WearCAM Personal Imaging

THE UNIVERSITY
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MEng Final Year Project

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http://www.isoft.demon.co.uk/wearcam/

Contents

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1.0 PC/104 Introduction

The PC/104 was brought about by the need for standardisation for embedded PC systems. The standard was brought about by AMPRO computers incorporated who until then had a “Minimodule” form factor board. They then created the non-profit PC/104 Consortium to serve as the custodian for the new standard.

[1]

The name PC/104 actually comes from the contactors on the two bus interfaces, 64 pins on P1 and 40 pins on P2.

[2]

1.1 PC/104 Basic Objectives

The specification is an open specification, which means there are several enhancements that have been made to the original specification of the years, such as the *plus* specification, which will be explained later. However the main objectives of the original system remain the same, these are:

- ***Compact*** 3.6 x 3.8 inches.
- ***Self-Stacking*** Expansion cards just stack on to the next level.
- ***Pin & socket Bus connector*** Reliable in very harsh environments.
- ***Four corner mounting*** Resistance to shock and vibration
- ***Low power consumption*** Low heat generation
- ***Fully PC Compatible*** Reduced development costs and time to market

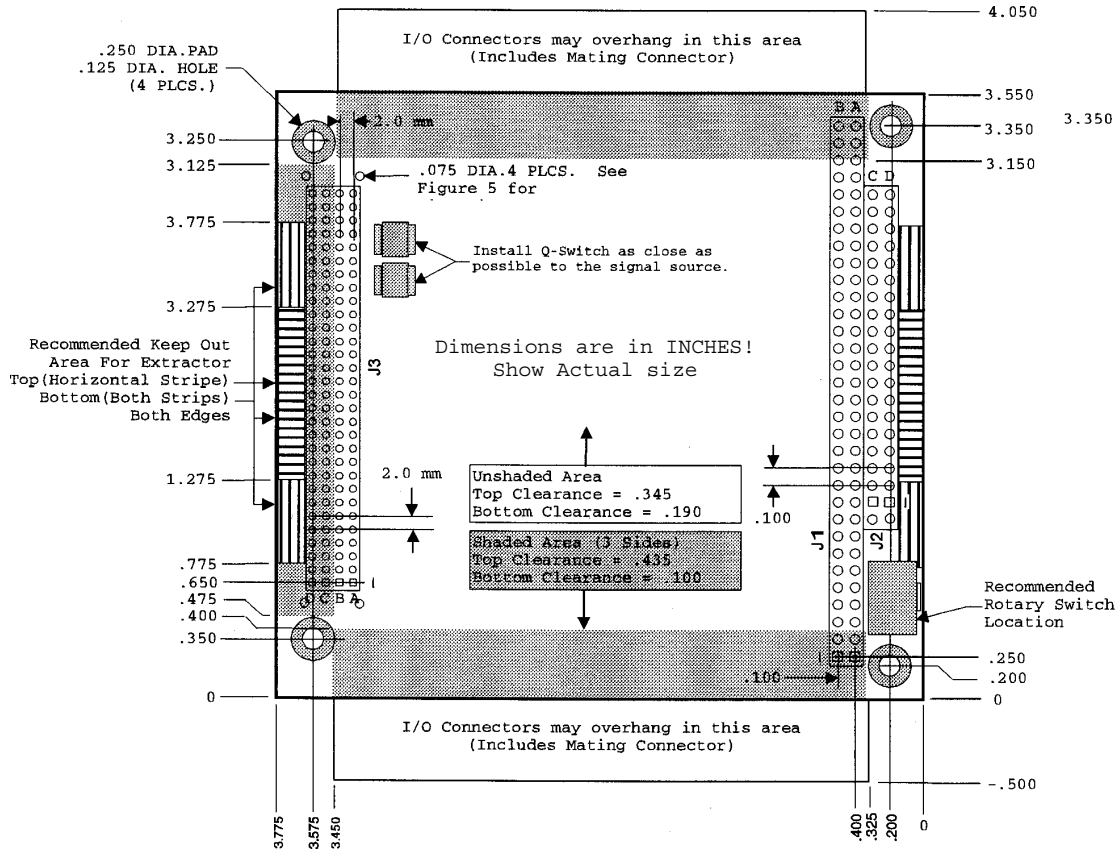
[3]

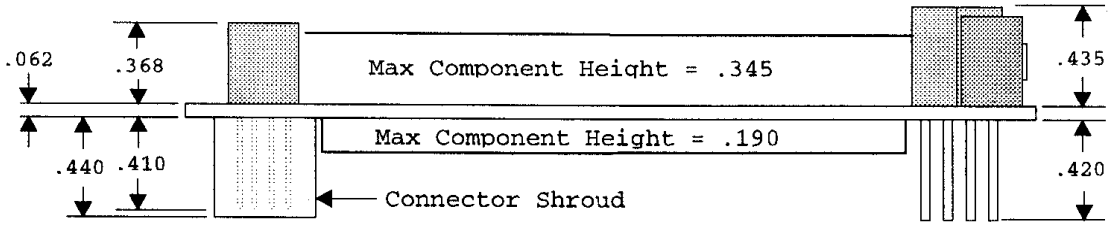
1.2 The PC/104-Plus Specification

The most notable feature of the PC/104 specification is the age. While the amount of time that the system has been around means there is good support with some 200 or so manufactures supporting the specification, there have been many advances since 1992 that have changed the implementation slightly. The most obvious change is the change of bus architecture back in 1992, the busses were a mix of 8 and 16 bit ISA types in PC's, this is the standard supported by the standard 104 interface. For a while, there were additions, to this bus such as the VESA local bus (VLB) but the Peripheral Component Interface PCI became the add-on bus of choice. The PCI interface offers a throughput of some 133Mbyte/sec compared to the 5Mbyte/sec of the standard PC bus.

For optimum compatibility and ease of use the PCI implementation had to preserve the original objectives whilst at the same time offering much better performance. This means the new board needs to be the same form factor, and have same electrical specifications.

1.3 Physical Dimensions PC/104-Plus





With reference to the above specifications, the PC/104 solution is very compact indeed for such a powerful module. The main difference with the PC/104-Plus is the large connector for the PCI bus, which is shown on the lower diagram on the left hand side.

The main PCB should contain the CPU and a system BIOS. Many models however now contain other items such as 10BaseT Ethernet, Video Outputs, LCD Outputs, Video Input, HDD connectors, FDD connectors and many other items, which is amazing when the fact that the PC/104 board has actually effectively got smaller

since the introduction of the PCI connector. There are many suppliers of PC/104 boards, such as AMPRO, but the cost even for low spec boards can be very high, but with a time spent on researching the boards, the prices for these boards vary very wildly, from specification and from manufacturer. There are many older boards that are still being produced and used, and hence are holding their price.

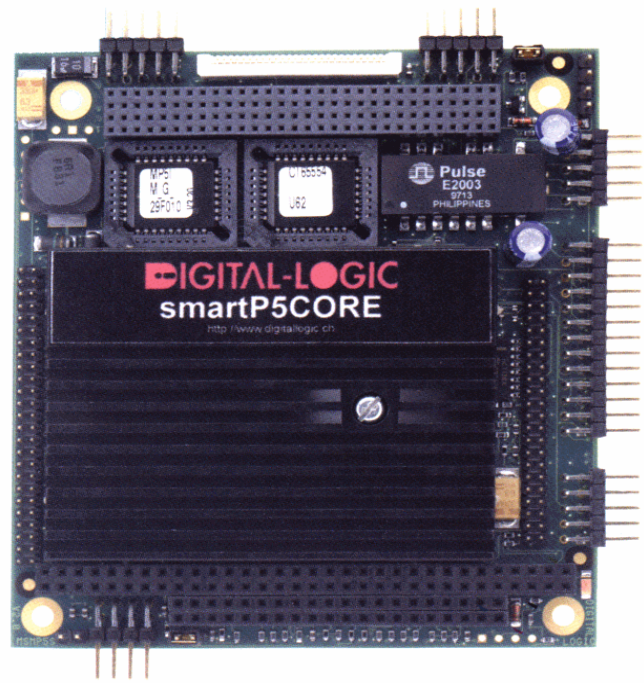
After a great deal of searching, the Microspace MSM-P5S was chosen. The MSM-P5S board is made by a company called Digital Logic (http://www.digitallogic.ch) and they have a very wide range of PC/104 boards as well as Slot PC's and all the peripherals such as frame grabbers, audio cards and network cards etc that are designed for the PC/104 form factor. It was thought that the large range of boards that they have produced shows that they are a proven supplier of high-quality boards.

It is apparent that the company seems to be a leader and whose boards are a long way ahead of those produced by others.

1.4 Microspace MSM-P5S OVERVIEW

The MICROSPACE MSM-P5S board integrates all functions of a standard PC on one board in the size of 90 x 99 mm. The onboard video interface is capable of driving VGA monitors and VGA compatible LCD panels. The operating system and the application program can be booted from floppy disk or hard disk. A watchdog timer can be programmed to supervise the activity of the CPU. The power consumption of 4W of the CPU, allows operating without any cooling. A LAN interface is available on the board.

FEATURES



- INTEL Pentium P5, 1,8V
- MMX 166MHz
- Onboard 3.3 V generator
- Power management
- 32MB/64Mbyte DRAM
- VGA/LCD with 2Mbyte Video RAM
- Three channel video input PAL/NTSC
- Hard disk interface, E-IDE
- Floppy disk interface: 3.5”
- EEPROM Set-up
- COMI, COM2
- LPTI
- Watchdog timer
- Real time clock
- Ethernet LAN

1.5 The SMART PC CPU

The MSM-P5S board incorporates the Smart P5 CORE which is a very small module containing almost the entire PC, all the I/O and the main processor. It is so efficient that even though it contains a Pentium class CPU, no fan or additional cooling is necessary.

The Smart Module is a MCM (Multiple Chip Module)

The Smart Module has many advantages for the system integrator. It is possible to make a custom board and just to use a smart module. The modules are swappable, the suppliers even claim that the MSM-P5S will be fully forward compatible with future smart CPU's, and that when the new Pentium III smart CPU becomes available it can just be plugged into the board, provided that the memory interfaces are compatible. This is a major advantage, because PC/104 boards are not usually bought with future upgradability in mind.

1.6 Storage

1.6.1 Flash Card Storage

For the WearCAM system, the primary objective is to capture and store digital images. This will require some sort of storage device. Modern digital still cameras store their images on flash disks. Flash disks are very small solid-state cards that hold a very small amount of data, maybe 32Mb, and using JPEG compression, this allows them to store quite a number of images. The number of images is however limited by the amount of memory available and the resolution of the images to be stored as well as the complexity of the image.

Since the chosen architecture for the WearCAM is an Intel based system, an operating system will be required to base the software on. (See operating system) This will also require storage.

1.6.2 Hard Disk Storage

Although a flash card could be used the most sensible solution is to use a small 2.5 " Hard disk drive such as those used in laptops. This is sensible because they are designed for mobile use, they only require a single supply voltage of 5 V, they are small and low power. A HDD opens up all sorts of possibilities and allows the storage of vast amounts of data, making the system useful for many applications.

2.0 Mobile Display Technologies

2.0.1 Display Technologies - History

Computer technology is a very powerful thing, and computers are content just to get on with their jobs, but often we, as humans need to see what is going on inside them. Computer displays have often been the limiting factor in the computer industry. The very earliest displays were also the storage for the computers using cathode ray tubes to store and display the contents of the registers to the operators. This was acceptable when the computer clocked at a few cycles a second and the registers contained only eight bits, but now with memory in the hundreds of millions of bits and the speed in the 600MHz+ region this would not be acceptable.

Even by the early 1970's computer displays were still limited and actually being able to display characters on a TV screen was a challenge since video requires high-speed circuitry, so even here a printer was the preference. Only in the late 1970's when TV type displays became readily available and people could debug their software on the fly, did the computer revolution really take off.

As early as the early 1980's, computers were small enough to be portable but here was the next hurdle, TV's are bulky and heavy and are no good for portable computing applications, so yet again the computer industry was stuck again until a portable display technology became available.

2.1 Flat Panel Displays

The answer to the mobile computing display dilemma was the Liquid Crystal Display. LCD's had been around for a while, but there were no standards for a dot matrix display, and getting the speed for addressing all the dots was a major stumbling block. Also the matrix idea of addressing a row and a column to get a dot meant that the display had to scan, and this gave a very sluggish slow and almost impossible to read display. There were also other problems at this time, the backlight. The backlight had to be invented especially for this application and it came in the form of

a cold cathode florescent tube. These require many thousands of volts to drive and they had a very limited life of a few tens of hours.

2.1.1 STN Displays

Super-Twist-Nematic is a method of producing a Liquid Crystal Display. LCD's work by having two polarised screens and then a crystal that then 'twists' the polarisation of the light whilst being stimulated by an electrical charge. It is found that polarised screens will only let light through in one orientation, so creating a crystal with variable orientation will produce a dot through which light transmission can be controlled. For early displays, the crystals were either on or off, which meant text and diagrams were fine but there were no greyscales.

Super Twist Nematic displays allow the dot to be controlled to create greyscales. This is done by pulsing the crystals at a high frequency to give them an average orientation and hence a value in between off and on. This type of approach however gives rise to problems with scan speed, having to control all of the dots in this manner produces a very slow acting screen with lots of noise.

The solution is to split the screen up into two halves and scan each half simultaneously. This speed up the display and give a better contrast. This is known as dual scanning. Dual Scan Twist Nematic (DSTN) displays have a very big place in the market because they are much cheaper than their TFT counterparts are. There are several enhancements still that can be made on these screens such as adding 3 horizontal dots per pixel which can produce a full colour display, and also splitting the screen up even further can product display called Fast-Scan displays. Most modern laptops that still have Dual-Scan displays actually have fast scan displays.

2.1.2 TFT Displays

The main drawback of STN displays is that they are still slow and produce washed out colours with a very limited viewing angle. This is because each line and column is driven with a single transistor; the whole display needs to be transparent and so uses transparent conductors. This gives rise to a significant amount of resistance.

This is why on DSTN displays, bright or dull objects appear to 'run' and there is so much wavy noise. A better solution is to drive each pixel with its own transistor.

This type of display is called the Thin Film Transistor display (TFT). In it each colour of each pixel is actually a tiny transistor and display then has two power planes and is addressed in the same manor as the DTN display. The display has a much faster response since each pixel is driven hard to the required value; the colour purity is much improved, as is the contrast.

There are however, disadvantages to TFT displays. The display is a very large array of transistors, which is very expensive to produce, and yield is a real problem in the manufacturing process. This is why all TFT displays have 'dud' pixels; usually there can be quite a high number of 'duds' that can appear as a solid colour of either red green or blue, and they can be stuck on or off. This is the reason why many of the manufactured displays are discarded, as there is no way of fixing them. A few years ago, the yield was as low as just 20%.

The other drawback to the TFT displays is one of power usage. Such a large array of active transistors uses more power than a passive array such as DSTN, however, the transistors are usually pulse width modulated and so the drain is much reduced in the latest displays.

2.1.3 Display Cost – Quality Trade-off

This leaves just cost as the major drawback with this technology. By cost, it's not just twice as expensive as DSTN its up to 20 times the cost, with a 17-inch display costing between £1,000 and £4,000! -Even at this price, you still get dud pixels, and if they happen to be in a particularly noticeable place, it can be very annoying. They have however, become almost to the stage where they can replace CRT's for normal desktop applications, their immense savings in desk space outweigh the cost or their inferior colour matching abilities

2.2 Head Mounted Displays

Above is the very latest is head mounted display technology from The Micro-Optical Corporation in America. With styling similar to the standard NHS glasses, fortunately made fashionable by Chris Evans! The only visible difference- from this side at least is a wire coming off the frame. This type of display is an overlay type of display. This means that instead of producing just a screen that you can look at, it produces an image overlaid over the real world.

The image produced is rather like the one on the left. The background is what you are normally looking at but over the top, you can see other information. Shown here are two windows. The

important thing to note here, particularly when it comes to designing the interface is that you can't have a colour darker than the background! Therefore, a full range of colours is only possible with a black background.

2.3 Other Display Technologies

2.3.1 Plasma Displays

Plasma displays are in there infancy at the moment. They are mainly used in applications where a large CRT would be used, but the thickness of a CRT is undesirable. This means that they are mainly very large displays such as home cinema screens. There are smaller versions available, but the cost is still very high.

Plasma screens also get very hot, people have been burnt in the past, and so this indicates that the screens consume far too much power for a mobile unit.

The plasma screen is fine for static large screen applications, but not for mobile applications like WearCAM.

2.3.2 Electro-Luminescent Displays

The display above is an EL display from planar offering the following features.

- A high-resolution
- 10.4" VGA-compatible electro luminescent (EL) display
- Delivering eight distinct colours
- Extreme ruggedness
- Extended operating range

Clearly, the EL displays are highly optimised for use in harsh environments or where visibility is limited such as in a car dashboard. Unfortunately, they cannot produce very many colours in this case just eight, which is because each cell can be on or off,

no greyscales are possible. On the good side, however the display can be driven just like a TFT or STN screen without modifications to the driving circuitry.

This makes the display ideal for the applications that it is designed for i.e. industry and automotive applications, but not for an imaging application like WearCAM.

2.3.3 Light Emitting Polymer Displays

A company called Cambridge Display Technologies has been developing a very small, lightweight, compact, and low power display type known as LEP. The Display works in a similar manner to other organic light emitting sources such as glowworms and even EL displays. The conversion from electricity to light is very efficient generating no heat.

What is different about the LEP displays is how they have managed to make a Polymer with this property allowing shapes or even matrix screens to be manufactured.

Colour screens can be manufactured, and they are that robust that they can be bent like a piece of paper. This means that they are a very good solution to a wearable system since they should be very difficult to damage.

3.0 Operating Systems

There are different Operating Systems that can be used on the PC/104 board without too much hassle. Due to its 100% PC compatibility, it can run any software that can run on any PC.

3.1 Suitable Operating Systems

Shown below is a table of operating systems in ascending order of processing power needed to run them.

1

1. DOS
2. Custom OS
3. Windows 3.x
4. Windows 95
5. Linux
6. Windows 98
7. Windows NT
8. Windows 2000

At the bottom of the list is DOS, which provides all of the basic features such as File I/O and allows software programs to be built up. This has the advantage of being very compact and very low on resource consumption. Integration with weird hardware and communications abilities are very limited.

A custom OS could be used, this would allow the developer to produce a system that only contains the features that are needed. This can be a good way to go if the board is to be used in a very specific application such as a Nuclear Power station, where the operating system needs to be very specific for safety reasons.

Windows 3.X offers a very intuitive interface, and is easy to build new applications for. Version 3.1 offers good stability and 32bit access to peripherals and memory,

which makes it more suitable than DOS, with the added advantage of connectivity which although limited are better than DOS. The support for hardware is patchy and it doesn't really have support for specific direct access hardware such as frame grabbers etc.

Windows95 brought about the largest change in underlying technology for PC's. Although the change to 95 made only small differences to the end users, the underlying workings are much more advanced with Plug and Play being implemented. It offers the same advantages of Windows 3.x but with much better 32 bit support and a great deal of speed increases and enhancements.

Linux is a UNIX based environment for x86 platforms. It is the most customisable operating system available for the x86 because it can be compiled by the end user to include only the necessary components. Its support for networking is its strongest point and there is an X Windows GUI, which can be installed. X Windows is in no way as easy to use as Windows 9x because there is a total lack of consistency between platforms. However, Linux is the OS of choice for many embedded applications such as in car entertainment system and other such systems. On the bad side however the support for hardware can be very bad, there is currently no support for DVD, USB, PnP, Win Modems etc that are only catered for by Windows.
Windows 98 offers many improvements over Windows 95, but none of them are applicable to the WearCAM project. In addition, the resources consumed by Win98 are higher than that for Win95, which makes it feel slower and is unnecessary for this application.

Windows NT and 2000 are based on the same technology known as NT, which rather ironically is supposed to stand for "New Technology". Strangely although Windows NT is supposed to be new technology and it looks like Windows 95 it is actually much older underneath and does not support PnP or any Direct X technology which makes it unsuitable for the WearCAM system. There are added benefits such as better filing system and enhanced security features but these are not concerns of such a system.

[1] Please see Anthony Schwirtz's work on interfaces and the user for various operating systems. 4th Year MEng FYP 1999 Dept of EEE - University of Birmingham, UK

3.2 OS Conclusion

The PC compatibility of the PC/104 board gives the advantages of being able to run anything and from the information above the operating system of choice really has to be Window 95.

Just to confuse matters and to check people are shelling enough money out to Micro$oft, there are several different flavours. There is Windows 95; this comes with hardly any connectivity as standard and plenty of bugs. Next, there is Windows 95 A, which can be obtained either by new installation or by a service pack for Windows 95. This includes Internet Explorer 3 as standard and lots of fixes and enhancements that were missing from the original release. Later on in 1997 came Windows 95 OSR 2 or B which came with a completely different underlying system for PnP which resolved all sorts of little issues that had still not been resolved by service pack 1. This meant that hardware could be added and removed, enabled and disabled without restarting the machine, which is a major bonus. It also supports FAT 32. FAT stands for File Allocation table, and from the early days of DOS, PC's have a map of where all the files are stored and this is done by splitting the disk into clusters. FAT 32 makes much better use of the disk and offers space savings. Just to really catch people out, it is not possible to upgrade to OSR2, unless it's fiddled by deleting all the win.com references.

4.0 The MSMP5s Board In Practice

TBA

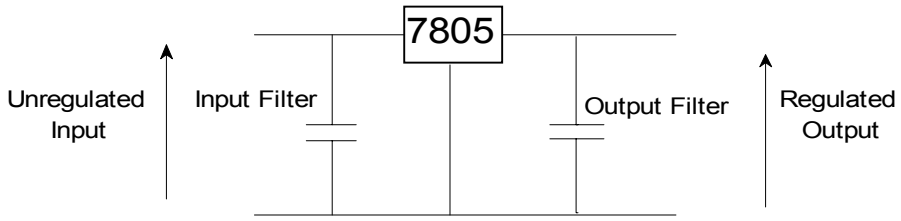
5.0 Power Management and Systems

5.1 Linear Voltage Regulation

The wearable computer system requires a single supply voltage of 5.0 volts and that 5.0 volts has to be 5.0 volts and not 5.5V or 4.5V. This is because the logic circuits need to have defined highs and lows.

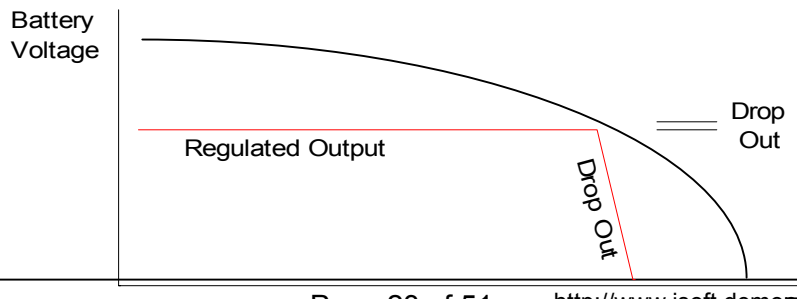
It is not possible to have a 5Volt battery, or at least if it was then the battery would not be exactly 5 Volts for very long.

It is therefore standard practice to use a higher voltage source than you require say maybe 9 Volts and then regulate the voltage to the main circuit by means of a voltage regulator. The regulation of choice for low power applications is a simple linear voltage regulator shown below.



The 7805 is an off-the-shelf IC that literally just has an input and output and a ground, from this it is able to keep a regulated output until such point as it drops out.

5.1.1 Drop-Out



Shown above is a typical voltage trace for a linear regulator over time. What is happening here is that there is a load drawing current from the voltage source through the regulator? This makes the battery voltage gradually decay. For this example, lets say the battery voltage is a nominal 9V and the regulation occurs at 5V.

The voltage regulator works by having a transistor internally that has a voltage drop and a Zener junction that has a fixed voltage across it, this means that in order for regulation to occur there must be a voltage drop across the transistor or else it will turn off. At turn off the voltage rapidly falls away to zero. This condition is known as dropout, and the drop out voltage is known as the minimum voltage at which the input must be above the regulated output voltage. For a typical 7805, this voltage is about 0.5 volts. So in order to guarantee 5 Volts the input must be above 5.5 Volts. There are Ultra-Low-Drop-Out regulators with a dropout voltage of less than 0.1V

5.2 Efficiency

In the description for a linear voltage regulator, it was stated that there is a transistor that 'drops' the unwanted voltage to produce an output voltage. This drop is a major concern in terms of efficiency.

5.2.1 Efficiency Example:

Suppose our battery was 10 Volts, We need an output of 5 Volts to run our system, and that our system requires 5 Watts. So that it 1 Amp flowing through our load. We also have a 5 Volt drop across our regulator, which also has 1 Amp flowing through it to feed our load. This means that there is a loss in our regulator or 5W! This means that this regulation is only 50% efficient, at best!

Clearly we are using a battery operated system and so we do not want this type of loss, because that would mean we are carrying around batteries that are twice as heavy as needed, or they only last half as long as we need. There are two options, lower the input voltage or use a much more efficient converter.

5.3 Input Head Room

Why is such a large voltage necessary on the input?

With reference to the battery voltage verses time graph it is notable that the battery undergoes discharge, and its internal resistance raises causing a drop in its output voltage. This is allowable with our regulation, and there are advantages.

A battery monitor circuit can be built that monitors this voltage and can produce a low battery warning condition. Also if a curve comparator is used, battery time remaining can be calculated, which can be very useful on this type of system, as it gives the user some time to protect unsaved work in volatile memory.

5.4 The quest for higher efficiency – DC-DC Conversion

For the Wearcam long battery life is needed and the power being lost in a normal converter could be 50%, this is lost in heat, and is very inefficient and undesirable. Fortunately, there are neat solutions to this problem, at the expense of complexity and noise.

The solution is to use a DC-DC converter circuit. This type of circuit works on the principle of chopping the input voltage up on a sort of Pulse Width Modulation basis and smoothing it out using an output filter. This is more efficient because the regulation transistor is either on or off, and not in the linear region at any time, so there is very little loss. [2]

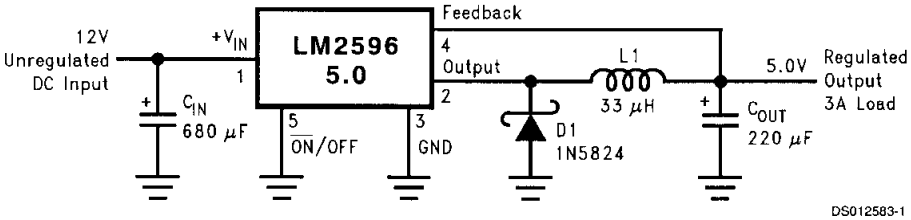
Efficiencies for this type of voltage conversion can be in the high 90%+ region depending on the type of regulation required and the load. Another advantage of switching converters is that they can work in two modes, Buck or Boost configurations. This allows them to produce outputs that are lower and higher than the input voltage: - Yes, they can produce a higher voltage at the output than the input. Conversion efficiency alters with the input voltage.

[2] Please note that the description for a switching regulator is actually more complicated and beyond the scope of this technical article, however the above explanation is sufficient for this purpose.

For the Wearcam project, efficiency greater than 80% can be expected and with access to high quality components, an efficiency of up to 90% can be achieved.

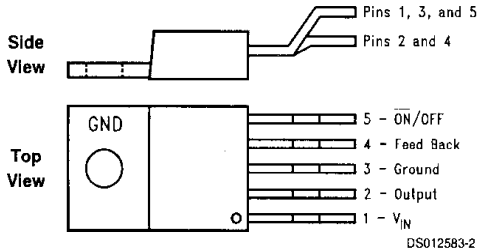
5.4.1 LM2596 Switching Converter

Typical Application (Fixed Output Voltage Versions)



[3]

Bent and Staggered Leads, Through Hole Package
5-Lead TO-220 (T)



Order Number LM2596T-3.3, LM2596T-5.0, LM2596T-12 or LM2596T-ADJ
See NS Package Number T05D

The LM2596 regulator contains circuitry that maintains the output voltage by means of a feedback loop as can be seen in the application note above. It can then vary the modulation duty cycle to maintain a steady output voltage when the load is fluctuating. The regulator works by building a current up in the inductor and then using the current characteristics of an inductor to inject current into the output capacitor. Typically, this circuit uses a switching frequency of about 150kHz, and this switching causes the output voltage to have a ripple and noise at the 150kHz fundamental and at several harmonics either side of the fundamental.

All digital circuitry have their own power supply de-coupling – which means that they filter the supply voltages for their own use and so the noise caused by our converter is not a problem in this configuration

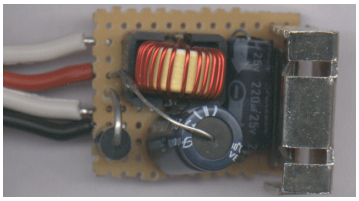
[3] Pictures taken from the data sheet.

Of course, there are enhancements that have been made to this 'simple switcher'; the most important is the enhancements to the main switching transistor. D-MOS transistors allow for a smaller ON-Resistance, which leads to a lower loss and allows a much higher switching frequency of ~240kHz.

240kHz, gives a higher frequency ripple that is easier to remove with smaller output filter capacitors, which leads to a smaller overall more efficient circuit.

5.4 PSU Design Testing and Performance

The PSU has been designed in accordance to the data sheet using an LM2596. The smallest inductor available at this time is a 47uH however; this is not a problem since it helps the unit withstand abuse better. The output stage capacitor is a 250uF electrolytic capacitor, which provides nice low ripple even at full load.

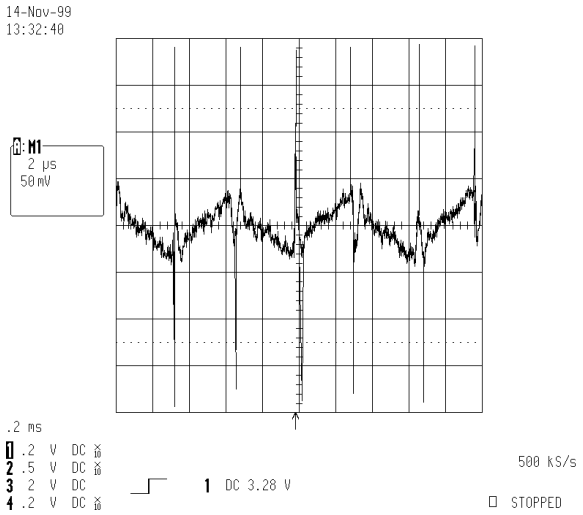


The actual PCB for this PSU is very small occupying some 35mm x 25mm the largest component being the input filter capacitor.

The following is the chosen configuration;

Component	Value	Rating
Input Filter	470uF	25V
Output Filter	220uF	25V
Inductor	47uH	3A
Diode	1N5822	5A
Switcher	LM2596	3A

5.4.1 PSU Performance



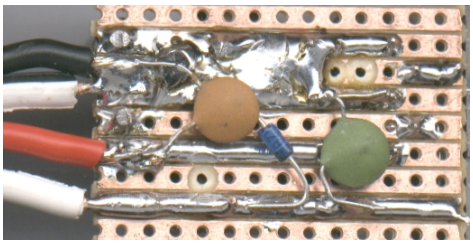
The actual performance of the circuit is very impressive offering an output voltage of 5.00 Volts. The circuit was tested with a range of different loads to see what the effect was on the output.

The graph on the left shows the output ripple greatly amplified. The rising slopes are caused by the inductor charging up the filter capacitor and the falling slopes are caused by the filter capacitor discharging through the load while the inductor current is building.

Because of the nature of a switched PSU, there will always be lots of noise in the output. In the case of our design here, the diode very rapidly changes from reverse biased at 12Volts to forward biased. This needs a very fast recovery diode called a shottky diode. The diode coupled with the inductive nature of the supply wires to the PSU that produce the spikes at the switching points. It can be seen that the switching spikes are very large and very fast.

Normally these spikes would not be a problem, however it would be a good idea to try to reduce them.

5.4.2 Modifications

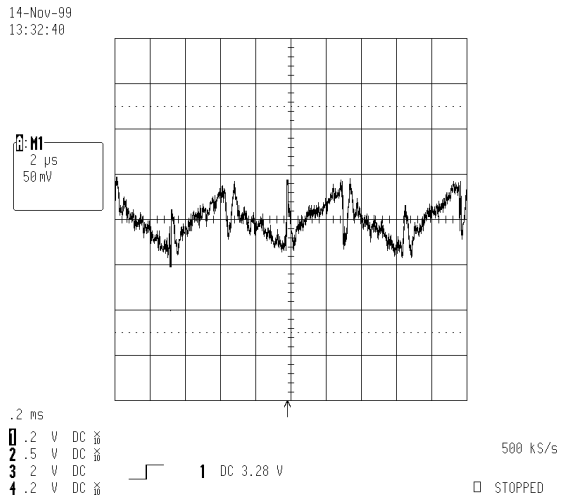


To help reduce the effect of the stray inductance the ground tracks are all in a single block. If this PSU were to be made on a PCB, it would be advisable to have a ground plane as this helps to keep the interference to other systems down as well.

Measurement on the input of the circuit shows the switching noise is high here despite the filter capacitor. This is because the current flowing in to the circuit is a square wave. The supply wires are shown in RED and BLACK. In addition to the

supply input capacitor, a further 100nF ceramic capacitor (brown) has been added to reduce high frequency noise.

On the output, there are two considerations to be made to ensure that no damage occurs to the rest of the system and these are voltage spikes, such as those produced by the switching and input transients. The output can produce transients above the 5V level if the load changes rapidly or if there is a brief interruption to the supply. Some protection is needed to prevent the output from going too high. The blue component is a ZENER diode. This has a fixed reverse breakdown voltage. In this application a 5V1 (5.1Volt) Zener has been used, and this will help clamp the output to 5.1 Volts should a transient occur thus protecting the system. It should be noted that this is a very small Zener and will only give protection for brief transients and should a fault occur it would not be able to sustain a 5.1 Volt output. Further benefits can be attained by using a much higher rated component should this be deemed appropriate. Also to help combat the high frequency switching noise on the output, a further 100nF ceramic disc capacitor has been added.

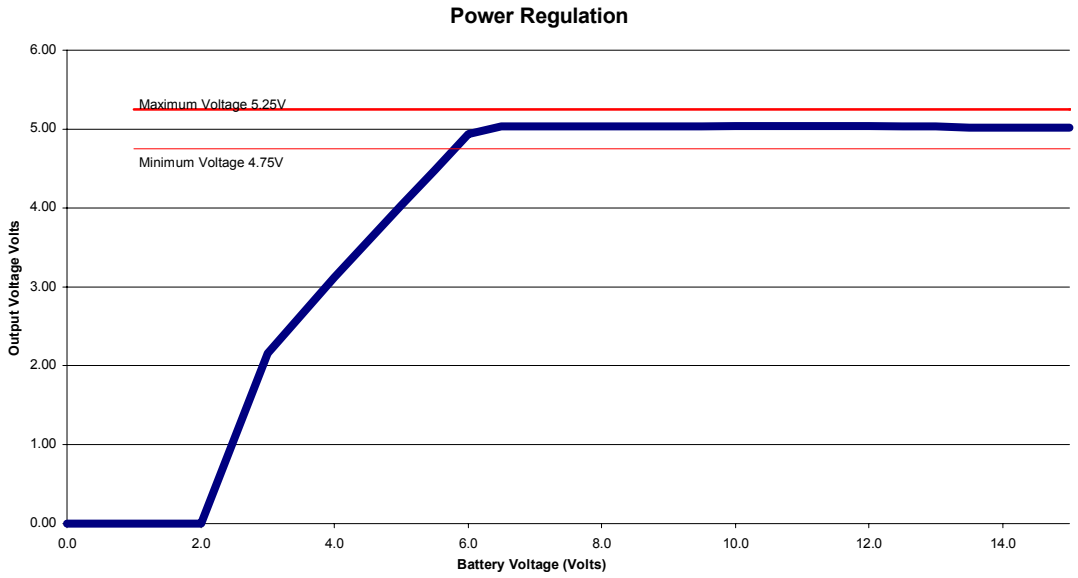


From the graph it is clear that the spikes have been virtually eliminated and the output voltage ripple is normal and to be expected[4]. The MSMP5S board is designed to run from a supply of 5V +/- 5 %, which means between 4.75 and 5.25 volts is acceptable. Here the PSU is producing 5.00 Volts with a ripple of about 75mV pk-pk.

4 The graph shown is a modified version of the original and is not an actual graph; this is because the graph shown is not available. This graph is for illustration purposes only based on actual observations.

5.4.3 Final Performance

The fact that the MSMP5 board cost is fairly high and can easily be damaged by a faulty supply means that extensive testing of the PSU is required before it is placed anywhere near the MSMP5 board.



Using a digital voltmeter and a variable power supply (LM 317T), the regulation was tested. This involves winding up the input voltage and noting the output voltage. The regulator in question was loaded to about 1 Amp, using a 5-Ohm load. This ensures that the circuit is actually driving something. The data sheet claims that the regulator can work from 7 to 40 [5]Volts, and here it can be seen that the PSU meets or exceeds this specification. It should be noted that the regulation is very good indeed with the voltage at 5.01 Volts over a very wide range of input values.

[5] Please note that the input capacitor is rated at 25 Volts

LM2596T Testing Results for the WearCAM Switching PSU

Vin	Vout	Min	Max	I Out
0.0	0.00	4.75	5.25	0.000
1.0	0.00	4.75	5.25	0.000
2.0	0.00	4.75	5.25	0.000
3.0	2.16	4.75	5.25	0.327
4.0	3.12	4.75	5.25	0.473
5.0	4.03	4.75	5.25	0.611
5.5	4.48	4.75	5.25	0.679
6.0	4.94	4.75	5.25	0.748
6.5	5.03	4.75	5.25	0.762
7.0	5.03	4.75	5.25	0.762
7.5	5.03	4.75	5.25	0.762
8.0	5.03	4.75	5.25	0.762
8.5	5.03	4.75	5.25	0.762
9.0	5.03	4.75	5.25	0.762
9.5	5.03	4.75	5.25	0.762
10.0	5.04	4.75	5.25	0.764
10.5	5.04	4.75	5.25	0.764
11.0	5.04	4.75	5.25	0.764
11.5	5.04	4.75	5.25	0.764
12.0	5.04	4.75	5.25	0.764
12.5	5.03	4.75	5.25	0.762
13.0	5.03	4.75	5.25	0.762
13.5	5.02	4.75	5.25	0.761
14.0	5.02	4.75	5.25	0.761
14.5	5.02	4.75	5.25	0.761
15.0	5.02	4.75	5.25	0.761

Overload Condition Load = 1 Ohm

Vin	Vout	I in	I out
12.12	**4.87**	**3.00**	**4.87**
%Rating	**162%**		

Pin	**36.360**	W
Pout	**23.717**	W
Eff	**65.23%**	

Normal Mode Load = 3.3 Ohm

Vin	Vout	I in	I out
12.12	**5.03**	**0.83**	**1.52**
%Rating	**51%**		

Pin	**10.060**	W
Pout	**7.667**	W
Eff	**76.22%**	

The regulator performed well, and was taken brutally beyond its designed operating point to see how it behaved. Even at 162% of its designed maximum load, the output voltage is still within 5% of 5V. The PSU was left to drive this heavy load for 5 minutes to check if any damage occurred[6], but no damage occurred (except the glowing smoking load resistor).

The PSU passes all the tests with flying colours.

[6] This is a state of affair known by the engineering community as the smoke test. An over stressed device can undergo rapid breakdown and failure under such conditions. Failure of the PSU can often lead to permanent damage or destruction of the main system, so testing is very necessary.

5.4.4 Supply Rise Time

The manufacturers of the MSMP5S board, Digital-Logic, specify in the user manual for the board, a supply rise time from 0 to 4.75V in 100us. If a normal linear regulator such as an LM7805 were to be used, the rise time would be in the order of a few tens of ms.

After a bit of investigation, it was believed that this rise time quoted by the manufacturers has to be incorrect. The reason for this conclusion is that if all the capacitances of the system including all the supply de-coupling for each of the IC's is added together, a rise time of 100us would require a few tens of amps to produce. This is using the well-known formula I=C (dv/dt) where the Current I is produced by a rate of change of voltage (dv/dt) across a capacitance C.

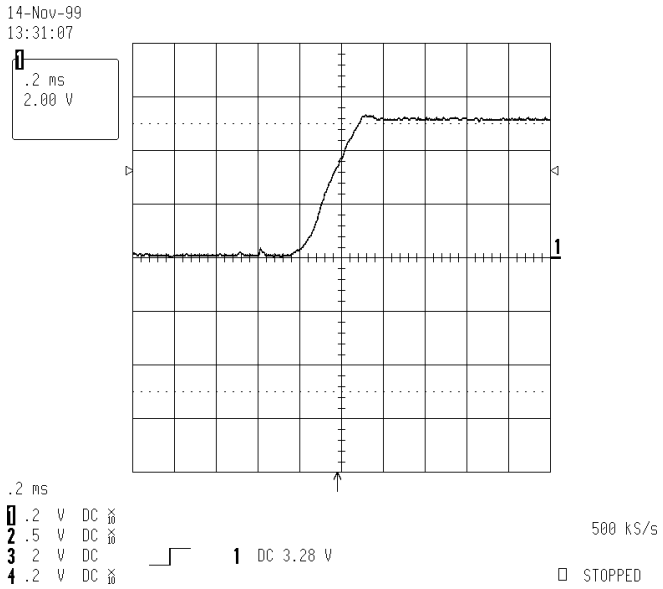
Steps were taken to chase up the supplier of the board to confirm our suspicions. It turns out that this rise time is that rise time quoted by Intel for the processor and that that is what they had put in the data sheet. It was pointed out that the processor runs on 1.8V and the board on 5V and that the 1.8V probably needs a rise time of 100us. The reply was;

```
The specification for the Power Rise Time of 100 micro Seconds (+10
%) is given from Intel.
That's why we are specifying this value in our manual as well. By
specifying this value, Intel is going to the safe side. The
experience shows, that available power supplies specifying 250 micro
Seconds (again on the safe side but in the other direction) are
working very well with our MSMP5S boards.

I hope this information will help you a little bit.

Regards
>Martin Niggli
```

So just what is the rise time of the switching supply? Its time to bear in mind that the converter uses a 150kHz oscillator, that's a full cycle, every 6us. With this in mind, the converter should have already been through quite a few cycles and be well on its way to 5V by the time 100us has elapsed, it should definitely be more than 1.8V by this time.



The converter was attached to a load that would simulate 1.5 Amp running load, 3.3 Ohms, and the graph above shows the rise time. It can be seen that the rise time is around 250us, which is most impressive and the overshoot is very small indeed. It's perhaps worth pointing out that a mechanical switch does not have a rise time as clean or as fast as this!

For the time being at least, the PSU design seems complete, there is nothing more to do until the board arrives.

The supplier of the board is satisfied from the graphs and the description, that the power supplies can more than adequately handle the board.

5.5 Power Supply Redesign

With the PSU being so efficient why is a redesign necessary? The original LM2596 based regulator ran fine, and turned out to have an average efficiency of somewhere in the 80 – 85 % range. This is ok for this type of application, but there were problems when it came to the height of the module. For a wearable system, there can be many boxes each being connected and part of the 'distributed system'. However, since there was no way in which the module would fit into the prototype enclosure, a separate box needs to be constructed. Hence, there is now a problem with the height of the module.

There are many different types of boxes available off-the-shelf which removes the need for a complete design of a box, but the height of these boxes scales proportionally with the size, as one would expect. This means that a box to fit the PSU module has to be a large one and has a great deal of wasted space. One solution is to bend the LM2596 flat to reduce the overall height. Unfortunately, this damaged a number of the legs on the IC rendering it unusable.

In the mean time, a later enhanced version of the simple switcher series was discovered and was RS. The new device the LM2676 uses a higher switching frequency of 260kHz. This means that the filter capacitors on the output and the input can be much smaller, because they have to supply the current for a much shorter time.

5.6 The LM2676 SIMPLE SWITCHER ®

5.6.1 High Efficiency 3A Step-Down Voltage Regulator General Description

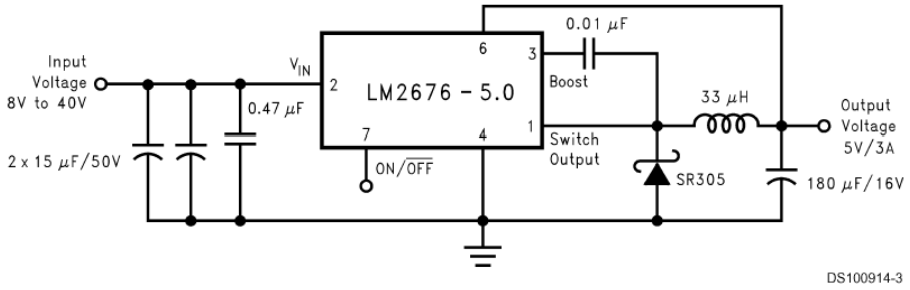
[*The LM2676 series of regulators are monolithic integrated circuits, which provide all of the active functions for a step-down (buck) switching regulator capable of driving up to 3A loads with excellent line and load regulation characteristics. High efficiency (>90%) is obtained using a low ON-resistance DMOS power switch. The series consists of fixed output voltages of 3.3V, 5V and 12V and an adjust-able output version.*

The SIMPLE SWITCHER concept provides for a complete design using a minimum number of external components. A high fixed frequency oscillator (260KHz) allows the use of physically smaller sized components. Families of standard inductors for use with the LM2676 are available from several manufacturers to greatly simplify the design process. The LM2676 series also has built in thermal shutdown; current limiting and an ON/OFF control input that can power down the regulator to a low 50µA quiescent current standby condition. The output voltage is guaranteed to a ±2% tolerance. The clock frequency is controlled to within a ±11% tolerance.

5.6.2 The LM2676 Features

- *Efficiency up to 94%*
- *Simple and easy to design with (using off-the-shelf external components)*
- *150 µΩ DMOS output switch*
- *50µA standby current when switched OFF*
- *±2%maximum output tolerance over full line and load conditions*
- *Wide input voltage range: 8V to 40V*
- *260 KHz fixed frequency internal oscillator*

Typical Application



]7

[7] Selections Taken from the LM2676 Data Sheet (National Semiconductor www.national.com)

The data sheet states that the device can be switched into a standby mode with a current of less than 50uA this would mean that in the future further modules could be added to better control the power such as a better power management system. An example of which would be a system that monitors the battery and works out the time left to save data for when the battery becomes too low to operate the machine.

5.7 LM2676 Design Details

All of the lessons learned in the construction of the earlier PSU were equally applicable to this design. Most notably the inclusion of high frequency by-pass capacitors as well as 5v1 the Zener to prevent the output from going above 5.1V.

The design used was a slightly modified version of the typical application where the inductor used was a 47uH and the output filter increased to 220uF 25V and the input filter reduced to a single 33uF 25V part. In addition the same high frequency filter capacitors and Zener were added as to the original design.

5.7.1 Testing

The testing details are identical to that of the original PSU, this is because from the outside it can be treated as a lumped component or black box, so there should be no observable difference. Therefore, it should behave the same as the original or better. The new device behaves even better than expected and leads to an increase in efficiency and a decrease in current from the batteries.

This decrease in current has two closely related benefits. The most obvious one is that the batteries last longer. However, the effect of a lower drain current gives a larger effective capacity for the cells.

6.0 Batteries

There are many different batteries available for many applications. The type of battery depends greatly on the application.

6.1 Power Requirements

For this application, it is known that the drain from a 12 V source is in the region of 750 – 850 mA nominal.

Power (P) =VI (Watts W)
=12X0.8
=9.6 W

This equates to about 9.6 Watts. Given that the 9.6W is constant, one can assume that as the battery voltage (V) decreases the current will increase because P is always equal to VI.

The PSU will be able to maintain 5V for the board until the battery voltage falls to about 7V where it will drop out (see regulation section) but, because the discharge curve for a battery is not linear and tends to fall of dramatically, we need to stop the discharge as soon as it falls to below 8V. Using the Power equation, this means the average current will rise to 1.2A.

It can also be noted that the further above 8V the nominal battery terminal voltage is the more easy it is to predict battery lifetime, and furthermore, the lower current will lead to a longer battery life.

Clearly, a design decision must be made as to what the battery voltage needs to be in order to choose the correct type of battery. Different battery types have different cell voltages.

6.2 Cell Types

There are many different types of battery available and there are many different reasons for them. First lets get the correct terminology. A cell is an individual package that can exist on its own; it is usually composed of two plates and an electrolyte. Nearly all cells are constructed in this manner. A battery means more that one cell. Usually a cell have a low terminal voltage so more than one cell is connected in series to form a battery of cells know just as a 'battery'. For one reason or another most will call a cell a 'battery' and a battery a 'battery pack'.

6.2.1 Primary and Secondary Cells

Cells come in two distinct classes Primary and Secondary. Primary cells are not normally rechargeable or at least if they are the performance is poor after recharging. This is because the chemical reaction inside the cells under discharge is not reversible by simply reversing the current flow.
By contrast secondary cells are specifically designed to be reversible and can be recharged by reversing the current flow, albeit not indefinitely.
The reason why most rechargeable cells fail is because the plates have to be turned from and oxide back into a metal under the charging process, and this re-plating is not uniform which results in a very rough surface and even total failure. Another point to note is that of the 'memory effect' which is an effect, which does not exist. Usually what one experiences as the memory effect is cell voltage depression where each cell still retains its capacity but has a reduced voltage, hence most battery management systems interpret this as a flat battery. The key therefore is to ignore effects like the memory effect and make sure that cells are charged carefully and one should find any cell would last at least 500 Cycles.

Energy density is one way of measuring cell performance in terms of the amount of energy available per unit weight. We could also compare D cells and their capacity. A good alkaline cell (Duracell) has a capacity of around 15Ah.

6.2.2 Nickel Cadmium

Nickel cadmium is an old technology as far as rechargeable cells are concerned and have been used in many applications particularly portable applications. Nickel cadmiums (Ni-Cads) have a terminal voltage of 1.2V, and a lifetime of up to 3000

cycles. The energy density of Ni-Cads is quite low. Compared with an alkaline its capacity for a D-Cell is about 4 Ah. Nickel Cadmium cells also exhibit self-discharge, which is the phenomenon where the cell loses its charge over time. This happens at around 2-5% per day. Unfortunately, they contain cadmium, which is a very toxic metal that makes the cells very bad for the environment.

6.2.3 Nickel Metal Hydride

Nickel Metal Hydride (NiMH) cells are very similar to Ni-Cads but they use a different composition, this makes them much less hazardous and they can be disposed of like any household rubbish. For the same weight, they offer performance that is 30 to 40 % better than Ni-Cad and the terminal voltage 1.2V is maintained for most of the discharge cycle. They can be cycled up to 1000 times, however the self-discharge rate of NiMHs is much higher than that of Ni-Cads because the cell chemistry is not as stable, typically 5 – 10% per day. For our rough energy density comparison, one can expect a D-type cell to have a capacity of about 5.5 Ah. They are more costly than their Ni-Cad counterparts are.

6.2.4 Lithium Ion

Lithium Ion technology is very new and perhaps the best. These cells are particularly suitable for high current and low current applications, as the self-discharge rate is very small, once charged they can be stored for months before use. In terms of energy density, they would be equivalent to about 14 Ah for our D-Cell comparison, making them ideal for a portable system. The cell voltage is unusually high at 3.6V per cell, which makes the comparison only an estimate and difficult, suffice it to say with two batteries in your hand, a Lithium and a NiMH of similar capacity the Lithium is noticeably lighter.

6.2.5 Lead Acid

Lead acid is one of the oldest battery technologies currently available going back over 100 years. In this time, the batteries had had a great deal of time to evolve. Lead acid batteries can produce very heavy currents easily, and will stand up to a great deal of abuse; car batteries are Lead Acid.

The Lead Acid battery is not quite, as menacing as it might sound, the terms Lead and Acid (sulphuric acid) make the battery sound dangerous as it is and the fact that the electrolyte is a liquid makes them a spill hazard. However, in the last few years, Sealed Lead Acid batteries have been developed which are impossible to spill and the electrolyte cannot be leaked. These batteries have a very low self-discharge rate of less than 1% per month, and they can be recharged a great deal of times, because the gasses given off during charging is actually recombined on discharge meaning there is no real loss. In terms of our D-Cell comparison, I estimate the Lead Acid to be nearly as good as a Lithium or Alkaline, however they are heavy. Very Heavy. One cannot get away from the fact that they contain Lead, which everyone knows is very dense. The cell voltage is 2.0 Volts. These are available in many shapes and sizes, even cylindrical shapes known as Cyclon cells.

6.2.6 Rechargeable Alkaline

It has been known for more than 50 years, ever since the Alkaline Primary cell was developed, that the discharge should theoretically be reversible. The reasons why this is actually quite difficult is complex but what we really need to know is that it has now been done successfully and the cells are commercially available. They have the same capacity as a regular alkaline cell, but they can be recharged up to 25 times.

Table 1. Cell Comparison

Cell	Primary	Ni-Cad	NiMH	Li-Ion	Lead Acid	Rechargeable Alkaline
Recharge	No	Yes	Yes	Yes	Yes	Yes
Cost	X	XX	XXX	XXXXX	XX	X
Capacity	XXXXX	XX	XXX	XXXX	XXXX	XXXXX
Life	1	3000+	1000+	500+	3000++	25-
Energy	XXXXX	X	X	XXXXX	XX	XXXXX
Charge	N/A	Easy	Easy	Difficult	Easy	Difficult
Voltage	1.51	1.20	1.20	3.60	2.00	1.50

Using this information, and taking cost as the dominant factor, for the prototype at least the most favourable choice is NiMH. This is suitable for the voltage and the current requirements. The best solution is to make a pack of 10 1.2V cells.

6.3 Charging and Discharging the Battery

As mentioned before, the key to a reliable system especially for a wearable system is careful charging.

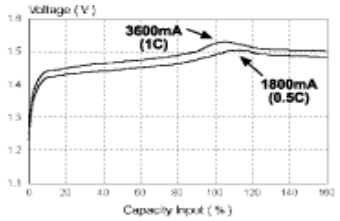
6.3.1 Cell Data Sheet

GP Batteries

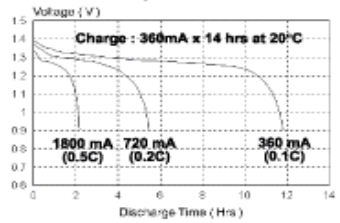
Data Sheet ***Model No.: GP360AFH***

Type	:	Rechargeable Nickel Metal Hydride Cylindrical Cell
Nominal Dimension (with Sleeve)	:	Φ = 17.5 $^{+0}_{-0.5}$ mm H = 66.7 $^{+0}_{-3}$ mm
Applications	:	Recommended discharge current 360 to 10800mA
Nominal Voltage	:	1.2V
Nominal Capacity	:	3600 mAh when discharge at 720 mA to 1.0V at 20°C
Charging Condition	:	360mA for 14 hrs at 20°C
Fast Charge	:	1800mA to 3600 mA (0.5C to 1C) with charge termination control Recommended control parameters: -ΔV : 0 - 5 mV dT/dt : 0.8°C/min (0.5C to 0.9C) : 0.8 - 1°C/min (1C) TCO : 45 - 50°C Timer : 105% nominal input
Service Life	:	>500 cycles (IEC standard)
Continuous Overcharge	:	360 mA maximum permissible current No conspicuous deformation and/or leakage
Weight	:	53 g
Internal Resistance	:	Average 17 mΩ upon fully charged range 15 - 25 mΩ at 1000 Hz
Max. Charging Voltage	:	1.5V at 360 mA charging
Ambient Temperature Range	:	Standard Charging : 0°C to 45°C Fast Charging : 10°C to 45°C Discharging : -20°C to 50°C Storage : -20°C to 35°C

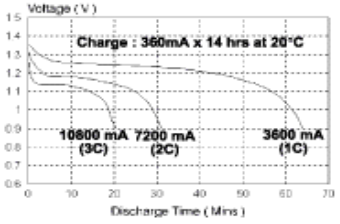
Fast Charge (Charge control required)

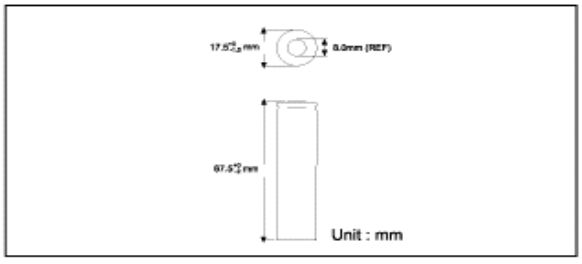


Low Rate Discharge



High Rate Discharge





* The information (subject to change without prior notice) contained in this document is for reference only and should not be used as a basis for product guarantee or warranty. For applications other than those described here, please consult your nearest GP Sales and Marketing Office or Distributors.

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Manufacturer reserves the right to alter or amend the design, model and specification without prior notice. *CRS3239 REV.03*

[8]

[8] Data Sheet from www.gpbatteries.com

6.3.2 Data sheet analysis

Size

From the data sheet, these cells are cylindrical measuring 67.5x17.5 This makes them quite small and a battery pack could be formed either by having 2x5 or 1x10 configuration.

Longevity

Remember, we need 12V at about 800mA. The recommended discharge rate of these cells is 360 to 10800 mA, so for our application, the cell is quite suitable, and would be well treated. Infact a curve is shown for our application at about 720mA (O.2C) showing a discharge time in the region of 5 Hours. The cells are guaranteed to meet the IEC standard of 500 Cycles, infact, with proper care many more should be expected.

6.3.3 Charging

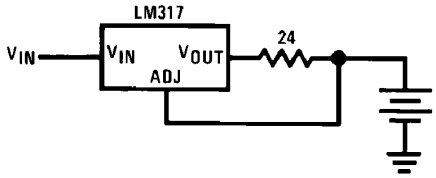
Most systems come with their own charging systems. Some better than other, most don't really take care of the batteries, because the average consumer wants a battery to last as long as possible, and charge in the minimum time possible. These two requirements are not compatible; a slow long charge of 14 Hours will see a very high capacity battery charged to the full, and a long service life. A short fast charge, both increases the temperature and the stress on the cell whilst diminishing its capacity and lifetime. Tempting, as it is, to construct a fast charger, damage will result unless the designer is very careful, for overcharge at the fast charge rate will kill the batteries in a few charges. The best method is to use constant current charging. This is best done at the maximum overcharge current.

Because of the way the cells are designed, protection is allowed for a certain maximum overcharge this is where the cell can dissipate the excess energy as heat without 'major' damage to the cell. For this cell, 360mA can be used to charge the cell and overcharge will be tolerated.

6.3.4 Charging Circuit

As stated in the previous section, the best method, and indeed the simplest method to charge the battery is by using a constant current.

50 mA Constant Current Battery Charger



TL/H/9063–27[9]

A simple circuit, such as that shown above can be constructed for virtually no cost. It will ensure the batteries will be charged both safely.

The only component value that needs to be obtained is that of the resistor. The LM317T is a linear regulator that can be used to regulate voltage or current. In this application, it drops excess voltage and keeps the voltage across the resistor constant, thus keeping the current at a fixed value. The formula is:

VRef/R = Current	So
R=VRef/Current	Given Current=360mA and VRef= 1.25V (From data sheet)
R=3.47 Ohms.	Nearest value = 3.3 Ohms

The only item to watch now is the power dissipation;

$$P = I^2R = 0.36^2 \times 3.3 = 0.428 \text{ Watts}$$

Thus, a ½ W resistor is adequate. The input voltage is not an issue provided it is a few Volts higher than the battery voltage, and not so high that the LM317T is getting too hot. Since the data sheet says that the voltage of the cell should not be more that 1.5V that makes 15V for the battery as one unit, 1.25 - 1.5 Volts for the resistor + 1 Volt for any current monitoring means at least 17.5 – 18 Volts.

[9] From LMx17 data sheet National Semiconductor May 1996 www.national.com

7.0 Enclosure Details

7.0 Glossary

It is not the intention of the author to produce a complete computer industry jargon list, but it is favourable to include definitions of any jargon that may be included in or is related to this document.

Keyword	Meaning
ACPI	Advanced Configuration & Power Interface, a standard that supersedes and combines both APM and Plug & Play. This standard is not fully supported by any hardware or software at this time. There is some support with Win98 and almost complete support with Win2K
API	Application Programming Interface; an interface through which applications may communicate with the system at a lower level. Win32 API represents an interface through which windows may be created, files manipulated etc.
APM 1.0	Advanced Power Management; A standard PC's use to manage power consumption.
APM 2.0	As APM 1.0 but with enhancements such as under-clocking and battery status enquiry.
BIOS	Basic Input Output System; The first block of code that is executed by the system to tell it how to talk to basic devices such as the HDD and Keyboard Display etc. BIOS's nowadays can handle more complex operations such as power management and PNP options.
BUS	A collection of wires in parallel along which data travels.
CCD	Charge Coupled Device; An array of light sensitive cells used to create pictures. CCD's are the standard for home video cameras, scanners and CCTV's etc.

CMOS Complementary Metal-Oxide Semiconductor; a form of RAM that requires very little current because there is never a conducting path from ground to supply.

COM COMmunications I/O port. Usually RS-232 standard of 9 or 25 pin connector. A standard for serial communication of any speed and format up to 115,200 bps.

CPU Central Processing Unit; The CPU is the general-purpose component that does most of the computation in a PC. Other devices such as graphics and soundcards now have their own CPU's, rather ironically they can be faster that the main CPU!

CRT Cathode Ray Tube; Description of a standard monitor as opposed to a flat panel screen.

DMA Direct Memory Access, a peripheral has the ability to dump its output directly into or out of memory without the main CPU. This gives a great increase of speed.

DOS Disk Operating System; the operation system that is loaded from a disk.

DRAM Dynamic RAM; See RAM, used for the system memory.

EEPROM Electrically Erasable Programmable Read Only Memory. ROM that actually can be updated if required such as a BIOS.

EL Electro Luminescent; Production of light by electrical stimulation of chemicals. The idea was stolen from nature.

EMC ElectroMagnetic Compatibility; Systems are so fast today that problems can be caused due to both their susceptibility and their EMI emissions.

EMI ElectroMagnetic Interference; Caused by high frequency switching along wires.

ETHERNET	A network type. Describes a system used for communication with other machines in the locality.
FLASH	A variant on EEPROM, it is the same only its performance is better and programming is faster.
FPU	Floating Point Unit. This additional part allows floating point operations to be speeded up by using Floating Point dedicated hardware. FPU's are built-in to processors since the 486DX.
HDD	Hard Disc Drive; large non-volatile storage device.
I^2C	A communications protocol and system for inter-device communication.
IDE	Integrated Drive Electronics; A standard by which the HDD looks after most of its own operations.
IRQ	Interrupt ReQuest line; There are 16 IRQ's in a PC, they are for hardware devices to interrupt the CPU so that it can respond to them.
ISA	Industry Standard Attachment; Interface to the standard AT bus.
JPEG	Joint Picture Experts Group, a form of compression of bitmaps. The compression describes the contents of the image rather than each individual pixel. This provides very significant savings in storage at the expense of much higher demands on processing for compression and de-compression. Since the format relies on encoding descriptions rather than specifics, a picture with high detail such as sharp edges is liable to noticeable artefacts.
LAN	Local Area Network.
LCD	Liquid Crystal Display.
LEP	Light Emitting Polymer; Technology to produce screens

LPT — paralLel PorT; for printers or other such devices require low to medium speed communication to the host PC.

MJPEG — Motion JPEG (jay-peg) is a standard that reduces video bit rates by encoding each frame as a JPEG. This offers significant savings in storage space, and is often performed in real time on today's machines. This helps to reduce the effect on video performance by waiting for storage devices.

MMX — Matrix Math eXtensions; Quickly changed to Multi Media Extensions by Intel for marketing reasons, these extra 57 instructions to the x86 architecture allow for much faster processing of matrix based operations hence giving a big boost for Multi-Media image manipulation.

MPEG — Motion PEG, is a method of reduction as with MJPEG but with the added benefit that it only encodes the differences from one frame to the next. This offers a much reduced bit rate but requires a powerful system to implement in real-time since it requires the storage of many frames and motion prediction to be of any use. MPEG has a fixed bit rate that has difficulty in noisy or fast moving scenes since the whole picture is moving.

MPEG II — An advanced version of MPEG that has a higher bit rate and can be used at many different sizes. An MPEG II supports interlaced video and has many layers that can be used to encode lots of soundtracks or subtitle information. Due to its higher bit rate the picture quality is very good, and this has been used for many video applications such as CATV, Digital TV and Satellite and DVD.

NIC — Network Interface Card; The card that connect the computer to a network.

NOS — Network Operating System.

NVRAM — Non-Volatile RAM.

OS	Operating System; software on a system that handles the gap between the software and the hardware/system BIOS, usually produces and environment in which to run applications.
OVERLAY	An overlay surface is a portion of Video RAM other than that being used to for the main display. Video cards that support overlay can show this portion of video memory in a window on the primary surface. This gives the advantage of allowing other devices to fill this RAM such as a video digitiser or an MPEG decoder card. Video cards that support overlay can usually perform colour space conversion on the overlay surface, which leads to stretching of the window without any impact on performance at all.
PC/104	Personal Computer, single board with a bus connector of 104 pins.
PC/104plus	As with the PC/104 but with the addition of a PCI bus connector.
PCI	Peripheral Component Interface; A high-speed bus that is separate from the AT bus.
Pentium	586 Processor, ‘Pent’ meaning 5.
Pentium Pro	686 Processor designed for accelerating 32 bit operations.
Pentium II	686 Hybrid, offering higher performance for 16 and 32 bit instructions. Available in many flavours, including Celeron which has no cache, the Celeron 128 that has 128k cache, Celeron 370 which is a different shape for mobile and low cost systems.
Pentium III	still a 686 since the only difference is extra instructions that allow the use of the FPU and MMX at the same time, thus increasing speed, since the P II uses the same registers for both which is slow, because they need to be purged.

PNP	Plug aNd Play; a system by which the BIOS detects devices and automatically assigns memory I/O and IRQ's automatically so they can be detected and installed automatically under PNP OS's.
PSU	Power Supply Unit; A module that performs power conversion to produce power suitable for the Main Board.
RAM	Random Access Memory; the system's working memory, this memory is volatile, which means that it is lost when the power is disconnected.
RFI	Radio Frequency Interference. See EMI and EMC.
ROM	Read Only Memory; Memory that cannot be changed and that can only be read.
RTC	Real Time Clock; An area of memory that is constantly updated with the current system time, even when the power is off.
SFI	Special Function Interface; an interface for fiddling many custom aspects of the motherboard.
STN	Super Twist Nematic; A passive matrix flat panel LCD screen.
TFT	Thin Film Transistor; An active flat panel LCD screen.
UDMA	Ultra DMA, where an IDE device can move data at twice the rate of conventional devices. (See DMA)
VGA	Video Graphics Array; Separately driven Red Green Blue colours on a display such as a monitor. As opposed to composite Video where all colours and chrominance is encoded on a single wire, hence limiting the bandwidth and hence the maximum resolution.
VRAM	Video RAM, Fast access ultra wide RAM for high performance 2D video applications.

WIN32 32 bit operating system based on the WIN32 API such as Win95, Win98, WinNT3.51, WinNT4 or Win2K.

X86 The X86 architecture has been the standard PC processor architecture for some time. There have been many generations of this processor, but processors from 386 upwards have really allowed PC's to become very powerful due to the way it handles memory. Further generations usually add instructions, pipelining and processing extensions, such as MMX, FPU etc. Giving roughly double the performance with each enhancement.

8.0 References

1,3 Ampro Computers Incorporated, http://www.ampro.com/forum/wpapers/i104p.htm

2 PC/104 Specification Version 2.3 June 1996 – The PC/104 Consortium