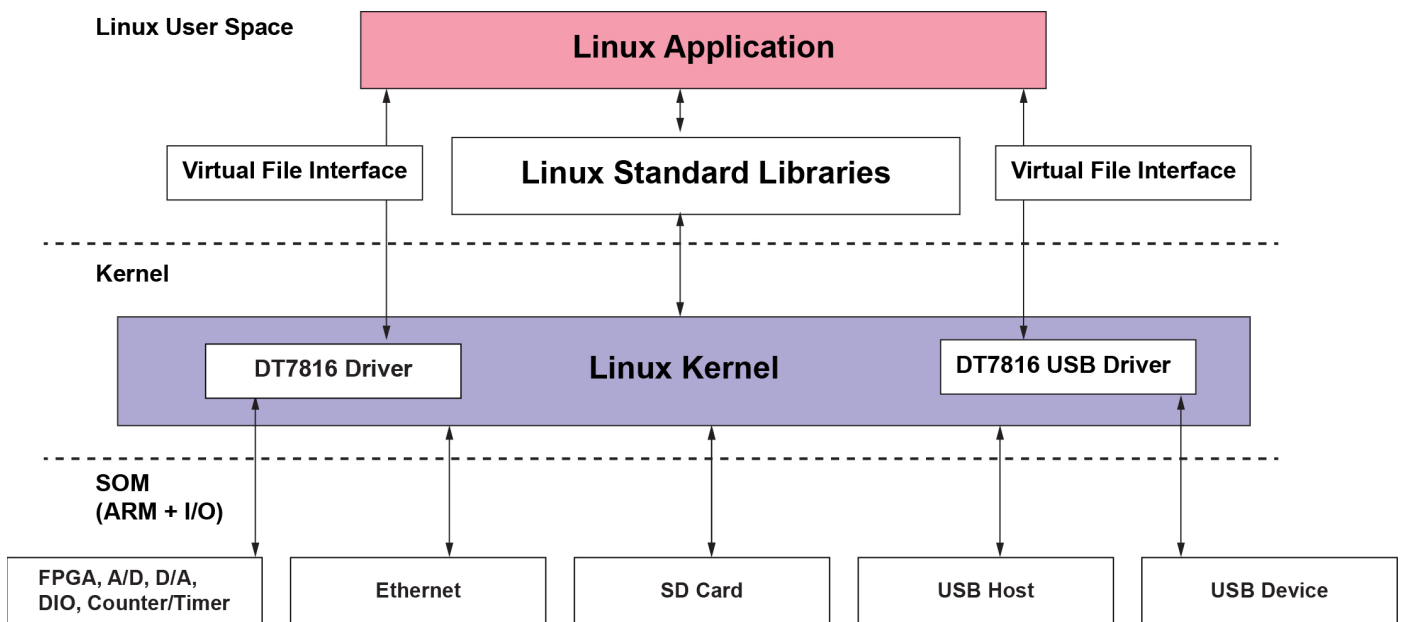
## Software

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.



*The DT7816 runs Linux 3.12 with custom loadable kernel modules – specifically 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.

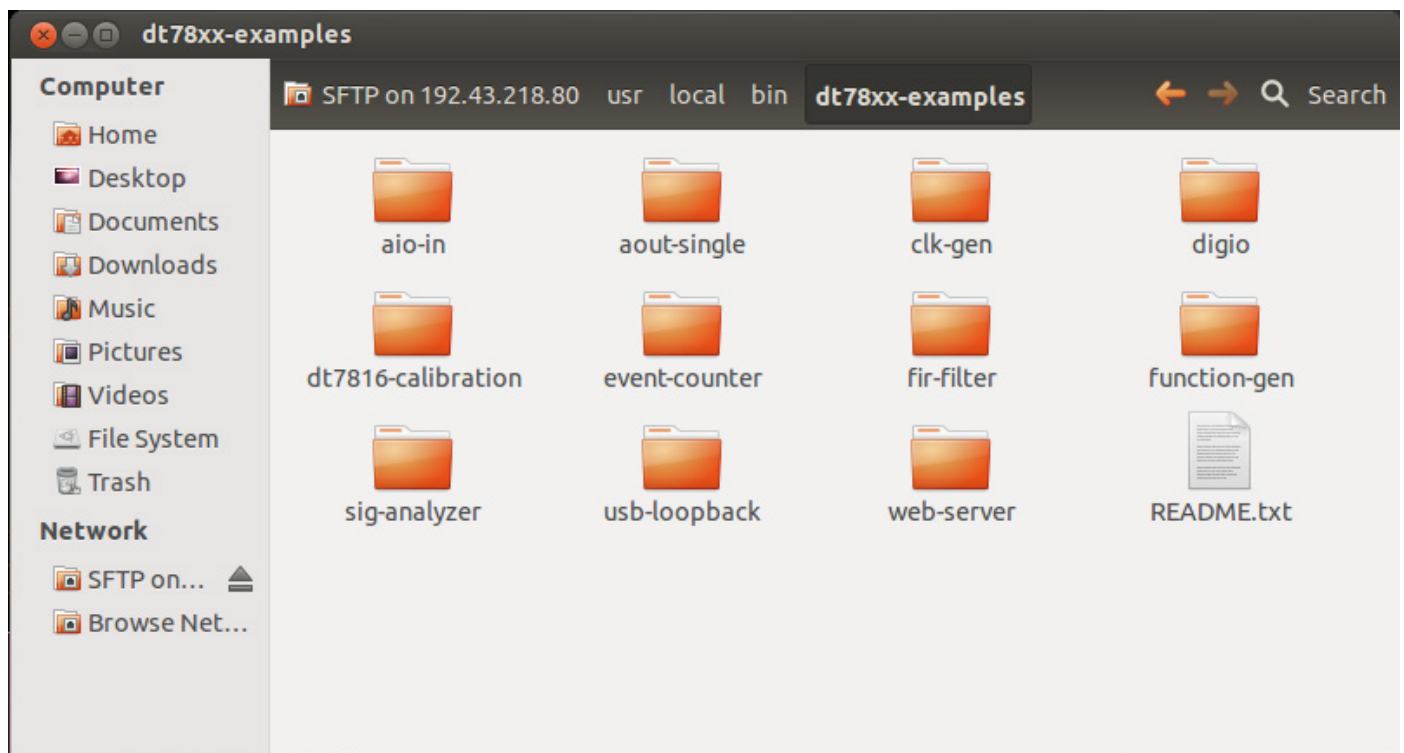
DT7816 USB device functionality is accessible to user-space embedded applications using the following files:

- /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 allow users to get up and running applications.*

## 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.

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 an FFT on the data. The results are displayed to a client's web browser when connected to the device.
- **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.
- **web-server** – An embedded web server that performs most of the functions of the DT7816 module and saves the acquired data to a file.

## Ordering Summary

### HARDWARE

- **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** – +5 V DC Power Supply and Cable