

# PIC Digital Geiger Counter



**There is something fascinating about an instrument that can sense that which is invisible and undetectable to all human senses. This article is about the design and building of a portable Digital Geiger Counter (DGC) device as shown in the photos with many unique features**

By ROBERT LANE & STEVE THOMPSON

**R**ADIATION is energy that comes from a source and travels through any kind of material and through space. Light, radio, and microwaves are types of radiation. The kind of radiation discussed in this article is called *ionizing* radiation because it can produce charged particles (ions) in matter.

## **Ionizing radiation**

There are three types of ionizing radiation. An alpha particle consists of two protons and two neutrons (i.e. the nucleus of a helium atom). The two protons give the alpha particle a positive charge. A Beta particle is simply an electron from the nucleus of an atom.

A gamma ray is a packet of electromagnetic energy – a photon. Gamma photons have about 10,000 times as much energy as the photons in the visible range of the electromagnetic spectrum. Gamma rays can penetrate deeply into the human body.

There are both natural and man-made radionuclides. Potassium-40 and Carbon-14 are weak beta emitters that are found naturally in our bodies. Large amounts of man-made Sr-90 were produced during atmospheric

nuclear weapons tests conducted in the 1950s and 1960s and were dispersed worldwide. Sr-90 has a half-life of 28.8 years so about 77% of the Sr-90 from a nuclear weapon test in 1945 has already decayed.

## **Characteristics**

- The 500V DC G-M tube biasing voltage is generated by a PIC micro-controller in a boost power supply configuration
- The display is menu driven with a four-line LCD digital readout
- Radiation measurements are date/time stamped by an internal real time clock
- Microprocessor 'sleep' mode is used to reduce power consumption
- Internal memory can store 125 radiation measurements using PIC18F2455, (375 using PIC18F2550)
- Built-in USB interface for data upload to a personal computer
- PIC firmware is written in freely available C language
- Personal computer software is written in latest version of Visual Basic.Net
- Device is portable, powered by four AA lithium hydride batteries (5 volts)

## Hardware design

The state of the art for radiation detection for hobbyists has changed very little since Hans Geiger invented the gas filled radiation detector while working with Ernest Rutherford in 1908. The design of this device was later refined in the 1920s by Hans Geiger and Wilhelm Mueller. It is sometimes called simply a Geiger counter or a G-M counter and is the most commonly used portable radiation instrument.

A GM tube is a gas-filled device that, when a high voltage is applied, creates an electrical pulse when radiation interacts with the wall or gas in the tube. These pulses are converted to a reading on the instrument's meter.

The main drawback of the G-M counter is its inability to provide information on the energy of the radiation it detects. To count alpha particles the G-M tube must also have a very thin delicate mica window. G-M tubes come in a bewildering assortment of shapes and sizes. For this project we chose the model LND712 because of its small size and alpha sensitivity.

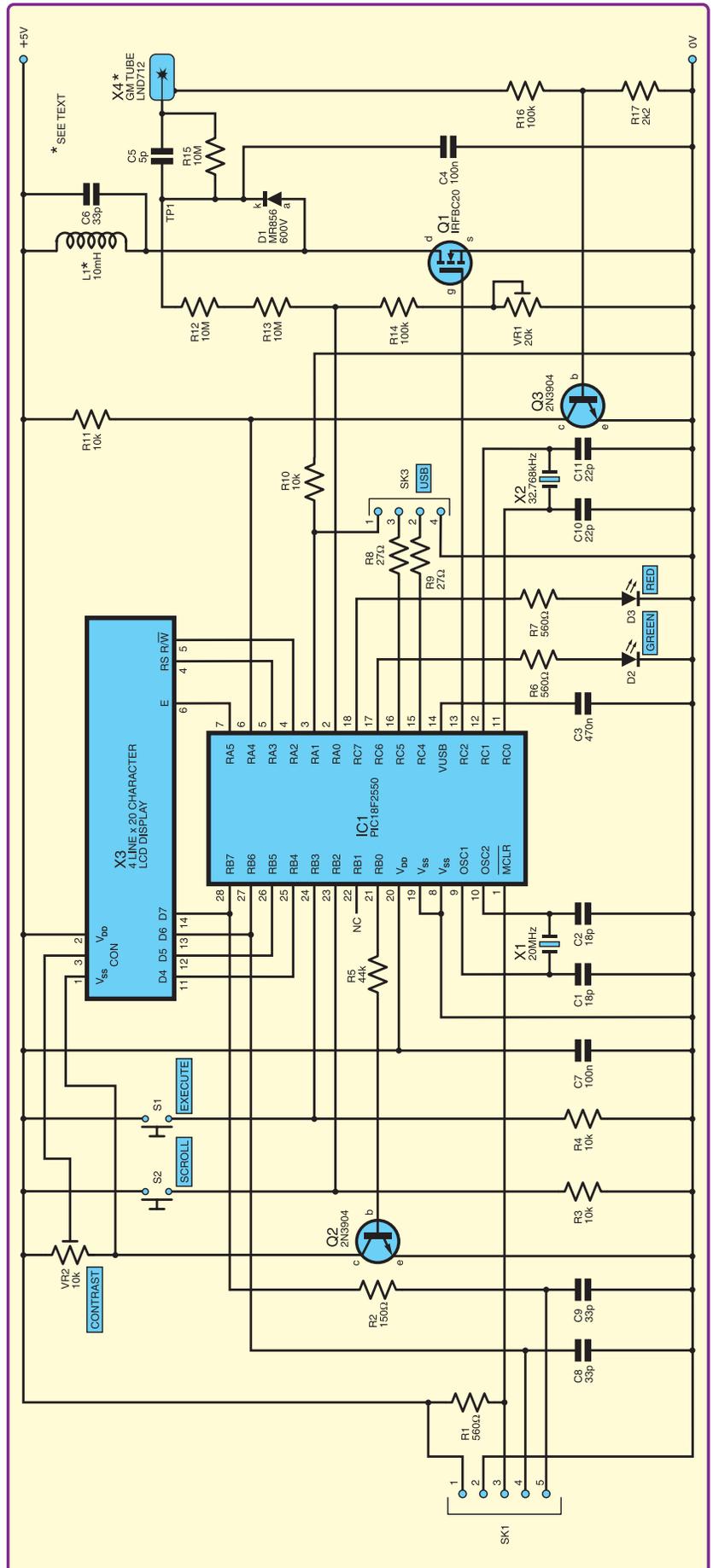
## Take your PIC

The Microchip PIC18F2455 micro-processor was chosen for this project. Several features recommended this chip:

1. Built-in full speed USB capability
2. Multiple built-in 10-bit analogue to digital conversion capability
3. 24K of flash program memory (8K of program memory will be used to store data)
4. Built-in Inter-Integrated Circuit (I<sup>2</sup>C) bus capability
5. Speeds up to 48MHz
6. Small 28-pin footprint (also surface mount)
7. Self programmability
8. Four separate timers
9. Low cost
10. Free C compiler and subroutine libraries available

Because the full speed USB module clock must run at 48MHz, the Microchip PIC18F2455 has a flexible oscillator scheme that allows the microprocessor and peripherals to run at other clock speeds. This is accomplished

**Fig.1: Complete circuit diagram for the PIC Digital Geiger Counter**



by a number of configuration bits that are set when the microprocessor is programmed.

These configuration bits allow the user to use almost any oscillator from 4MHz to 48MHz to drive the PIC18F2455. By setting these bits (PLLDIV=5, CPU\_DIV=OSC1\_PLL2, USBDIV=2 and FOSC=HSPLL\_HS), we can use a 20MHz crystal to drive the microprocessor at 48MHz and the USB at full speed.

If you are going to program your own PIC18F2455, the circuit board has been designed with a programming connector that can be used to download the PIC firmware from a computer. If you use a preprogrammed chip, the programming connector and associated components can be deleted.

The PIC18F2550 can also be used for this project. The F2550 has 32K bytes of program memory and can store 250 additional radiation measurements.

## Circuit

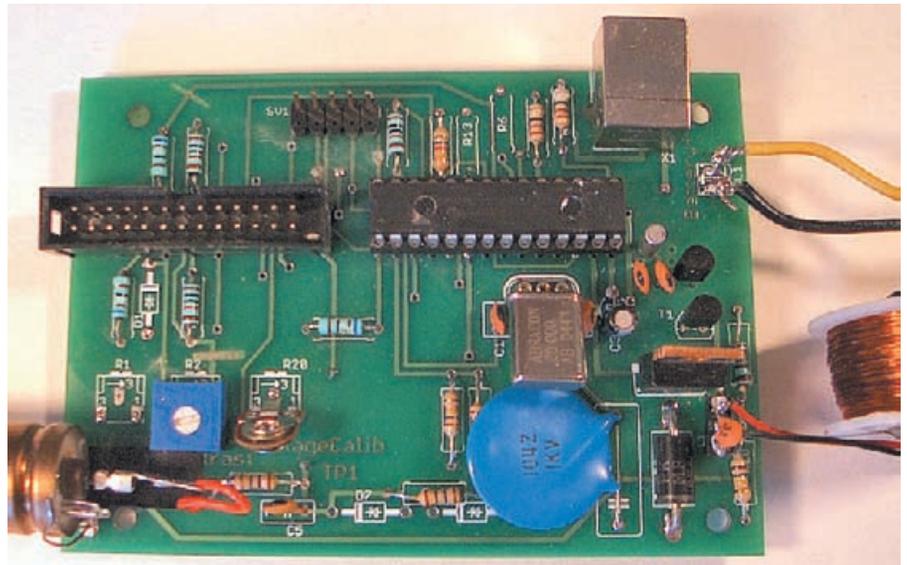
The full circuit diagram for the PIC Digital Geiger Counter is shown in Fig.1. The GM tube requires 500V to 1000V DC to operate. Always take extreme caution when working on high voltage circuits.

The LND Inc. 712 GM tube operates at 500V. To generate this we have used the built-in pulse width modulation (PWM) feature of the PIC18F2455 in a boost power supply configuration. This is used to generate a 4000Hz squarewave with a 50% duty factor output on pin 13 (RC2). This square-wave is used to switch the IRFBC20 MOSFET (Q1) on and off.

The inductor L1, diode D1, and capacitor C4 shown in Fig.1 are used as a boost power supply to increase the voltage from 5V DC to over 500V DC.

Radiation will cause the insulating property of the gas in the GM tube to momentarily break down, which will cause a voltage spike on the tube output. This voltage spike is sent to Q3, an 2N3904 NPN transistor. The positive pulse causes the transistor to switch and its collector (c) is brought to ground. Each negative transition on pin 6 of IC2 causes the TIMER0 value to increase by one, up to a maximum count of 65535.

One of the challenges was in getting the Digital Geiger Counter (DGC) to keep track of time. Microchip suggests



Component layout on the prototype double-sided PCB

## Parts List – PIC Digital Geiger Counter

- 1 PC board, code 607, available from the *EPE PCB Service*, size 98mm × 70mm
- 1 plastic instrument case 152mm × 95mm × 57mm
- 1 LND712 or ZP1401 or similar 500V Geiger tube (Ref 1)
- 1 20MHz crystal
- 1 32.768kHz crystal
- 1 12mH inductor – see text – 60m of 36swg (32awg) enamelled copper wire
- 1 4-line × 20 character alphanumeric LCD – HJD44780 based
- 1 2-pin header
- 1 5-pin header
- 1 20-pin header
- 1 USB connector
- 1 4AA battery holder
- 1 20-pin IDC socket for LCD
- 2 square momentary contact switches
- Fixings for PCB and LCD, 18- way ribbon cable, connecting wire

### Semiconductors

- 1 PIC18F2455 or PIC18F2550 (see text) preprogrammed microcontroller
- 1 IRFBC20 power MOSFET
- 2 2N3904 npn transistors
- 1 MR856 fast 600V diode
- 1 red LED
- 1 green LED

### Capacitors

- 1 18pF ceramic
- 1 470nF ceramic
- 1 5pF ceramic
- 1 33pF ceramic
- 1 22pF ceramic

### Resistors (0.25W 1%)

- 1 47kΩ
- 1 2.2kΩ
- 5 10kΩ
- 3 10MΩ
- 3 100kΩ
- 1 20Ω
- 3 560kΩ
- 1 27Ω
- 1 150kΩ
- 1 660Ω

### Potentiometers

- 1 10k carbon preset
- 1 100k carbon preset

implementing a simple low power real time clock on the PIC18F2455 by adding an external 32.768kHz crystal and two 22pF capacitors on Timer1 inputs (Ref.1).

In order to keep accurate time, microprocessor IC1 needs to be powered at all times. This eliminates the need for a manual power switch. The microprocessor uses an interrupt scheme and the 'sleep' operating mode to keep battery drain to a minimum.

When the microprocessor is put to sleep, the main 20MHz oscillator stops and IC1 executes no instructions. Transistor Q2 is used to turn off the LCD before entering sleep mode and turn on the LCD when the microprocessor wakes up.

In sleep mode, the 32.768kHz crystal connected to TIMER1 will continue to oscillate and TIMER1 will continue to increment. When TIMER1 overflows (once per second), an interrupt will occur and the microprocessor will wake up, increment the time and go back to sleep.

In sleep mode with the display off, the DGC will use about 2mA of timekeeping current. In normal operating mode the DGC uses about 38mA. When the high voltage is being generated the total current used is 48mA.

When the microprocessor wakes up, once each second, it will also check to see if the EXECUTE menu button has been pressed. It will also check to see if the DGC has been plugged into a computer USB port.

If either of these conditions has occurred, the microprocessor will remain awake and the user can interact with the DGC through the menu system. If the DGC is unplugged from the USB port or the user selects the GEIGER COUNTER OFF menu option, the DGC will turn off the LCD and go back to sleep.

### Building the counter

All components fit easily into a 100 x 60 x 150mm plastic box. Drill holes for the LEDs, menu buttons and LCD display in the box top and holes to mount the circuit board and battery pack in the bottom of the box. Since the plastic box is more than enough to block all alpha particles, a 12mm hole in the short side allows access for the G-M tube. A hole was also drilled for the USB connector.

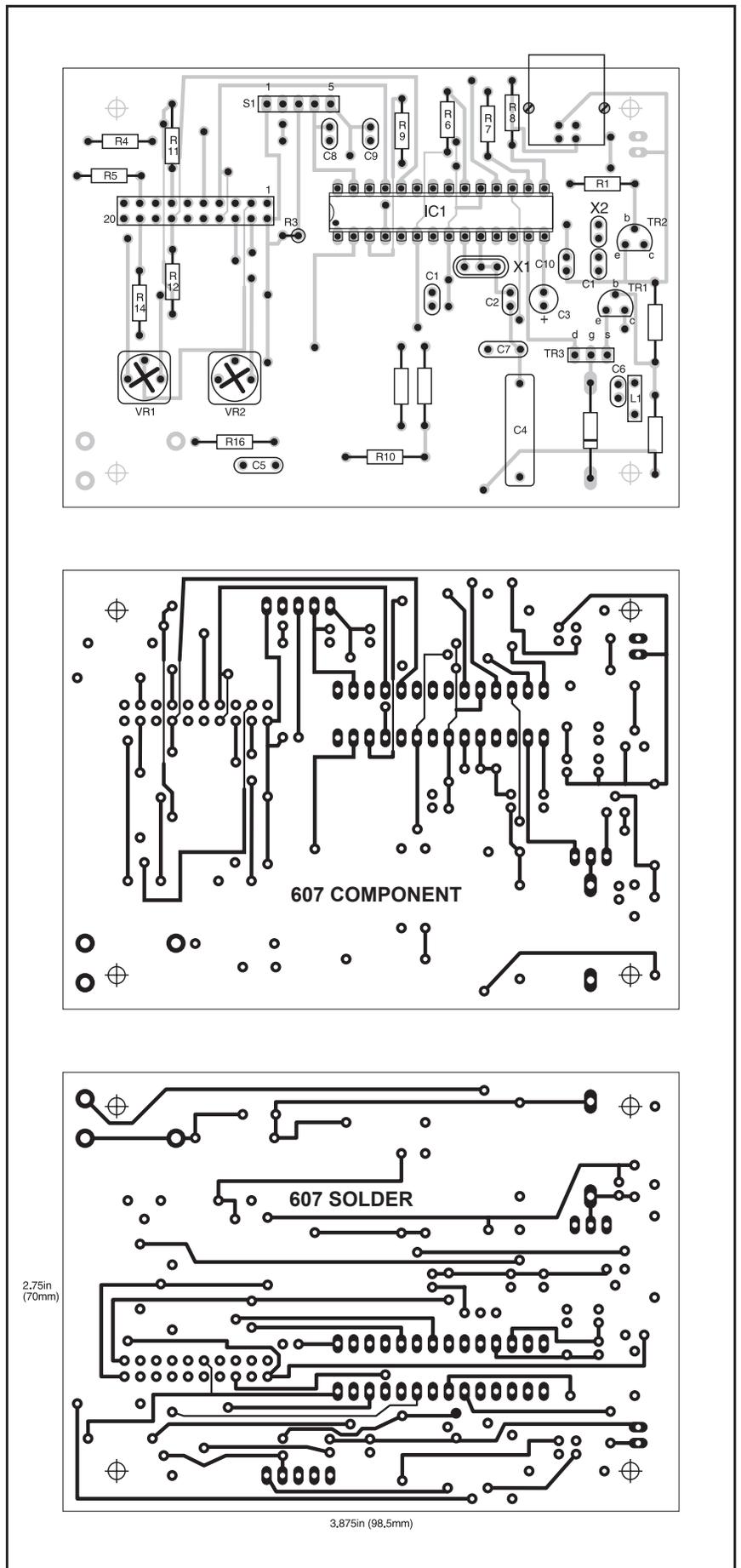
Inductor L1 should be 10 to 12mH and this can be made from 60 metres of 36swg (32awg) enamelled copper wire wound on a plastic bobbin. The bobbin can be made from 10mm outside diameter plastic tubing 25mm long with two 25mm discs cut from a sheet of plastic.

The discs are epoxied onto the tubing 13mm apart, as shown in the photograph. Sixty metres of wire can be measured by creating a half metre wooden former and wrapping sixty times as shown in the background of the photo. The actual bobbin winding can be accomplished with an electric screwdriver. The final specification of the inductor is 12mH and 36 ohms.

### Circuit board

Most of the components for the Geiger Counter are mounted on a double-sided printed circuit board (PCB). The component layout and full-size copper track masters are shown in Fig.2. This

**Fig.2: Printed circuit board component layout and copper foil master patterns. Some copper pads/components need soldering on both sides of the PCB**



board is available from the *EPE PCB Service* code 607.

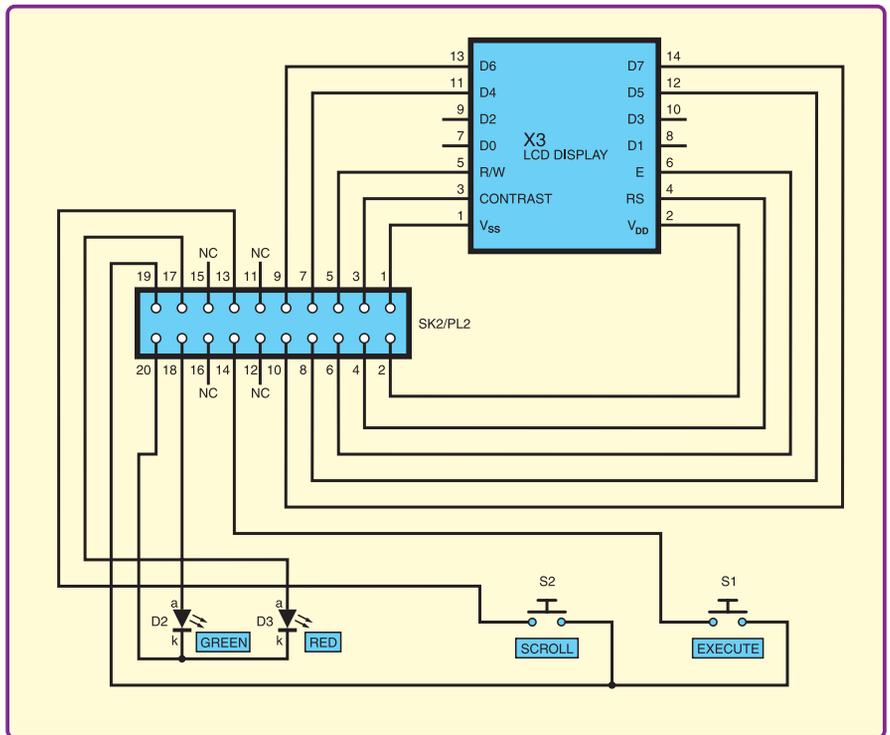
Begin the board construction by mounting the resistors and other low profile components to the top of the board as shown in Fig.2. The high voltage portion of the circuit is on the bottom half of the circuit board. Capacitors C3 and C6 are very important. If C3 is omitted then the microprocessor will not run reliably at USB full speed. If C6 is eliminated the counter will pick up noise from the 4000Hz PWM.

The board is connected to the front panel mounted components by SK2/PL2 (not shown on the circuit diagram to aid clarity). Fig.3 shows the wiring arrangement for this.

The photographs show the completed DGC with connections to the LCD display on the front panel. The case cutout for the GM tube is to the left of the GM tube and is covered by a nylon mesh screen to keep objects away from delicate mica window on the tube. The large inductor, L1, is not mounted on the circuit board, but is mounted on the case. Do not use a steel bolt to mount L1 because that will drastically change the inductance.

## Software

Two programs were written for use with the DGC. The first program, GM\_COUNTER, runs on the PIC18F2455 and performs all the Geiger counter functions. The second program, WINDGC, runs on a PC and handles the uploading of data from the DGC and data analysis.



**Fig.3: General wiring arrangement, in schematic form, to front panel mounted components**

The software program on the DGC, GM\_COUNTER, operates in two modes: DGC and USB. In DGC mode, the software is controlled by the user menu and choices are available to make and store radiation measurements. In DGC mode, the user can manually monitor the high voltage, erase the data memory, or set the time/date on the DGC.

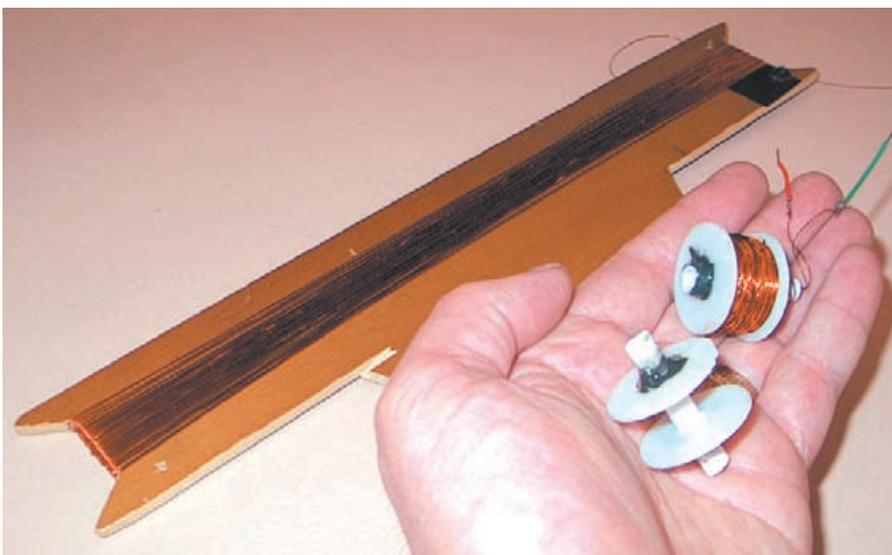
In USB mode, the user menu inputs are disabled and all control is via the USB port. Data can be uploaded to the

PC, data can be erased on the DGC, and the time/date can be set on the DGC in USB mode. USB mode is automatically activated when the DGC is plugged into a USB port.

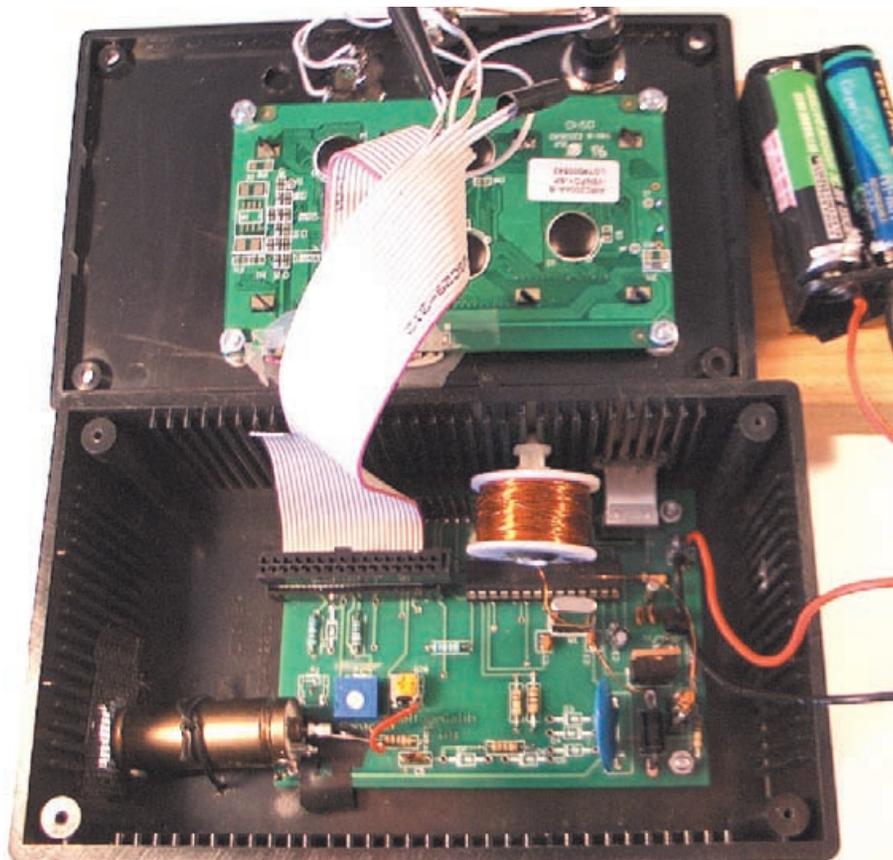
The program was written to handle all of the above functions using a freely available C compiler for the PIC18F2455 from Microchip. A free C18 student edition 'C' compiler program is available at – see reference 2. The C18 compiler integrates flawlessly into the MPLAB integrated development environment (Ref 3).

The C18 compiler also includes libraries of functions (Ref 4) that can be linked directly into your application using the MPLINK linker. These libraries provide simplified control of hardware peripheral functions like analogue-to-digital conversion, pulse-width modulation and timers. In addition, the libraries provide integer math functions, memory and string formatting functions, and character output functions. We made use of these functions to keep the C program short and concise.

All source code for the GM\_COUNTER software is available from the *EPE* website under 'Downloads'. The compiled C program is called GM\_COUNTER.HEX and it can be programmed into the microprocessor or a preprogrammed microprocessor can



**The homemade, power booster inductor is made up from a plastic bobbin and 60 metres of 36swg (32awg) enamelled copper wire. The wire was measured out using a half-metre wooden former.**



**Prototype DGC showing general component positioning inside the plastic box. The lid-mounted components, including the LCD module, are interlinked to the PCB via the ribbon cable.**

be obtained from Magenta Electronics or Reference 5.

The menu system is based on a number of different machine states. There is a unique machine state for each screen. Machine states of related screens are grouped together. For example, all machine states relating to the opening screen are in the 1 to 9 range. The machine state is controlled by the variable `MENUSTATE`. Generally, navigation between the different machine states is done with the `SCROLL` and `EXECUTE` pushbuttons.

### Pulse counting

When the user begins the count, the `STARTCOUNT` routine is called. `STARTCOUNT` calculates the number of one second intervals in the desired count time and stores this value as `TIME_TARGET`. `TIME_ELAPSED` and the pulse count are cleared by writing 0 to `TIMER0`. G-M tube pulses provide the clock input to `TIMER0`. A `COUNTING` flag is set.

`TIMER1` will cause the interrupt routine to execute every second and

increment `TIME_ELAPSED`. If `TIME_ELAPSED` equals `TIME_TARGET`, then the desired count time has elapsed and `TIMER0` is closed to stop the counting. `MENUSTATE` is set to 60 to display the final count value and the `COUNTING` flag is cleared.

Automatic counting periods of 15, 30, 45 seconds and 1, 5 and 10 minutes can be selected from the menu. In addition, multiple measurements can be made by selecting the 'MULTIPLE SAMPLE' menu option.

### Memory and USB interface

The program can remember up to 125 data measurements in flash program memory at addresses 0x5000 to 0x5fff. This memory is not volatile and measurements will not be lost when the DGC batteries are removed. When the batteries are installed, the DGC will determine the number of the next data point to be stored. The routines `MemcpyRam2Flash` and `MemcpyFlash2Ram` are used to store data in flash program memory and read data out of flash memory.

For the USB interface, we used the approach of Reference 6 which is to define the DGC as a USB communication device. This approach has two major advantages:

1. Microchip has written and freely distributes PIC software for the Communication Device class to emulate RS232 over a USB connection
2. From the PC side, the DGC will look as if it is connected to a standard COM port to the Windows software. This simplifies the PC software.

The USB specification allows peripherals to be plugged and unplugged without powering down the computer. The enumeration process involves communicating with the peripheral to discover the identity of the device driver that should be loaded. A unique address is assigned to each peripheral during enumeration to be used for run-time transfers. During



**Front panel layout of the completed DGC unit**

**Table 1: USB Status is reported by the LEDs presented by the GM\_COUNTER program**

RED	GREEN	MODE	CONDITION
ON	OFF	USB	USB Device has been reset.
OFF	ON	USB	USB Device has been addressed.
ALTERNATE BLINKING	ALTERNATE BLINKING	USB	USB Device is configured. All descriptor information has been successfully received by the personal computer.
SYNCHRONISED BLINKING	SYNCHRONISED BLINKING	USB	USB device is in a suspended state
ON	NA	DGC	High voltage being generated for GM tube
NA	BLINKING 1 OUT OF 10 SECONDS	DGC	Timekeeping oscillator (32.768kHz) oscillator running.
OFF	OFF	See Condition	If LCD is off this means DGC is in sleep mode. If LCD is on this means timekeeping oscillator has not yet started oscillating after inserting batteries.

run-time, the host PC initiates transactions to specific peripherals and each peripheral accepts its transactions and responds accordingly. The data for the enumeration is contained in the USBDESC.C file.

Two free programs are useful for verifying that the USB connection is working: USBVIEW [Reference 7] and USB Command Verifier (USBCV) [Reference 8]. USBVIEW reports the results of the enumeration process as shown. USBCV is the compliance test tool which evaluates full-speed USB devices for conformance to the USB Device Framework, Chapter 9 of the USB specification.

The DGC device with GM\_COUNTER software has passed all twenty-two of the USBCV tests. The output of the USBCV tests is available at the RESOURCES download site.

GM\_COUNTER reports the status of the USB interface in LEDs as shown in Table 1. If the USB is in the configured state, then user data may be transferred to the PC. The GM\_COUNTER program uses a very simple command/response protocol to communicate with the PC.

### Sleep mode and real time clock

The menu item 'GEIGER COUNTER OFF' can be used to save power. This option turns off the LCD display, turns off the LCD power, and puts the microprocessor into power-saving sleep mode.

The one second interrupt from

TIMER1 wakes up the microprocessor if it is asleep and updates the real time clock. The microprocessor will go back to sleep if it has been sleeping, unless the DGC has been plugged into a USB port or the EXECUTE switch has been pressed.

If the EXECUTE switch has been pressed, the Geiger counter enters DGC mode. If the counter has been plugged into a USB port, it enters the USB mode.

### PC software design

In order to upload and analyse data from the DGC, PC software is required. The WINDGC program presented here

is the latest incarnation of Visual Basic called VB.NET. As mentioned previously, by defining the DGC as a USB communication device class, the USB connection will appear as a standard COM serial port to the VB software. Microsoft has examples of VB.NET software that will communicate with COM serial port. The WINDGC PC software performs the following functions:

1. Uploads data from the DGC
2. Erases all data from the DGC
3. Sets date and time on DGC to system date and time on PC
4. Adds data to database
5. Plots data from database

**Table 2: USB Commands and Responses used to transmit data between the DGC and a PC**

COMMAND	PC SEND	DGC RESPONSE
QUERY	Q	nR
ERASE	E	R
SETCLOCK	Smdyhms	R or N
UPLOAD	Ux	xtccmddyhhmmss zzzzzzzzzzzzzzR or N
Send N if proper # of characters are not received		

x is a specific datapoint  
n is the total number of data points z bytes are currently unused

Lower case characters are binary bytes Upper case characters are ASCII characters.

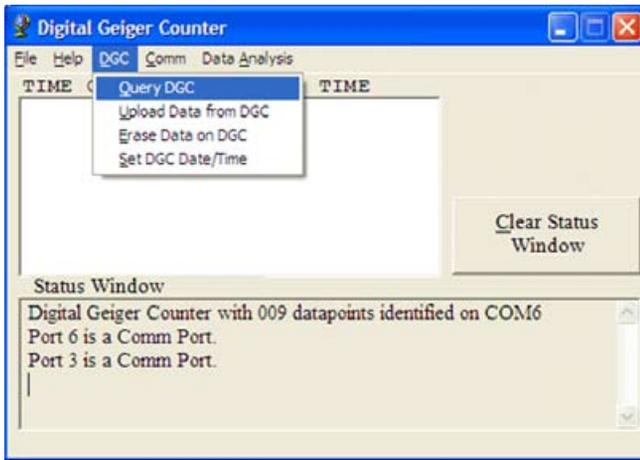


Fig.4: The WINDGC opening screen shows the result of the QUERY DGC menu item on COM6

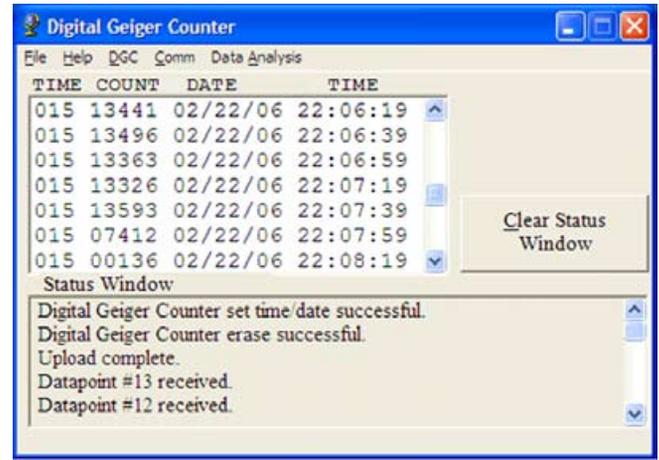


Fig.5: The WINDGC screen showing the result after an upload of 13 data points

## 6. Statistically analyses data

The complete source code for the WINDGC program is available from the EPE website. As you look through the source code, you will notice that there is never a call to any USB function. That is because, as far as the PC is concerned, the program is talking to a standard serial COM port, not a USB port. If you do not have a copy of VISUAL BASIC.NET, you can use the executable that is supplied on any PC running the Windows XP operating system.

The WINDGC program begins by testing for COM ports 1 through 9. When the program finds an active COM port, it reports it as shown above. The first step is to select a COM port using the Comm menu. The next step is to select the 'Query DGC' menu item on the DGC menu. This determines if the selected port is actually connected to a DGC. If a DGC is connected to the selected port, then the number of saved datapoints on the DGC will be reported in the status window as shown above.

There are menu items to erase the data on the DGC and to set the date/time on the DGC. The most important menu item is 'Upload Data from DGC'. Fig.5. is the result of an 'Upload Data from DGC' menu selection.

At this point the data can be plotted using the Data Analysis menu. We had originally planned to use the Excel component library to do the data plotting, but decided against this option because it would limit the of the program to only those users who had Microsoft Excel installed on their computer. The approach used was to write all the graphical and data

processing functions directly in Visual Basic.Net.

Writing the functions in VB.NET was more work, but resulted in a smaller program that everyone can use. The Data Analysis menu allows the user to plot and gather statistical data about selected points. Moving the mouse over a particular data point will report the X and Y coordinate in the MOUSE (X,Y) LOCATION textbox.



Fig.6: The LCD display after welcome on power-up

## Testing phase 1

The first test is to verify that the LCD is working. Plug in the LCD and make sure the LCD contrast control, VR2, is set to midrange. Power up the unit and the welcome screen should appear followed by the main menu as shown in Fig.6. You should be able to set the real time clock using the menu system. If there is a problem with the 32.768kHz oscillator the LCD time display will not increment.

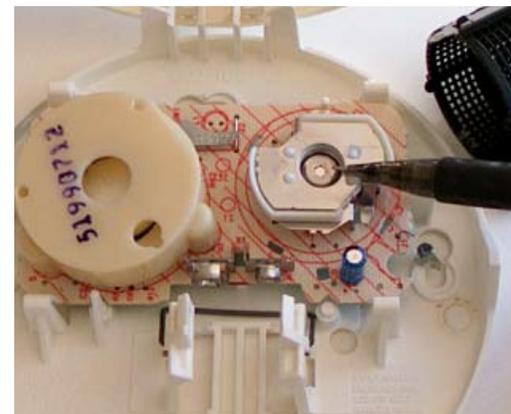
Once the display and clock are working properly, select the HIGH VOLTAGE screen from the UTILITY menu. You should measure approximately 500V DC at TP1. You should now be able to read 500 volts on the LCD display when the high voltage is

on. You can calibrate the display to your voltmeter by adjusting R20. Be aware that your voltmeter may reduce the high voltage output during the calibration. Now you are ready to connect the LND712 Geiger Mueller tube.

Select the 'GEIGER COUNTER OFF' menu option and plug the device into a PC using a USB cable. You should point the hardware wizard to the DGC.INF file supplied with the GM\_COUNTER software. Reading the DGC.INF file will cause the Windows XP communication device drivers to be loaded.

## Testing phase 2

After checking out the electronics, the first thing to do is to try to measure a radioactive source. Where do we get this radioactive source? For about £5 you can buy a one microcurie Americium-141 alpha source in the form of an ionizing smoke detector. Ionizing smoke detectors having a radioactive source will have a warning label stating the type and strength of the source.



Locating the alpha source, under a black grid/cage, in a ionising smoke detector

As shown in the photograph, the alpha source, pointed to by the pencil, is located under a black grid. As far as danger is concerned, a sheet of paper or a few centimeters of air will reduce the radiation from this alpha particle source to a negligible level.

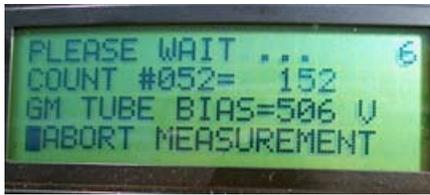


Fig.7: Measurement screen

You can check the previous statement for yourself. Place the Americium-141 alpha source (smoke detector) about 3mm from the G-M tube's mica window. Take a number of samples in MULTIPLE SAMPLE mode. Now insert one sheet of paper between the alpha source and the G-M tube and continue taking samples. Finally, remove the alpha source completely and take a few more samples.

Place the DGC in sleep mode by selecting the 'GEIGER COUNTER OFF' menu item and plug into the personal computer's USB port. The DGC will wake up when plugged into the USB port. Start the WINDGC program on the PC. Query the DGC and then upload the data. Select the data analysis menu and display the data graphically. Your data should look like Fig.4.

By selecting different parts of the data to analyse, it was determined that the average count with the alpha source was 54168 counts/minute. With the sheet of paper inserted, the average count dropped to 536 counts/minute. Finally, when the alpha source was removed completely, the count dropped to a background average of 24 counts/minute. A sheet of paper is an effective shield (factor of 100 reduction) against alpha particles.

## Trinity and ground zero

Living in New Mexico, I was aware that the first nuclear weapon was exploded at 5:29am on July 16, 1945, at the Trinity Site (33°40'30"N, 106°28'30"W). The site is about thirty miles southeast of Socorro, New Mexico on what is now the White Sands Missile Range.

The 1945 explosion was a test of an implosion-design plutonium bomb, the same type of weapon later dropped on Nagasaki, Japan. The detonation

was equivalent to an explosion of around 20 kilotons of TNT. This was where we decided to conduct the final test of the DGC.

We contacted White Sands and told them what we had in mind and they said we would be welcome to make measurements any time during the 12 hours a year that the Trinity ground zero site is open to the public [Reference 9]. On the appointed day, we began the 135 mile drive to the Trinity site.

After passing over the now only 20 foot wide Rio Grande and about twelve



Fig.9: Upload screen

miles East of San Antonio, there is a small wooden sign which says:

## Trinity Site

World's first atomic explosion occurred here on July 16, 1945. This marked the beginning of the atomic age and the culmination of the Manhattan Project. The site is now part of the White Sands Missile Range and is closed to the public.

After a picture identification and weapons check at the White Sands Missile Test range Stallion Gate, we proceeded on Range Road 7. Approximately 18 miles from the Stallion Gate we arrived at the Trinity site nestling at the base of the Oscura Mountains rising 8600 feet towards the east. The half-mile diameter site is surrounded by a metal wire fence. We took some

## References

**Reference 1** Geiger Mueller tubes from LND Inc at <http://Indinc.com/product.htm>. Price \$79 (US) plus tax and shipping, email info@Indinc.com (UK shipping and export handling \$50, plus import duty if shipped to the UK). The Centronics (ZP1401) tube is available from Alrad Instruments at [www.alrad.co.uk](http://www.alrad.co.uk) Tel: 07000 425723, email sue.parkin@alrad.co.uk, price £75.79 including UK p&p and VAT.

**Reference 2** C18 C compiler (student edition) Version 3.0 free 22Mb download retrieved 10/28/2005 from [http://www.microchip.com/stellent/idcplg?IdcService=SS\\_GET\\_PAGE&nodId=1406&dDocName=en010014&part=SW006011](http://www.microchip.com/stellent/idcplg?IdcService=SS_GET_PAGE&nodId=1406&dDocName=en010014&part=SW006011)

**Reference 3** MPLAB IDE Version 7.22 free 31Mb download retrieved 10/28/2005 from [http://www.microchip.com/stellent/idcplg?IdcService=SS\\_GET\\_PAGE&nodId=1406&dDocName=en019469&part=SW007002](http://www.microchip.com/stellent/idcplg?IdcService=SS_GET_PAGE&nodId=1406&dDocName=en019469&part=SW007002)

**Reference 4** MPLAB C18 C Compiler Library Reference download retrieved 10/24/2005 from [http://ww1.microchip.com/downloads/en/DeviceDoc/MPLAB\\_C18\\_Libraries\\_51297f.pdf](http://ww1.microchip.com/downloads/en/DeviceDoc/MPLAB_C18_Libraries_51297f.pdf)

**Reference 5** Preprogrammed PIC18F2455 microprocessors are available from Magenta Electronics at [www.magenta2000.co.uk](http://www.magenta2000.co.uk) and the Digital Geiger Counter website at <http://home.comcast.net/~rblang/dgc/dgc.htm>

**Reference 6** Rojvanit, Rawin, 'Migrating Applications to USB from RS-232 UART with Minimal Impact on PC Software,' Microchip Application Note AN956 available at [http://www.microchip.com/stellent/idcplg?IdcService=SS\\_GET\\_PAGE&nodId=2121&fragment6\\_NextRow=151](http://www.microchip.com/stellent/idcplg?IdcService=SS_GET_PAGE&nodId=2121&fragment6_NextRow=151)

**Reference 7** The USBVIEW program is available at <http://www.ftdichip.com/Resources/Utilities.htm>

**Reference 8** The USB Command Verifier test program (USBCV) is available at <http://www.usb.org/developers/tools/>

**Reference 9** White Sands Missile Range website at <http://www.wsmr.army.mil/pao/TrinitySite/trinst.htm>

## BIO

Robert Lang is a professional electrical engineer interested in embedded microprocessors, mechanical musical instruments and MIDI. He is a freelance writer for electronic hobbyist, computer and synthesizer magazines. He can be reached at [rblang@comcast.net](mailto:rblang@comcast.net) or by a GOOGLE search for HARPSITRON.

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much of the Trinitite was removed by the Atomic Energy Commission. Some Trinitite can still be found at the site. Our typical contact Trinitite readings were about 400 counts per minute.

As we were exiting the site, we noticed a sign that said the radiation at ground zero was about ten times background. We were pleased that we were able to confirm that sign with our measurements, 240 vs 24. The radiation level at ground zero was said to be about 1/1000 Roentgen Equivalent Man (REM) per hour. This provided us with a convenient conversion factor for our DGC (240 counts/minute = 1mREM/hour). To put this in perspective, a typical flight from London to New York gives a dose of 2mREM from cosmic rays. **EPE**



The authors comparing results at the Trinity site ground zero marker (Photo: Neal Ulevich)

DGC radiation measurements outside the fence and found the readings to be normal background, about 24 counts/minute.

We proceeded to walk the ¼ mile to the Trinity ground zero marker and took additional radiation measurements. We measured about 240 counts per minute or about ten times normal background radiation at ground zero.

Because the bomb was on a 100 foot tower, the explosion made a small depression instead of a crater. The heat of the blast vaporized all of the steel tower, except for one reinforced concrete footing and melted the desert sand into an ugly green glassy, porous, and brittle substance. After the blast, this green Trinitite completely covered the depression. The depression was later filled and

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