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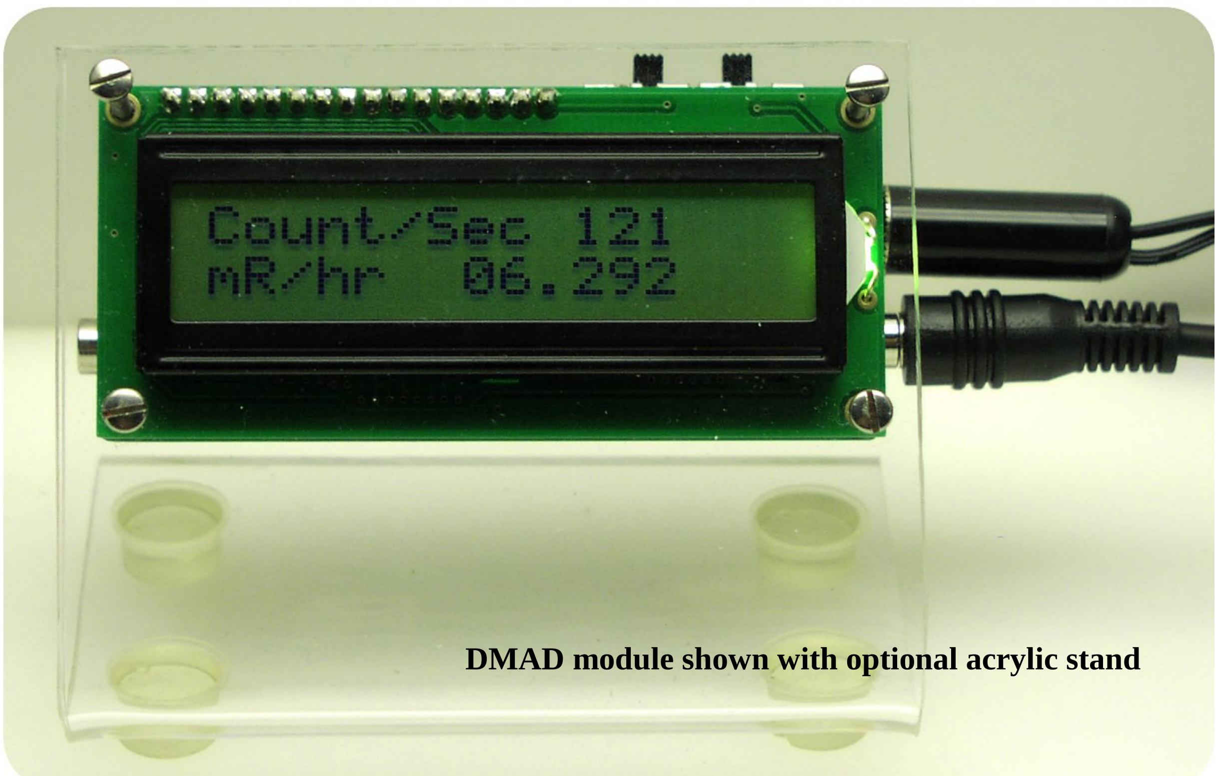
DMAD-04 Expansion Module
Adding digital capabilities to Analog Geiger Counters



DMAD module shown with optional acrylic stand

The new Digital Meter Adapter is now a universal expansion module. This unit combines our Digital Meter Adapter with a Random Number Generator. It also add the capability to connect an analog Geiger counter to a PC through use of a TTL serial cable. The new DMAD has ability of adding additional features to enhance the capabilities of Analog Geiger Counters. Please visit our website to see when new features are added.

Important Safety Warning

By using this product, you agree not to hold Images SI Inc. liable for any injury or damage related to the use or to the performance of this product. This product is not designed for, and should not be used in, applications where the malfunction of the product could cause injury or damage.

Contacting Images SI Inc.
You can check the Images SI website at http://www.imagesco.com/ for latest information about the Geiger Counters & Accessories.

We would be delighted to hear from you about your project and your experience with our Geiger Counter range of products. You can contact us by email at imagesco@verizon.net. Tell us what we did well, what we could improve, what you would like to see in the future, or anything else you would like to say!

Notes on DMAD radiation conversion accuracy:

The Digital Meter mode of the DMAD is made to work with a large number of different Geiger counters. While the count in CPS ad CPM will be accurate, the conversion of those numbers to a radiation value are only approximate, based upon a general conversion program. They should not be considered accurate.

The New DMAD Adapter

The DMAD has evolved into a universal expansion module that allows the user to choose between several different functions. It can currently be used as a Digital Meter with a TTL serial digital output or Random Number Generator . The TTL serial digital output can be used to connect the Geiger counter to a PC. It provides a single module solution for adding various extra features to enhance capabilities of Geiger Counters. New features are currently being developed and updates will be available on the Images website. The DMAD can connects any Analog Geiger counter with a TTL pulse output. To connect to Images Analog Geiger counter, you can use the included male to male 3.5 mm mono plug. This plug can be connected to the digital output of most Analog Geiger counters. This connection expects to see a +5V TTL pulse every time the Geiger counter detects a radioactive particle.
Functionality is selected by a switch located on the backside, A7.

Digital Meter Function:

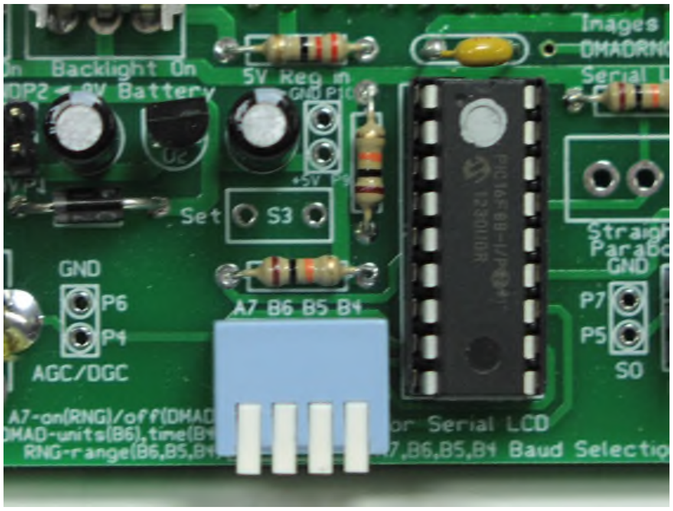
Digital Meter provides the count in either CPS (Counts per Second) or CPM (Counts Per Minute) on the top line of the LCD display. The bottom line of the LCD display provides the approximate radiation level.

A7 Switch/Up Position = Digital Meter with serial digital output for USB PC Interface

When A7 is not set (switch in up position, open), the module will function as a Digital Meter. The A7 switch is checked for position when the module is turned on, so switch setting should be changed only when module is off. Changing the switch setting while the module is powered will not change functionality of module.

Usage

Switch A7 In up position (Unset) selects Digital Meter mode with digital output mode In this mode, the module has four options that may be selected using the switches on the back of the circuit, see Figure below.



Switch Table

A7	B6	B5	B4	Function
Up	Up	XXX	XXX	mR/hr
Up	Down	XXX	XXX	mSv/hr
Up	XXX	XXX	Down	60 Seconds
Up	XXX	XXX	Up	1 Second

Up = unset Down = set XXX = Don't care

Switch B6 sets whether the output radiation level is given in conventional terms mR/hr (milliRads/milliRem per hour) or System International (SI) mSv/hr (milliSiverts per hour).

Switch B4 sets the timing mode of either one minute or one second. When B4 is set to one-minute mode, the radiation level is given in µR/hr or µSv/hr. This mode is convenient for checking the local background radiation.

Irrespective of the selection of CPS/CPM, CPS data will be sent out serially every second, which can be interfaced with PC for Graphing & Charting Purpose. The USB/TTL interface cable sends the counts per second information transmitted to the PC via USB in two bytes. A high byte, that is multiplied by 256 and added to the low byte for the total count. The USB/TTL cable is seen on the PC as a COM Port.

To use the DMAD as a Digital Meter, set the switches for the units/time you want, see chart above. Plug the 3.5mm Male to Male cable into the Digital out of the Analog Geiger counter, and the opposite end of the cable into the Serial input (AGC/DGC in), J1 on the DMAD board. see Figures 5 and 5 on the next page.

Turn the Geiger counter on, then turn this module on. After powering on the module, its LCD screen will be empty for 1 second, the module's LCD is initializing during this time. Then Screen will read "**DMAD for AGC**" on top line & "**Counting…**" on bottom line of LCD for another 1 second. After that counts & radiation level calculations will commence as per radiation particles detected by the Analog Geiger Counter. The LCD screen will display counts & radiation levels as per time & units selected & radiation particles detected by Analog Geiger Counter. LCD display should now resemble to that of Figure 2 on page 3.

If there is no display on the LCD, adjust the contrast control on the back of the Digital Meter Adapter, as seen in Figure 3.

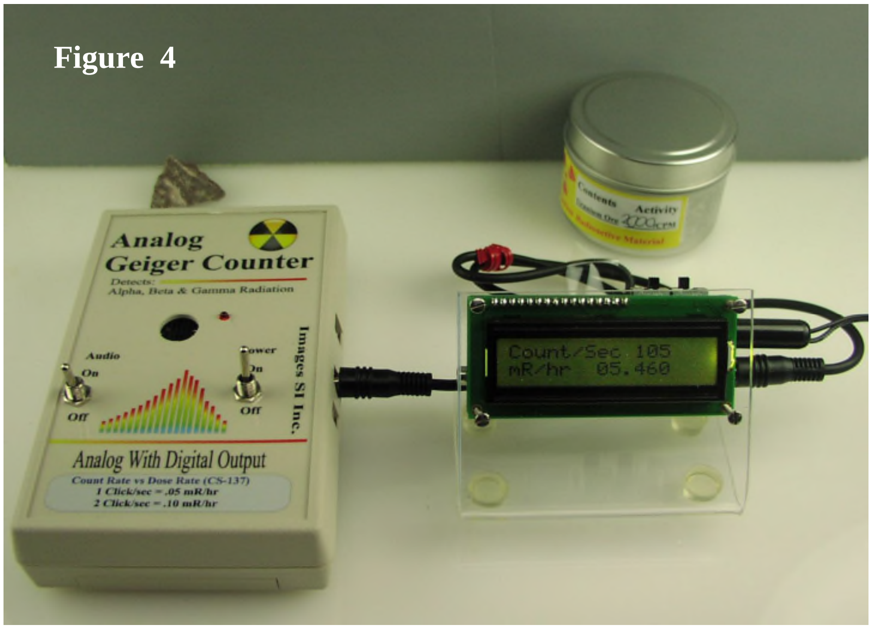


Figure 4

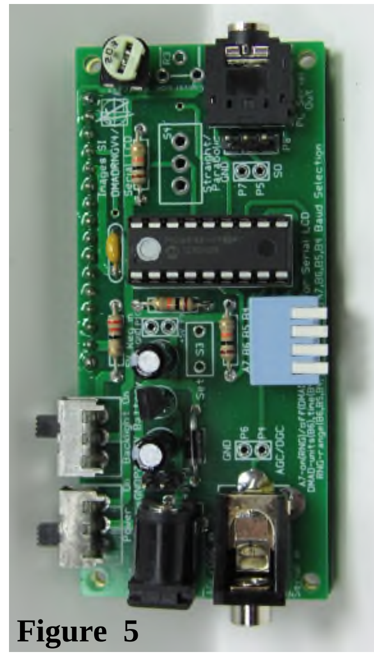


Figure 5

USB Adapter

You can use PC's USB port to connect to module using USB/TTL Cable. When using the USB to TTL cable set the program to read either COM port 3 or 7. After the driver for the cable is installed, it sets the COM port at 3 or 7, depending on the version of Windows you are running.

The USB to TTL cable and driver are available on Images SI Website at:

http://www.imagesco.com/semiconductors/usb-3.5mm.html

Geiger Counter Graphing & Logging Software

Geiger Counter measurements can be used for Graphing & Logging purposes by connecting Analog Geiger Counter to PC via this module, using various PC Softwares. Images SI offers one such software on our website website.

Geiger Counter Charting Software is proprietary of Images SI, and is available free of charge at: http://www.imagesco.com/catalog/geiger/counter_accessories.html.

Geiger Counter Charting Software runs on Windows. Download the software installation file from Images SI website & install it on your PC. Connect the module to PC's USB port via USB to TTL stereo cable. The module should be set to operate in DMAD / PC interface mode by setting switch A7 Up.

Make sure the program's COM port is set to the correct COM port where the module is connected. Both the module and Geiger counter must be on and properly connected for the program to begin graphing. The graphs generated by the program may be saved to disk and loaded for viewing and analysis later on. See screen image on page 6.

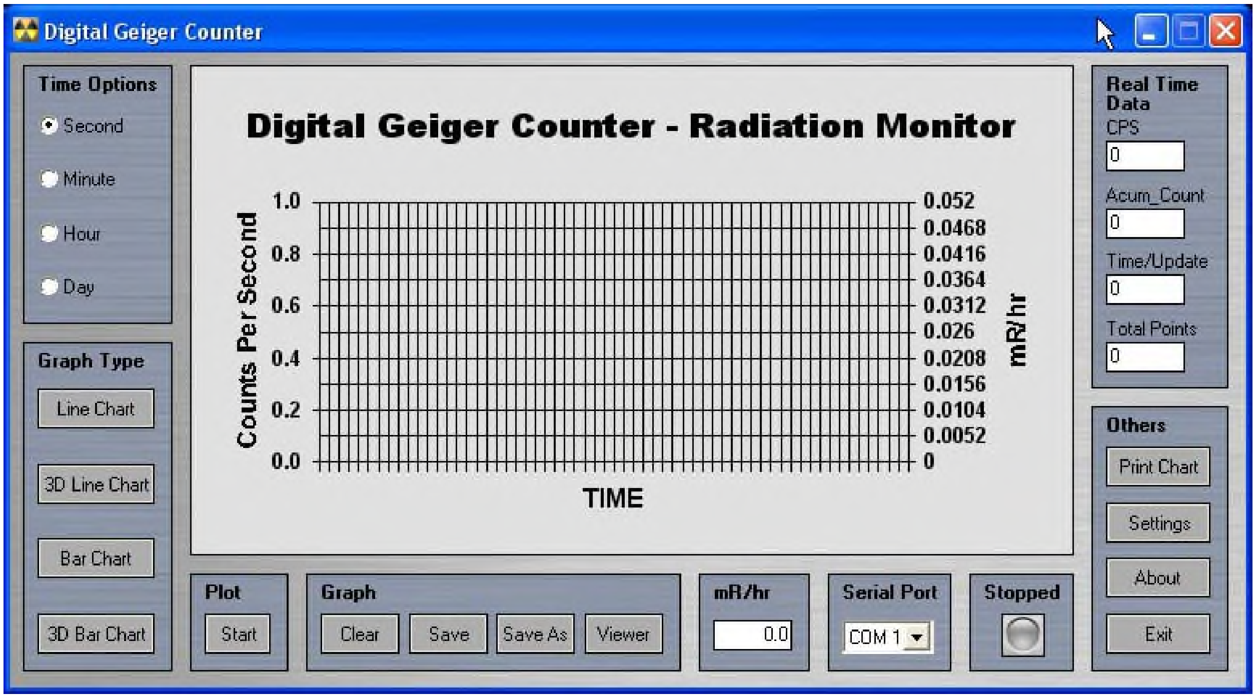


Figure 6

Random Number Generator Function

A7 Switch Set = Random Number Generator:

A7	B6	B5	B4	Range
Down	Down	Down	Down	1-2
Down	Down	Down	Up	1-4
Down	Down	Up	Up	1-8
Down	Down	Up	Down	1-16
Down	Up	Up	Down	1-32
Down	Up	Up	Up	1-64
Down	Up	Down	Up	1-128
Down	Up	Down	Down	1-128

Figure 7

When A7 switch is in its Down position it is set and the module will function as Random Number Generator. Switch A7 is only checked when the module is initially turned on, so switch setting should be changed only when the module is off. Changing the switch setting while the module is powered on will not change functionality of module.

Random Number Generator functionality generates random numbers true in nature. For this purpose, the module can be used with either of Analog or Digital Geiger Counters. The module plugs into the Digital out of the Analog Geiger Counter & Audio out of Digital Geiger Counter. The range of random numbers generated is selected by the combination of switch settings for B6, B5, B4.

The TTL serial sends the random number generated to the PC via the interface. The information is transmitted as a single byte. This data is used by various PC programs for monitoring and graphing.

When using the DMAD in Random Number Generator mode the Geiger counter should be set up to read background radiation. Typically, depending upon your location (background radiation is location dependent), the generator will generate 20-40 random numbers per minute. The random numbers generated are truly random since they are based on naturally occurring radioactivity. These random numbers are displayed on the LCD Display & are sent out via a TTL serial port that may be interfaced to a micro controller or PC. Serial communication specifications are: 9600 baud, 8N1.

To use the DMAD as a Random Number Generator, The A7 switch on the back of the module should be set before the module is powered on, in order to select the RNG mode of operation. Module has three options switches, B6 to B4 (see Figure 3) for selecting number range. The current version of RNG module can produce 7 different ranges of random numbers,

Set the switches for the range of your choice. Plug one end of the 3.5mm (1/8") male to male cable into the Digital out of the Analog Geiger counter / Audio out of Digital Geiger counter. Insert the other end of the 3.5 mm cable into the J1 "Serial in (AGC/DGC in)" socket on the DMAD. Turn the Geiger Counter on, then turn the module on. If there is no display on the LCD, adjust the contrast control on the back of the module.

When the module is powered on, the LCD Screen will be blank for 1 second (LCD screen is initialized during this time) & then a splash screen will be displayed with text "**Random Number**" appearing on top line of LCD Screen, followed by text "**Generator**" on bottom line of LCD Screen. The splash screen will be displayed for a minimum of 1 second, after random number generation commences. The module will display the random number generated on the LCD screen only when the Geiger counter detects a radioactive particle. This can take a while (average background radiation particles count per second is 20, if background radiation level is low in your location). Until the first radioactive particle is detected, the LCD Screen will display the splash screen (Figure 7).

Figure 8

Once random number generation commences, for each random number generated the LCD Screen will show text "**Range : 1 to 2**" in top line, (range selected is 1 to 2 for this example). The bottom line will display text "**Generated :**" followed by the random number generated. This display will be present until next number is generated, after which display will be refreshed to display current number.

In reality random numbers generated inside a microcontroller for any selected range starts from 0 instead of 1. Before the generated number is displayed on the LCD Screen and serially sent out, 1 is added to generated number to shift the range from starting 0 to starting 1. This is done because conventional counting system starts from 1.

As each radioactive particle is detected by the Geiger Counter, a new random number is generated and displayed on the LCD. At the same time the number is sent out via the TTL serial port ,that can be accessed by header I/O & 3.5 mm socket on the back of the DMAD Module. This allows any system to take the random numbers generated by this module for further use. PC can be connected to this module with a USB to TTL cable and a proper interface to read random numbers generated. Serial Data format is 9600 Baud, 8N1 with a byte wide data for random number.

Writing Your Own Software to Communicate with the Adapter

You can write your own software to communicate with this module. Serial data is sent out as a two byte number (most significant byte first) with the following specifications: 9600 Baud, Inverted, 8 data bits, no parity and one stop bit.

CONSTRUCTION

Figure 8 below shows the schematics of the DMAD-04. The circuit uses a pre-programmed 16F88 microcontroller and a standard 16 x 2 LCD display. Module derives its power from either an 9V external battery, or optional power supply. Power is regulated on board to 5V. Input to module comes via 3.5 mm mono jack, J1. The module features a TTL serial out port via a two pin header or 3.5 mm stereo jack, J2, which can be interfaced to a PC using Images' USB/TTL Serial Cable. The back of DMAD Module has a Power switch, LCD backlight switch, Contrast control, and Selection switches, see Figure 10.

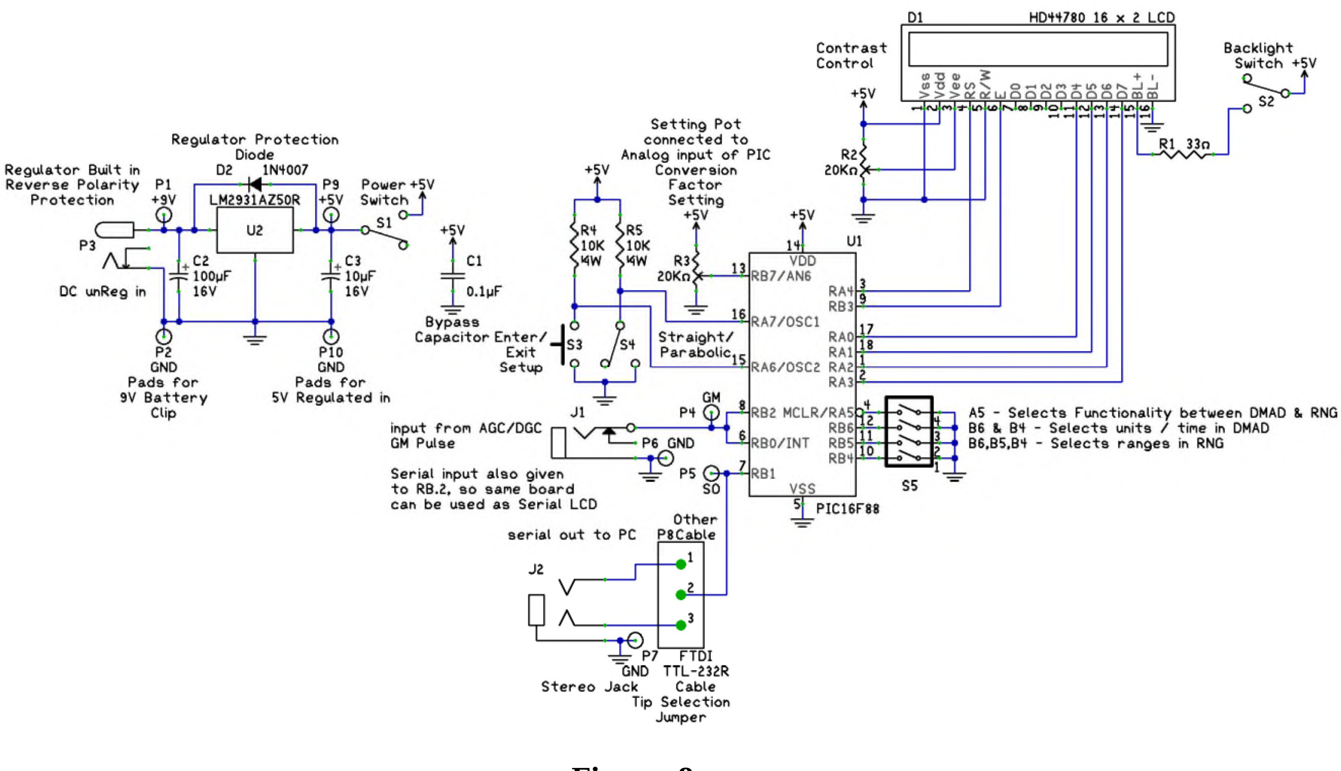
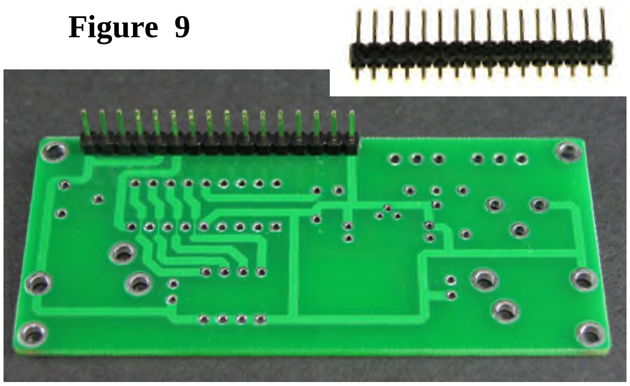


Figure 8

Begin by mounting and soldering the 16-pin header on the bottom of the board (the side with **no** silkscreen) as shown below Figure 9.

Figure 9



Now, on the top of the board (silkscreen side), mount and solder the two slide switches marked S1 & S2, followed by power jack, P3. Next, mount and solder the resistors. R1 is a 33 ohm resistor (color bands orange, orange, black). R4, R5, & R6 are 10K ohm resistors (color bands brown, black, orange). Next mount the 1N4007 diode, D2, making sure to align the stripe on the diode with the strip on the silkscreen.

U2 is the regulator. When mounting the regulator, be sure the flat side is oriented with the flat side of the silkscreen. Next mount the two 2-pin headers in the top two sets of holes marked P1,P2 then P4,P6. Mount the 3-pin header marked P8. These headers provide an alternate method of connecting to the board to supply power, digital input, and serial output respectively.

Now, mount C1, the 0.1uf capacitor and the two 10uf 16V capacitors marked C2 & C3. When mounting these capacitors be sure the longer lead is oriented to the hole marked positive.

Mount and solder the Serial Input jack, J1 and Serial Output jack, J2. Followed by the 20K pot in the spot marked R2 for the Contrast Control. Mount and solder the 4-position switch in S5.

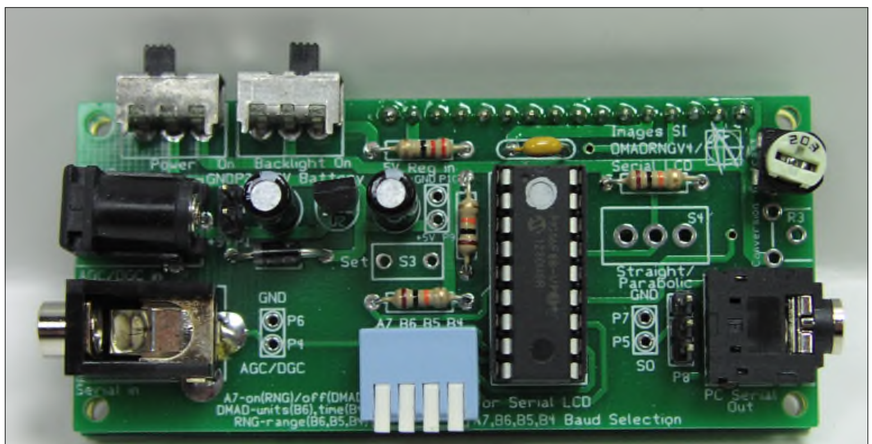
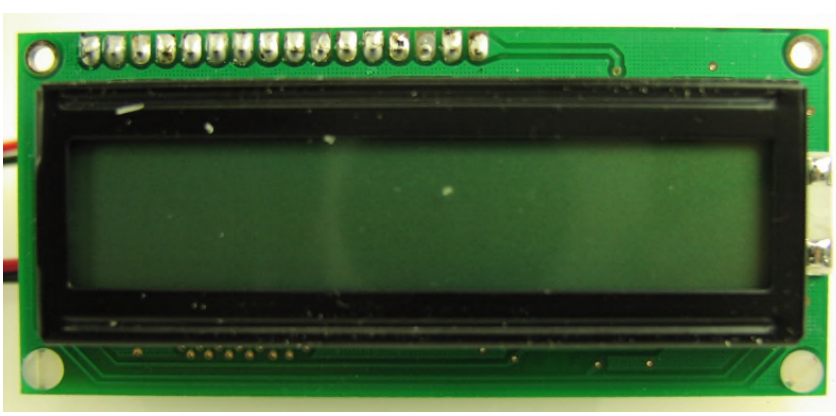


Figure 10

Next, mount and solder 18 Pin socket U1 to the PC board making sure that it is oriented according to the outline on the silkscreen. Insert the preprogrammed 16F88 microcontroller matching the notch on the chip to the notch on the socket.



Next mount and solder the LCD module to the 16-pin header. Figure 11 is a photo of the top of the completed circuit.

Figure 11

Random Number Generation Theory

True random numbers are useful for data encryption (cryptography), statistical mechanics, probability, gaming, neural networks and disorder systems, to name a few.

Random numbers generated by a computer are notoriously random in an exact defined- pattern. So much so that they are many times referred to as pseudo-random numbers. The random numbers generated by this module are truly random.

The way the RNG module operates is simple to understand. However, its fundamental function is best described using a mechanical analogy. Imagine a sequence of numbers painted on the outer edge of a revolving wheel. There is a pointer on the outside of the wheel that points to the number at the top of the wheel. The wheel is set into motion, spinning very rapidly. Then at any given "random" moment in time the wheel is instantly stopped, and the number under the pointer becomes our random number. Once read, the wheel is set back into motion again for next random number generation.

The electronics follow pretty close to the mechanical analogy. The microcontroller spins the sequence of numbers internally. The random point in time when the sequence of numbers is instantly stopped is generated by the detection of a radioactive particle by the Geiger Counter. Background radiation is an ideal quantum mechanical random time-delay generator because it is impossible to predict with any accuracy the exact moment a radioactive particle will be detected. When a particle is detected, a positive pulse is sent to the Digital out of Analog Geiger Counter / Audio out of Digital Geiger Counter. This module is connected to Digital out of Analog Geiger Counter / Audio out of Digital Geiger Counter. On RNG Module, the positive pulse is connected to microcontroller input pin. This positive pulse generates an interrupt in the microcontroller that stops the numbers from spinning. The number is read, displayed and sent out serially on the TTL port.

We determine how many numbers are painted on the wheel by setting the jumpers on the back of this module i.e. setting the range of random number being generated.

There is a simple test to find the trueness of random numbers. If you add all the random numbers that are generated (let's call this number N) and divide that by number of samples you added together (Let's call this number S) the answer should be approximately 50% of your number range (Lets call this number R).

For example using a range of 1 – 10, so R = 10. The number of random number samples, is 100, so S = 100. We add those 100 random numbers together, that equals N. So N/S = .5 R In this case the number N when divided by S (100) should equal approximately 5. This would show an even distribution of random numbers though out the range of 1 - 10.

Following link has a test program that will read a file of random numbers and analyze the randomness of the numbers in the file. http://www.fourmilab.ch/random/ **We have not tested random numbers generated by this module with the above test program.**

Background radiation consists of three sources; Cosmic radiation from the sun and stars. Terrestrial radiation from low levels of uranium, thorium, and their decay products in the soil, air and water. Internal radiation from radioactive potassium-40, carbon-14, lead-210, and other isotopes found inside our bodies.

Radiation Measurement Theory

There are a few scales that one can use to measure radiation. Depending upon your application, one scale may be better than the others.

Radiation Measurement Units

Roentgen: Is the measurement of energy produced by Gamma γ or X-ray radiation in a cubic centimeter of air. It is abbreviated with the capital "R". One milliroentgen, abbreviated "mR" is one-thousandth of a roentgen. One microroentgen, abbreviated "µR" is one-millionth of a roentgen.

RAD (**Radiation Absorbed Dose):** Original measuring unit for expressing the absorption of all types of ionizing radiation (alpha α, beta ß, gamma γ, neutrons, etc) into any medium. One Rad is equivalent to the absorption of 100 ergs of energy per gram of absorbing tissue.

REM (**Roentgen Equivalent Man):** Is a measurement that correlates the dose of any radiation to the biological effect of that radiation. Since not all radiations have the same biological effect, the dosage is multiplied by a "quality factor" (Q). For example, a person receiving a dosage of γ radiation will suffer much less damage than that of a person receiving the same dosage from α particles, by a factor of three. So α particles will cause three times more damage than γ rays. Therefore, α radiation has a quality factor of three. Following is the Q factor for a few radiation types.

Radiation	**Quality Factor (Q)**
ß, γ and X-rays	1
Thermal Neutrons	3
Fast n, α, and protons	10
Heavy and recoil nuclei	20

The difference between the Rad and Rem is that the Rad is a measurement of the radiation absorbed by the material or tissue. The Rem is a measurement of the biological effect of that absorbed radiation.

For general purposes most physicists agree that the Roentgen, Rad and Rem may be considered equivalent.

System International (SI) of Units

The System International of unit for radiation measurements is now the official system of measurements. This system uses the "gray" (Gy) and "sivert" (Sv) for absorbed dose and equivalent dose respectively. The conversion from one system to another is simple:

1 Sv = 100 Rem	1 Rem = .01 Sv
1 mSv = 100 mR (mRem)	1 mR = .01 mSv
1 Gy = 100 Rad	1 Rad = .01 Gy
1 mGy = 100 mRad	1 mRad = .01 mGy

How Much Radiation is Safe?

In the United States the U.S. Nuclear Regulatory Commission (NRC) determines what radiation exposure level is considered safe. Occupational exposure for worker is limited to 5000 mRem per year. For the general population, the exposure is 500 mRem above background radiation in any one year. However for long term, multi-year exposure, 100 mRem above background radiation is the limit set per year.

Let's extrapolate the 100 mRem number to an hourly radiation exposure rate. There are 365 days/yr x 24 hr/day equals 8760 hours/yr. Divide 100 mRem by 8760 hours equals .0114 mRem/hr or 11.4 µRem/hr. This is an extremely low radiation level. The background radiation in my lab hovers around 32 µR/hr. Am I in trouble? No. Typically background radiation in the United States averages 300 mRem/yr, or 34 µRem/hr. The NRC specifications is for radiation above this 34 µRem/hr background radiation.

Notice that my lab readings are in microRad (µR/hr) and the exposure limit is given in microRem (µRem/hr). I do not know what type of radiation (α , ß or γ) the Geiger counter is reading in my lab at any particular instant, so I do not know the Q factor of the radiation and therefore can not calculate the mRem. However for general purposes I consider them the one and the same.

Common Radiation Exposure Source	**Exposure (General Population) Dose (conventional)**	**Dose (SI)**
Fight from LA To NY	1.5 mRem	.015 mSv
Dental X-ray	9 mRem	.09 mSv
Chest X-ray	10 mRem	0.1 mSv
Mammogram	70 mRem	0.7 mSv
Background Radiation	300 mRem	3.0 mSv

Background radiation consists of three sources; **Cosmic** radiation from the sun and stars. **Terrestrial** radiation from low levels of uranium, thorium, and their decay products in the soil, air and water. **Internal** radiation from radioactive potassium-40, carbon-14, lead-210, and other isotopes found inside our bodies.

Links for addition information on Radiation:

U.S. Nuclear Regulatory Commission
http://www.nrc.gov/

CDC – Center for Disease Control maintains a radiation emergency website:
http://www.bt.cdc.gov/radiation/index.asp#clinicians

Health Physics Society
http://www.hps.org

U.S. Environmental Protection Agency
http://www.epa.gov/radiation

DMAD-04

Parts List

(1) PCB-74	
(1) PIC16F88	U1
(1) ICS-18	
(1) CAP-.1uf,-50V	C1
(2) CAP-10uf-16V	C2 C3
(1) SMH-16	D1
(2) SMH-02	P1&2 P4&6
(1) SMH-03	P8
(1) POT-20K STT	R2
(1) RES-33ohm 1/4	R1
(3) RES-10K 1/4	R4 R5 R6
(1) LCD-01-16x2	
(1)LDO-5V	U2
(1) SW-26	S5
(2) SW-27	S1 S2
(1) PJ-102B	P3
(1) Jack-05	J1
(1) Jack-13	J2
(1) 1N4007	D2

(1) Male-Male 2 foot, 3.5mm Cable

(1) Power Plug

Optional

Acrylic Stand w/4 machine screws and nuts

USB to TTL Cable