

# Mini-ITX Power Solutions

Micro DC-DC Converters  
&  
Automotive Applications

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v,1.1 07/14/2003 ab

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## Introduction

This article covers a series of mini-ITX micro power supply solutions focusing on operating VIA's mini-ITX boards in car environments. To be more precise, the ITPS power sequencer and regulator are described in greater detail. Such power sequencer devices are vital in automotive applications. Also, the article covers some Compact Flash embedded solutions, suitable for environments where high vibrations and low power consumptions are a must.

Several schematics, and the micro-controller code are being released as Open Source for the Mini-ITX community. We hope this will shed some light onto one of the most interesting and challenging computing areas, the general-purpose automotive computing.

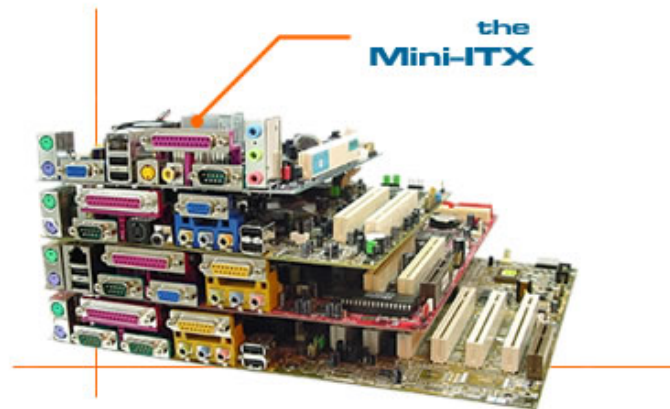
First, for the readers that are unfamiliar with the mini-ITX products, here is a brief introduction.

## ITX, the Ultimate Form Factor

In late 1999, Via Technologies took the computing industry by storm with the introduction of the mini-ITX form factor motherboards. The Mini-ITX main board is the ideal platform for an almost unlimited variety of Extreme Value PC, Information Appliance, Set Top Box, Personal Video Recorders, and Industrial PC designs. By using high level of integration previously available only in embedded computers, and the ultra low power x86 processors VIA was able to break through several frontiers at once:

### The mini-ITX Form Factor

Measuring just 170 x 170 mm<sup>2</sup>, the mini-ITX is the smallest mass produced.



*Fig 1.0 - The Mini-ITX form factor*

## Low Power Consumption

Consuming only 10 W, the EPIA boards broke the x86 power consumption records, while running cooler than ever. For more information on power consumption measurements, please see the Power Consumption Charts chapter.

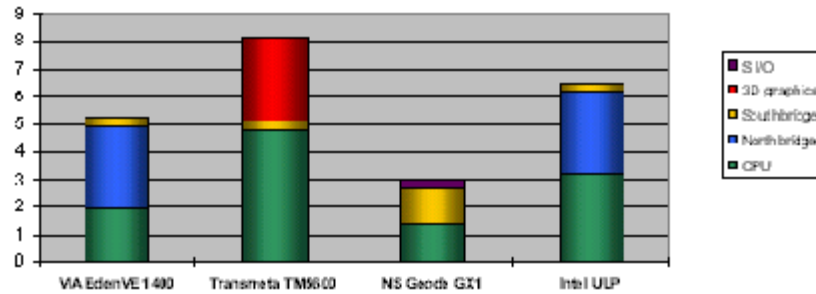


Fig 1.1 - Power consumption chart

### Performance

While reducing the footprint of a motherboard, performance of a motherboard usually decreases. However, this is not the case with VIA's mini-ITX mainboards. By providing high levels of integration, the Mini-ITX boards often challenge and in some cases exceed the performance of full sized motherboards. Overall, VIA's "Per Clock" clock performance is better than that of world's leading CPU manufacturer.

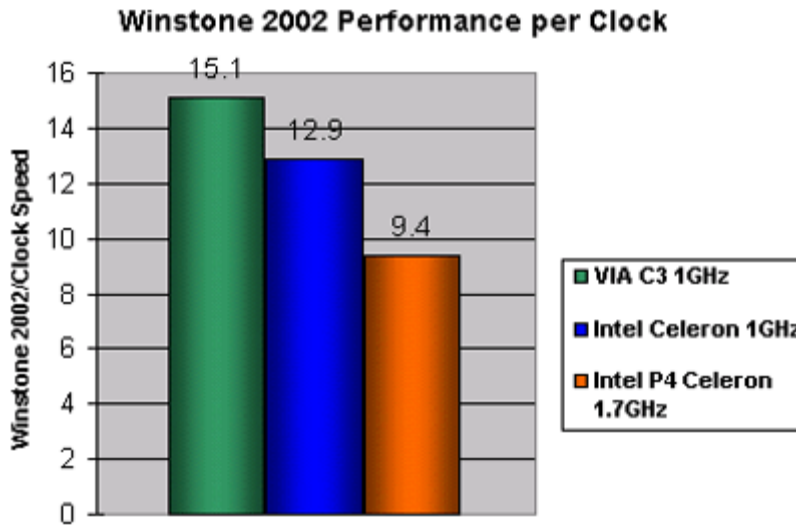


Fig 1.2 - Winstone Performance per Clock

### Embedded or Consumer PCs?

While Intel's and AMD's processors are getting bigger and hotter and National's Geode is stagnating at about 300Mhz, VIA's x86 CPUs are getting smaller, faster and cooler, thus providing a real solution for today's challenging computing environments. Consumer PC OEMs and system Integrators love it. The embedded projects developers love the Mini-ITX platform for its flexibility, low cost and low power requirements.

In an unprecedented move, VIA technologies is blurring the line between the worlds of consumer PCs and embedded systems. Both worlds benefit from this move (smaller, better PCs and embedded systems at very low costs).

## Power Requirements for Small Computer Design

Along with availability of low-power processors and main boards, one of the main challenges of building a small computer is peripheral size and power consumption. The computer industry has provided many solutions in the storage arena such as miniature 2.5" Hard Drives, Slim-CD CDROMs and DVDROMS and lately Compact Flash disk storage solutions used to store operating systems and content. For more information on Compact flash adapters, please see the final portion of this article.

NOTE: If you are planning to develop a car PC application, use 2.5" disk drives, as they are rated for greater shock protection and lower power consumption. While the cost per MB on a 3.5" might seem appealing, keep in mind that 3.5" drives are not designed for mobile applications.

## Peripherals Power Facts

**Q)** How much power does a 7200 RMP drive needs?

**A)** A 7200 RPM drive consumes 10-15 W, mostly from the 12 V rail. A 5400 RMP drive consumes less. Please refer to the manufacturer product spec for detailed power consumption charts. If you plan on using multiple 3.5" drives, use the PW-60a and the PW-70a dc-dc converters. See more information below.

**Q)** How much power does a laptop drive consume?

**A)** Peak power consumption is only 5 W with an average power consumption of 2.5 W. All dc-dc adapters can handle laptop drives.

**Q)** How about CD-ROMS and DVD-ROMS and slim-CDs?

**A)** Depending on CD-ROM type, your unit can consume anywhere between 5 and 20 W. Very fast CDROMS (48X) tend to draw a lot of power from the 12 V rail at spin-up time. Slim-CDs consume an average of 5 W. When not in use, the power consumption drops to 0.1 W.

**Q)** How about USB devices?

**A)** Usually USB devices consume 5 W or less by design. If more power is required by the device, an external adaptor is used.

**Q)** What is the power consumption of a CF disk?

**A)** Less than 0.5 W! CF disk are ideal for embedded applications. See the "Compact Flash to IDE" section of this article for more information on Compact Flashes.

**Q)** What is the power consumption of an 2x20 or 2x16 LCD display?

**A)** Depending on model and type, the power consumption is less than 2.5 W. Larger LCD displays tend to consume more power.

## PSU, the Ultimate Challenge for Small PCs

While hard drives, CDROMS and Flash storage units are getting smaller, power supplies seem to lag behind in the small footprint race. Higher power required by faster processors have driven the power supply industry into a race for bigger and more powerful solutions.

With the introduction of the mini-ITX platform, the power requirements have dropped, but the power supply size remained the same. Fig 1.3 shows a typical ATX power supply with dimensions of W150 x H86 x D140 (mm). As you can see, this power supply is almost as big as the mini-ITX board!

Carefully look at the EPIA-M main board. See the green 'snap-in' module? This is the PW-70 micro power supply from mini-box.com. Find below for more information.



Fig 1.3 - Typical ATX power supply next to an EPIA-M with a micro PSU.

### The ATX Power Supply Standard

The ATX power standard provides manufactures with a way to use the same power supplies across many main board designs. All mother board manufacturers and power supply companies agreed on this particular standard. The latest addition to the ATX power standard was made in early 2002 (ATX power standard version 1.2). A special 12 V power connector (see +12 V power connector) was introduced so that it can deliver more power for P4 (ATX12 V). A dc-dc power supply design must follow the ATX power standards.

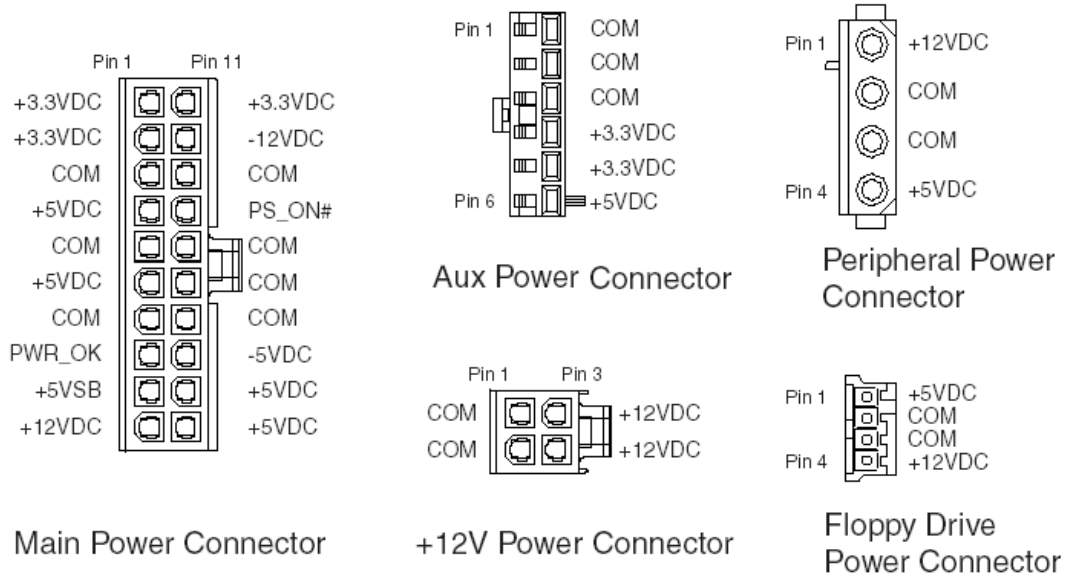


Fig 1.4 - ATX connector and voltages.

## Power Rails Description

All ATX power supplies have several power outputs. Please see below a matrix indicating the uses for each power rail along with comments related to the power consumption.

Rail	Circuit Type	Board Type	Comments
+12 V	3.5", 5.25 motors, fans, P4 power	Mostly P4 boards (lots of power), FET drive on all boards (little power).	Use PW-60a or PW-70a only when using 3.5" drives or P4s.
+ 5 V	General M/B and disk circuitry, memory, laptop drive motors.	All Boards	All our DC-DC converters have adequate power on this rail
+ 3.3 V	CPU core, memory	EPIA-5000, 800, V, M-1000, M-2, CL, etc	PW-60/PW70 DC-DC converters have adequate power on this rail in all cases.
-12 V	Some (older) serial ports chipsets	EPIA-M, EPIA-M2 (EPIA-5000/800/V does not use the -12 V for serial ports)	Check the serial driver chipset. Modern serial chipsets do not use the -12 V rail.
- 5 V	Obsolete	NONE	No longer needed on any boards.
+5 V SB	Memory, vital sleep functions.	ALL	Uses little power.

## Power Consumption Charts

The EPIA boards consume different amounts of power in different situations. When idle, the boards consume little power, when in use by highly demanding applications they tend to consume more. Please see below the power consumption charts for various mini-ITX boards.

Hint: It seems that the mini-ITX boards consume the most power when the computer is in the BIOS administration pages. Do not ask why this happens, it is a fact! If you want to check the thermal design of your enclosure without having to run intensive applications, just put your PC in the BIOS mode.

To measure the total power consumption of your system, connect a digital Amp Meter in series with the 12 V in of your DC-DC power converter. (Do not try to measure the current consumption of your AC power supply as this operates at high voltages). Multiply the reading from your Amp Meter and multiply it by 12 to get the total power consumption. For example, if your EPIA-5000 current consumption is 0.7 A, then the total power consumption is 8.4 W.

EPIA 5000 Power Consumption				
<b>Playing DVD</b>				
Nominal Voltage	Actual Voltage, $V_A$	Actual Current, I	Power, $P = V_A \times I$	
+3.3 V	3.37 V	2.43 A	8.19 W	
+5 V	4.97 V	1.21 A	6.01 W	
5 V SB	5.04 V	0.038 A	0.19 W	
+12 V	12.28 V	0.064 A	0.79 W	
<b>Total Power: 15.18 W</b>				
<b>Playing MP3</b>				
Nominal Voltage	Actual Voltage, $V_A$	Actual Current, I	Power, $P = V_A \times I$	
+3.3 V	3.37 V	2.01 A	6.77 W	
+5 V	4.97 V	1.15 A	5.72 W	
5 V SB	5.04 V	0.038 A	0.19 W	
+12 V	12.28 V	0.065 A	0.80 W	
<b>Total Power: 13.18 W</b>				
<b>Running Network Applications</b>				

Nominal Voltage	Actual Voltage, $V_A$	Actual Current, I	Power, $P = V_A \times I$
+3.3 V	3.37 V	1.80 A	6.07 W
+5 V	4.97 V	0.86 A	4.27 W
5 V SB	5.04 V	0.038 A	0.19 W
+12 V	12.28 V	0.064 A	0.79 W
<b>Total Power: 11.32 W</b>			
<b>Idle</b>			
Nominal Voltage	Actual Voltage, $V_A$	Actual Current, I	Power, $P = V_A \times I$
+3.3 V	3.37 V	1.64 A	5.53 W
+5 V	4.97 V	0.63 A	3.13 W
5 V SB	5.04 V	0.038 A	0.19 W
+12 V	12.28 V	0.064 A	0.79 W
<b>Total Power: 9.64 W</b>			
<b>Running Office Applications</b>			
Nominal Voltage	Actual Voltage, $V_A$	Actual Current, I	Power, $P = V_A \times I$
+3.3 V	3.37 V	2.016 A	6.79 W
+5 V	4.97 V	1.22 A	6.06 W
5 V SB	5.04 V	0.038 A	0.19 W
+12 V	12.28 V	0.065 A	0.80 W
<b>Total Power: 13.84 W</b>			

EPIA 800 power consumption			
Playing DVD			
Nominal Voltage	Actual Voltage, $V_A$	Actual Current, I	Power, $P = V_A \times I$
+3.3 V	3.37 V	2.43 A	8.19 W
+5 V	4.90 V	2.07 A	10.14 W
5 V SB	4.95 V	0.52 A	2.57 W
+12 V	12.54 V	0.11 A	1.38 W
<b>Total Power: 22.29 W</b>			
Playing MP3			
Nominal Voltage	Actual Voltage, $V_A$	Actual Current, I	Power, $P = V_A \times I$
+3.3 V	3.37 V	1.99 A	6.71 W
+5 V	4.90 V	1.71 A	8.38 W
5 V SB	4.95 V	0.41 A	2.03 W
+12 V	12.54 V	0.107 A	1.34 W
<b>Total Power: 18.46 W</b>			
Running Network Applications			
Nominal Voltage	Actual Voltage, $V_A$	Actual Current, I	Power, $P = V_A \times I$
+3.3 V	3.37 V	1.88 A	6.34 W
+5 V	4.90 V	1.13 A	5.54 W
5 V SB	4.95 V	0.23 A	1.14 W

+12 V	12.54 V	0.105 A	1.32 W
<b>Total Power: 14.33 W</b>			
Idle			
Nominal Voltage	Actual Voltage, $V_A$	Actual Current, I	Power, $P = V_A \times I$
+3.3 V	3.37 V	1.57 A	5.30 W
+5 V	4.90 V	0.74 A	3.63 W
5 V SB	4.95 V	0.11 A	0.54 W
+12 V	12.54 V	0.105 A	1.32 W
<b>Total Power: 10.78 W</b>			
Running Office Applications			
Nominal Voltage	Actual Voltage, $V_A$	Actual Current, I	Power, $P = V_A \times I$
+3.3V	3.37 V	1.85 A	6.23 W
+5V	4.90 V	2.05 A	10.05 W
5VSB	4.95 V	0.49 A	2.43 W
+12 V	12.54 V	0.107 A	1.34 W
<b>Total Power: 20.05 W</b>			



EPIA M E6000 power consumption			
Playing DVD			
Nominal Voltage	Actual Voltage, V <sub>A</sub>	Actual Current, I	Power, P = V <sub>A</sub> x I
+3.3 V	3.37 V	3.36 A	11.32 W
+5 V	4.92 V	1.69 A	8.33 W
5 V SB	5.02 V	0.14 A	0.70 W
+12 V	12.40 V	0.164 A	2.03 W
			<b>Total Power: 22.39 W</b>

Playing MP3			
Nominal Voltage	Actual Voltage, V <sub>A</sub>	Actual Current, I	Power, P = V <sub>A</sub> x I
+3.3 V	3.37 V	3.06 A	10.31 W
+5 V	4.92 V	1.50 A	7.40 W
5 V SB	5.02 V	0.14 A	0.70 W
+12 V	12.40 V	0.164 A	2.03 W
			<b>Total Power: 20.44 W</b>

Running Network Applications			
Nominal Voltage	Actual Voltage, V <sub>A</sub>	Actual Current, I	Power, P = V <sub>A</sub> x I
+3.3 V	3.37 V	2.99 A	10.08 W
+5 V	4.92 V	1.08 A	5.37 W
5 V SB	5.02 V	0.14 A	0.70 W
+12 V	12.40 V	0.163 A	2.02 W
			<b>Total Power: 18.17 W</b>

Idle			
Nominal Voltage	Actual Voltage, V <sub>A</sub>	Actual Current, I	Power, P = V <sub>A</sub> x I
+3.3 V	3.37 V	2.79 A	9.40 W
+5 V	4.92 V	0.83 A	4.09 W
5 V SB	5.02 V	0.14 A	0.70 W
+12 V	12.40 V	0.162 A	2.01 W
			<b>Total Power: 16.21 W</b>

Running Office Applications			
Nominal Voltage	Actual Voltage, V <sub>A</sub>	Actual Current, I	Power, P = V <sub>A</sub> x I
+3.3V	3.37V	3.10A	10.447W
+5V	4.92V	1.77A	8.7261W
5VSB	5.02V	0.14A	0.7028W
+12 V	12.40V	0.164A	2.0336W
			<b>Total Power: 21.9095W</b>

EPIA M 9000/10000 power consumption			
Playing DVD			
Nominal Voltage	Actual Voltage, V <sub>A</sub>	Actual Current, I	Power, P = V <sub>A</sub> x I
+3.3 V	3.37 V	3.38 A	11.39 W
+5 V	4.89 V	2.52 A	12.32 W
5 V SB	5.02 V	0.14 A	0.70 W
+12 V	12.51 V	0.164 A	2.05 W
			<b>Total Power: 26.47 W</b>
Playing MP3			
Nominal Voltage	Actual Voltage, V <sub>A</sub>	Actual Current, I	Power, P = V <sub>A</sub> x I
+3.3 V	3.37 V	2.98 A	10.04 W
+5 V	4.89 V	2.05 A	10.02 W
5 V SB	5.02 V	0.14 A	0.70 W
+12 V	12.51 V	0.162 A	2.03 W
			<b>Total Power: 22.79 W</b>
Running Network Applications			
Nominal Voltage	Actual Voltage, V <sub>A</sub>	Actual Current, I	Power, P = V <sub>A</sub> x I
+3.3 V	3.37 V	2.92 A	9.84 W
+5 V	4.89 V	1.35 A	6.60 W
5 V SB	5.02 V	0.14 A	0.70 W
+12 V	12.51 V	0.161 A	2.01 W
			<b>Total Power: 19.16 W</b>
Idle			

Nominal Voltage	Actual Voltage, V <sub>A</sub>	Actual Current, I	Power, P = V <sub>A</sub> x I
+3.3 V	3.37 V	2.73 A	9.20 W
+5 V	4.89 V	0.98 A	4.79 W
5 V SB	5.02 V	0.14 A	0.70 W
+12 V	12.51V	0.161 A	2.01 W
<b>Total Power: 16.71 W</b>			
Running Office Applications			
Nominal Voltage	Actual Voltage, V <sub>A</sub>	Actual Current, I	Power, P = V <sub>A</sub> x I
+3.3 V	3.37 V	3.12 A	10.51W
+5 V	4.89 V	2.51 A	12.27W
5 V SB	5.02 V	0.14 A	0.70W
+12 V	12.51 V	0.163 A	2.04W
<b>Total Power: 25.53W</b>			

Intel 845 chipset-based main board - Pentium 4 1.8G power consumption			
Playing DVD			
Nominal Voltage	Actual Voltage, V <sub>A</sub>	Actual Current, I	Power, P = V <sub>A</sub> x I
+3.3 V	3.37 V	2.82 A	9.50 W
+5 V	5.06 V	0.77 A	3.90 W
5 V SB	5.04 V	0.058 A	0.29 W
+12 V	11.96 V	0.179 A	2.14 W
CPU 12 V	11.99 V	3.10 A	37.17W
<b>Total Power: 53.00 W</b>			
Playing MP3			
Nominal Voltage	Actual Voltage, V <sub>A</sub>	Actual Current, I	Power, P = V <sub>A</sub> x I
+3.3 V	3.37 V	2.62 A	8.83 W
+5 V	5.06 V	0.77 A	3.90 W
5 V SB	5.04 V	0.058 A	0.29 W
+12 V	11.96 V	0.179 A	2.14 W
CPU 12 V	11.99 V	2.015 A	24.16 W
<b>Total Power: 39.32 W</b>			
Running Network Applications			
Nominal Voltage	Actual Voltage, V <sub>A</sub>	Actual Current, I	Power, P = V <sub>A</sub> x I
+3.3 V	3.37 V	2.55 A	8.59 W
+5 V	5.06 V	0.77 A	3.90 W
5 V SB	5.04 V	0.058 A	0.29 W
+12 V	11.96 V	0.18 A	2.15 W
CPU 12 V	11.99 V	0.91 A	10.91 W
<b>Total Power: 25.85 W</b>			
Idle			
Nominal Voltage	Actual Voltage, V <sub>A</sub>	Actual Current, I	Power, P = V <sub>A</sub> x I
+3.3 V	3.37 V	2.53 A	8.53 W
+5 V	5.06 V	0.76 A	3.85 W
5 V SB	5.04 V	0.058 A	0.29 W
+12 V	11.96 V	0.18 A	2.15 W
CPU 12 V	11.99 V	0.796 A	10.91 W
<b>Total Power: 24.36 W</b>			
Running Office Applications			
Nominal Voltage	Actual Voltage, V <sub>A</sub>	Actual Current, I	Power, P = V <sub>A</sub> x I
+3.3 V	3.37 V	2.61 A	8.80 W
+5 V	5.06 V	0.77 A	3.90 W
5 V SB	5.04 V	0.058A	0.29 W
+12 V	11.96 V	0.178 A	2.13 W
CPU 12 V	11.99 V	4.67 A	55.99 W
<b>Total Power: 71.11 W</b>			

## DC-DC Converters

Another alternative to traditional ATX power supplies is the use of several DC-DC converters to provide power to all the necessary rails from a single input, usually running at 12 V. This is not a new concept, laptop computers have been using DC-DC converters for a long time.

However, with the introduction of low power mini-ITX boards DC-DC conversion is the natural choice, especially when the designer does not have enough room for a traditional ATX power supply.

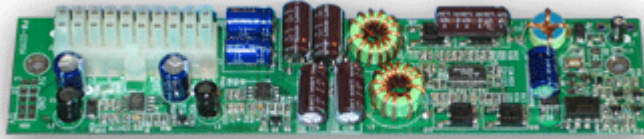
Another advantage of using DC-DC converters is that they are 100% silent. The internal oscillators of a DC-DC converter operate at 300-600Khz, therefore they do not produce any audible noise. By using highly efficient 'step down' BUCK converters (linear regulators are very inefficient), the heat dissipation is small. For example, a 60 W DC-DC converter does not require any active cooling and it can operate at 40-50 Celsius with no heat sinks.

A single 12 V input is used to step down to 3.3, and 5 V and invert to -12 V and -5 V (if needed). Also, 5 V SB power is provided for sleep functions. The 12 V output can be regulated by boosting 5 V to 12 V or simply switching ON/OFF with a P-channel FET (see below for more information on car applications).

There are several DC-DC converter manufacturers. However, the DC-DC converters developed by mini-box.com are designed specifically for the VIA mini-ITX boards:

A unique snap-in daughter-board design allows you to plug the DC-DC converter directly into the mother board's ATX connector, thus reducing space and not using the messy ATX power cable extenders. At this time, mini-box.com provides 2 types of snap-in power modules. The PW-60 was designed for the EPIA-5000, EPIA-800, EPIA-V while the PW-70 was designed for the EPIA-M form factor.

These DC-DC ATX power converters operate from 12 V and are highly efficient. Applications range from portable to automotive and small form factor embedded robotics, or solar powered computer systems.



*Fig 1.5 - PW-60 snap-in micro PSU from mini-box.com*

The PW-60 snaps in the ATX connector. Enough clearance is provided for the IDE0 and IDE1 hard disk sockets. The total mini-ITX and PW-60 assembly was designed to be under 1U (1.75") so that it can fit in rack mounted equipment. More information regarding PW-60 can be found at <http://www.mini-box.com>

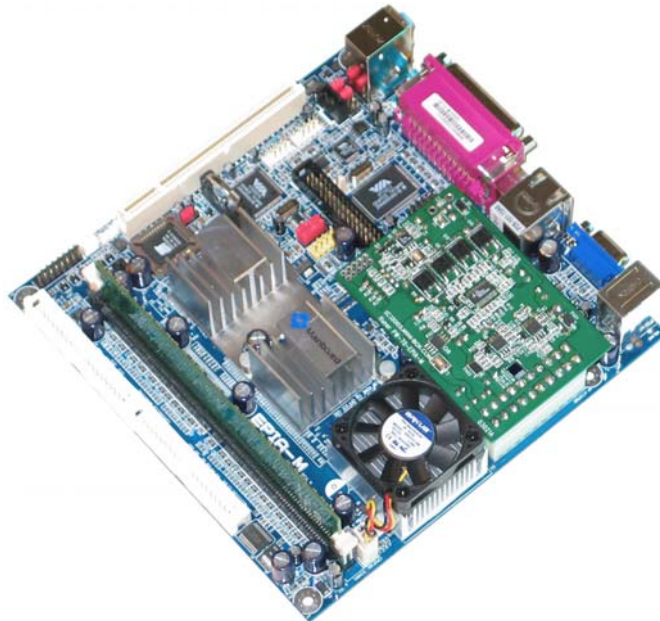


*Fig 1.6 - PW-60 snapped into an EPIA-800 board*



*Fig 1.7 - PW-70 designed for EPIA-M series*

The PW-70 snaps into the ATX connector of an EPIA-M, fitting in between the CPU and the back connectors. The PW-70 is a credit card sized power supply and it is the smallest DC-DC snap-in ATX power supply in the market. Details about PW-70 can be found at <http://www.mini-box.com>



*Fig 1.8 - PW-70 snapped into an EPIA-M board (in between CPU and keyboard connector)*

### **Power Solutions for Automotive Use**

This section describes in detail a *LDO regulator + power sequencer* design to be used with off the shelf DC-DC converters. Schematics and microcode are provided free of charge for readers' reference implementation without providing development support for designs incorporating them. However, fully working units along with car wiring kits are available from [mini-box.com](http://www.mini-box.com). Please visit <http://www.mini-box.com> for more details.

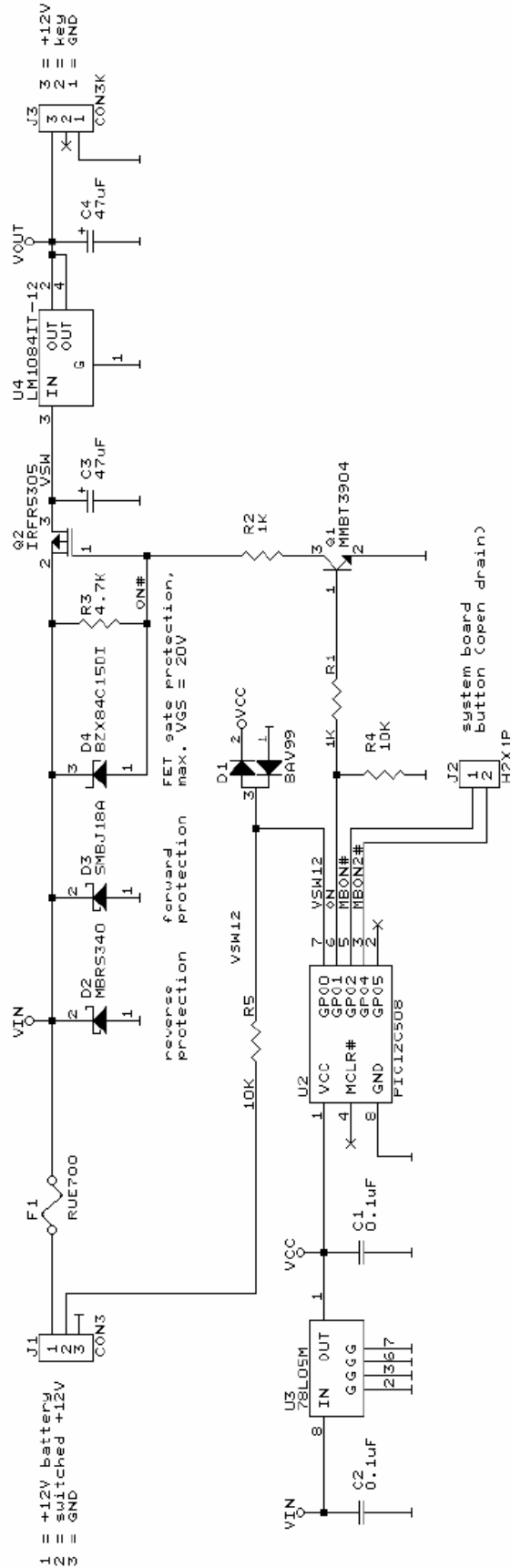


Fig 2.0

## ITPS Mode of Operation

Switched and un-switched battery goes into J1 via F1 (6A polyfuse). D2 and D3 provide reverse and forward protection. The power is controlled by U2 microcontroller (PIC 12C508). GPIO 1 controls the 12 V in via the Q1 and Q2 (power P-channel FET). GPIO 2/4 are connected to the Motherboard button (open drain) to turn OFF/ON the board. For more information on how the power sequencer works, see the “Power Sequencing” chapter.

The output of Q2 goes into U4, and the 12 V/5V LDO LM-1084-12 into your DC-DC converter. For more information on regulation, see “Regulation for Automotive Use”

Microcode and timing charts are available below.



Fig 2.1, ITOS photo (board size 120x16mm)

## Regulation for Automotive Use

While many DC-DC converters can operate directly from a 12 V source, it is a good idea to regulate the car 12 V output prior to applying it to the input of the DC-DC converter. Cars do have voltage regulation. However, in some instances the voltage can spike up as high as 18-20 V, activating over-voltage protection circuitry on the DC-DC converter as well as on your motherboard.

Since a typical car voltage is in between 13.4-14.5 V, an LDO (low dropout) regulator can be used to provide a clean 12 V output. Proper heat sinks must be used with LDO circuits. The power dissipation on the LDO regulator is

$$P_D = (V_{in} - V_{out}) \times I_{in},$$

where  $V_{in}$  is the input voltage,  $V_{out}$  is the 12 V regulated voltage, and  $I_{in}$  is the total current consumed by your mini-ITX board. Here is an example:

$$P_D = (13.8 \text{ V} - 12.0 \text{ V}) \times 2\text{A} = 3.6 \text{ W},$$

indicating that you do need a heat sink! Look up [www.digi-key.com](http://www.digi-key.com) for more information on TO-220 heat sinks. A good heat sink model used in the ITPS power sequencer project is Digi-Key HS104-2-ND – TO220 PWR CLR 1.45” 10 W.

The LDO used in this project is National's LM1084, 12 V 5A LDO regulator. For more information on this 3pin IC, check <http://power.national.com> or lookup Digi-Key LM1084IT-12-ND (U4).

Please note that in some transient situations, car battery voltages can drop below 9-10V, causing a reset of PW-60/PW-70. A simple way of preventing voltage dips is to have a small sealed acid battery in parallel with your un-switched battery terminals, isolated by a diode. The capacity of the SLA battery does not matter because these transient situations occur only for few seconds. A good example of a voltage dip situation is when leaving your car at the gas station with ignition turned on. When starting the car, the 12V source could drop below 10V.

### Power Sequencing

Another important design consideration for a car application is power sequencing. While the LDO regulator ensures that regulated power is fed into the PW-60 or PW-70 dc-dc converters, power sequencing is necessary to turn on, turn off and shut down the power in a predefined order. This design ensures that both soft and hard power shutdown signals are sent your motherboard and DC-DC converter so that your PC gracefully turns off. Also, the power will be cut off when the car is not running to prevent battery discharge. When the car is not running, the power sequencer is still on, consuming just few mW of power, far less that your alarm system or your radio.

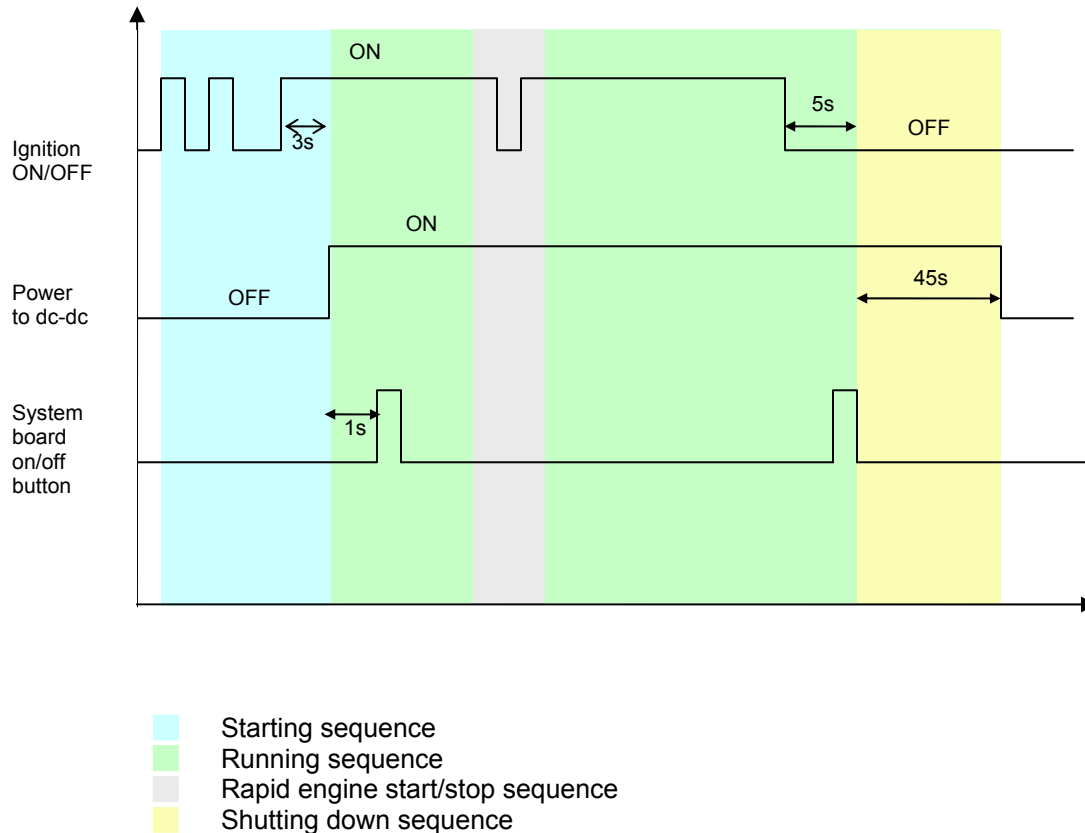


Fig 2.2 - Power sequencing diagram

The self-documented power sequencer assembler code is described in the ITPS Software box. To burn the software, you can use a Needhams EMP-21 programmer. The assembler used was a Microchip MPASM.



### ITPS Software

```

;
; Ituner power sequencer
;
; pd 030611 initial code

LIST    p=12C508A      ;Target processor
#include "P12C508A.INC" ;Header file for target processor

; GP0 = VSW12   input   1 = ignition turned on
; GP1 = ON      output  1 = turn power on
; GP2 = MBON#   o.d.    0 = power button pressed
; GP3 = n.c.    input
; GP4 = MBON2# o.d.     0 = power button pressed (parallel out,
;                makes connector flip-tolerant)
; GP5 = n.c.    output  0 = terminate unused pin

; Equates

PWR_OFF equ    0x00    ;power off state
PWR_ON  equ    0x02    ;power on state

SW_ON   equ    0x09    ;direction for switch on
SW_OFF  equ    0x1d    ;direction for switch off

ONDELAY equ    .15     ;power on delay 3 seconds
ONDELAY2 equ    .5      ;wait 1 second until push button
BUTTON  equ    .2      ;push button for 400 ms
OFFDELAY equ    .25     ;shut down 5 s after ignition off
HARDOFF equ    .25;&&&225 ;hard off after 45 seconds

; Register variables

cblock  0x10
        cntr    ;state counter
        cntr2   ;state counter
        waitl   ;delay counter low
        waitm   ;delay counter mid
        waitH   ;delay counter high
endc

; ORG 0x1FF ; processor reset vector
; Internal RC calibration value is placed at location 0x1FF by Microchip
; as a movlw k, where the k is a literal value.

; Reset entry

org     0

reset   movwf   OSCCAL ;set oscillator calibration

        movlw   PWR_OFF ;set initial state
        movwf   GPIO
        movlw   SW_OFF ;set pin directions
        tris    GPIO
        movlw   b'11001101' ;set option register (pg. 17)
        ;disable wake-up on GP pin change
        ;disable weak pull-ups
        ;timer0 internal clock, positive edge
        ;prescaler -> WDT, 1:32 -> ~0.5s

        option
        clrwdt ;clear watchdog

; initial state - wait until ignition is on for ONDELAY

initial movlw   ONDELAY ;initial power on
        movwf   cntr

initwait call    delay200 ;wait
        btfss  GPIO,0 ;ignition on ?
        goto   initial ;no: clear counter
        decfsz cntr,f ;initial time-out
        goto   initwait

; turn power on, wait ONDELAY2

```

```

turnon  movlw  PWR_ON
        movwf  GPIO
        movlw  ONDELAY2      ;wait for ONDELAY2
        movwf  cntr
turnon1 call  delay200      ;wait
        decfsz cntr,f
        goto  turnon1
        btfss  GPIO,0      ;ignition on ?
        goto  reset       ;no: turn off again

        ; push the system board power button

        movlw  SW_ON      ;push the button
        tris  GPIO
        movlw  BUTTON     ;wait for BUTTON
        movwf  cntr
button1 call  delay200      ;wait
        decfsz cntr,f
        goto  button1
        movlw  SW_OFF     ;release the button
        tris  GPIO

        ; power on state - shut down if ignition off for OFFDELAY

onstate movlw  OFFDELAY
        movwf  cntr
onstate1 call  delay200
        btfsc  GPIO,0      ;ignition on ?
        goto  onstate     ;yes: reset timer
        decfsz cntr,f
        goto  onstate1

        ; shut down - push the system board power button

        movlw  SW_ON      ;push the button
        tris  GPIO
        movlw  BUTTON     ;wait for BUTTON
        movwf  cntr
button2 call  delay200      ;wait
        decfsz cntr,f
        goto  button2
        movlw  SW_OFF     ;release the button
        tris  GPIO

        ; turn-off state - turn off power after HARDOFF
        ; go back to restart after ONDELAY

        movlw  HARDOFF
        movwf  cntr
        movlw  ONDELAY
        movwf  cntr2
shut1   call  delay200
        btfss  GPIO,0      ;ignition on ?
        goto  shut2       ;:no
        decfsz cntr2,f
        goto  turnon      ;go turn-on if ignition on for ONDELAY
        goto  shut3

shut2   movlw  ONDELAY     ;ignition off - restart on timer
        movwf  cntr2
shut3   decfsz cntr,f
        goto  shut1       ;keep waiting
        goto  reset       ;do hard power off

        ; 200 ms delay routine

delay200  clrwdt          ;tickle the watchdog
        movlw  .2         ;note count is +1 (decfsz !)
        movwf  waith
        movlw  .0
        movwf  waitm
        clrf  waitl
dell    decfsz  waitl,f    ;delay loop - 3 us per iteration
        goto  dell
        decfsz  waitm,f
        goto  dell
        decfsz  waith,f
        goto  dell
        retlw  0

```

```

; define configuration bits

__config _MCLRE_OFF & _CP_OFF & _WDT_ON & _IntRC_OSC

;_MCLRE_ON          EQU    H'0FFF'
;_MCLRE_OFF        EQU    H'0FEF'
;_CP_ON            EQU    H'0FF7'
;_CP_OFF          EQU    H'0FFF'
;_WDT_ON          EQU    H'0FFF'
;_WDT_OFF        EQU    H'0FFB'
;_LP_OSC          EQU    H'0FFC'
;_XT_OSC          EQU    H'0FFD'
;_IntRC_OSC       EQU    H'0FFE'
;_ExtRC_OSC       EQU    H'0FFF'

end

```

As you can see, there are several variables that can be changed if you wish to tune the power sequencer:

**ONDELAY:** The delay before aping power to the DC-DC converter. This is required so that the battery voltage will rise above 12 V. This usually happens very fast, but it is always good to have a safety margin in place.

**ONDELAY2:** The delay in between applying power to the DC-DC converter and actually turning the motherboard ON. This is required so that the DC-DC passes the start sequence.

**BUTTON:** How long the motherboard power-ON” button will stay ‘pushed’

**OFFDELAY:** This is the delay after then ignition has been turned off. After the OFFDELAY, the motherboard will receive an power-OFF command.

**HARDOFF:** After the HARDDOFF delay, the power to the DC-DC converter will be cut off. In some instances (especially when running Windows) the operating system might not respond to power-OFF commands, therefore it is necessary to cut off the power to the entire system so that your car battery won’t drain.



*Fig 2.3 ITPS mounted in the mini-box M-100*

Fig 2.3 shows the ITPS module mounted inside the mini-box.com M100. All M-100 units have mounting space for ITPS, thus making the M-100 a perfect candidate for automotive applications.

### Stuff List

This is the list of components required to build the ITPS power sequencer.

All components are available for on-line purchasing from Digi-Key.com. The DigiKey heat sink part number is not included (see specification above).

```

Stuff list for ITPS1A                                Options:

SMT resistors:

  2 #9      R4 R5                                R 10kR 5% 0.1W 0805
  2 #17     R1 R2                                R 1kR 5% 0.1W 0805
  1 #40     R3                                  R 4.7kR 5% 0.1W 0805

SMT capacitors:

  2 #114    C1 C2                                C 0.1uF 20% 50V Z5U 0805

SMT active:

  1 #56     D1                                  BAV99 dual diode SOT-23
  1 #823    D2                                  Schottky diode MBR340 3A 40V SMC
  1 #853    Q2                                  FET IRFR5305 p-ch DPAK
  1 #290    U3                                  IC 78L05M SO8 regulator
  1 #856    D3                                  TVS SMBJ18A
  1 #31     Q1                                  Transistor 2N3904 SOT23
  1 #850    D4                                  Zener BZX84C15 15V SOT23

Through hole:

  2 #849    C3 C4                                C 47uF 50V elyt. 6.3 x 11 mm
  1 #70     J2                                  Header 2x1 polarized
  1 #852    J3                                  Header 3x1 0.156" pol. no pin 2
  1 #851    J1                                  Header 3x1 0.156" polarized
  1 #855    F1                                  PolyFuse RUE600 6A PTH
  1 #185    U2                                  Socket DIP8

Second hand load:

  1 #186    U2                                  IC PIC12C508A DIP8 Uc

```

### Installing the ITPS in a Car

Switched and un-switched battery can be easily found in a car. Remove the keys from ignition and, using a voltmeter, look for the continuous 12 V. Usually, the alarm system as well as your radio/CD unit use un-switched (continuous) power. Using a T-TAP (see fig 4.0) and a “fast disconnect male” connector, wire the continuous 12 V to the +12 V pin on your ITPS and the ground to GND. Use 12-16 AWG cables.

If uninterrupted 12 V cannot be easily found inside the passenger compartment, you can always wire it directly from the car battery. You just need to find a hole into the car’s firewall, usually covered by a removable plastic cap. If a removable plastic cap is not found, you can use existent holes to bring in your wires from the engine compartment inside your car.



*Fig 4.0 - T-TAP connector from 3M, PN-06153*



*Fig 4.1 - Quick disconnect male*

Follow the same procedure to find the switched battery outlets, this time switching the ignition off and on to ensure that you are indeed using a switched battery outlet. Since the switched battery input does not require high current (it is used to read only ignition status) any type of wire gauge can be used. Alternatively, a cigarette lighter adapter, can be used to sense the ignition status (Digi-Key APP-001-ND).

Note that most 12 V car wirings are 12 V switched.

Good luck with your car project. A fully built ITPS power sequencer and DC-DC converters such as the PW-70 and PW-60 are available for on-line purchasing from <http://www.mini-box.com>.



*Fig 2.4 M-100 operating inside a Volvo 850*

### Compact Flash to IDE Adapters

A good choice for automotive and small enclosure design is the use of Compact Flash Adapters. The IDE to Compact Flash adapter enables OEMs to replace hard disk drives with economical, rugged Compact Flash cards. This is a convenient interface that allows Compact Flash modules to be used in any system that includes a standard IDE 40 pin connector. Once the platform starts with the adapter and the CF card attached, the compact flash module appears to the system as a standard disk drive. Unlike other flash storage systems such as DiskOn-Chip modules, this solution does not require drivers or additional software to run the unit. The CF card can be the primary boot device containing the OS and application.

The uniqueness of this particular Compact Flash to IDE adapter is that it does not require any IDE cables, it snaps directly into the EPIA-5000/800/V motherboard!

Other Compact Flash form factors are available. See more pictures below. These compact flash adapters are available at <http://www.mini-box.com> and <http://www.epia-power.ch>, as well as at other few more sites.

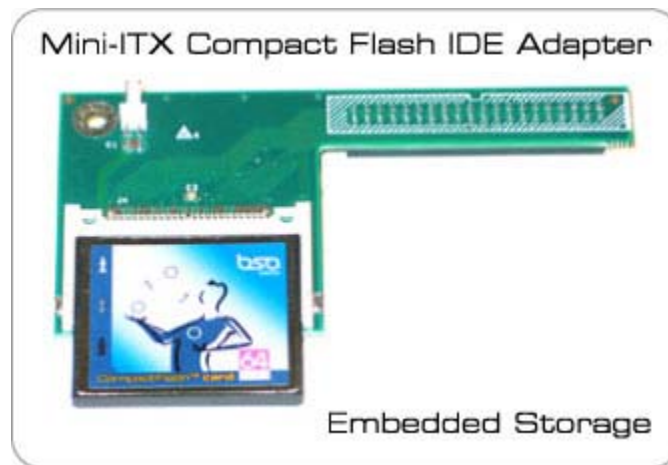


Fig 3.1 - CF adapter "daughterboard" for EPIA-800

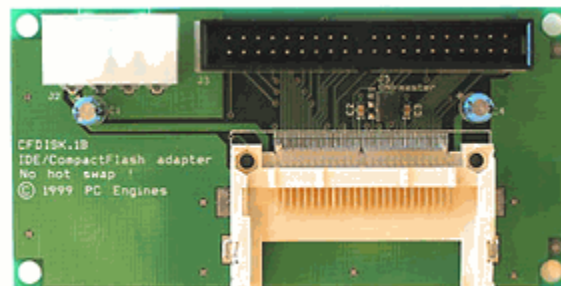


Fig 3.2 - CFDISK 1C, 40pin IDE

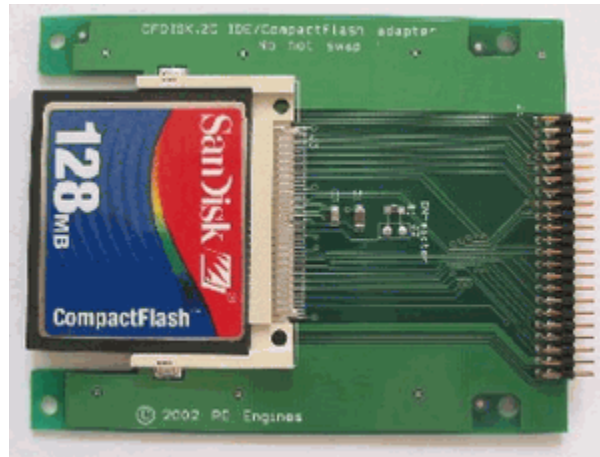


Fig 3.3 - CFDISK 2D, 44 pin adapter, Laptop drive replacement.

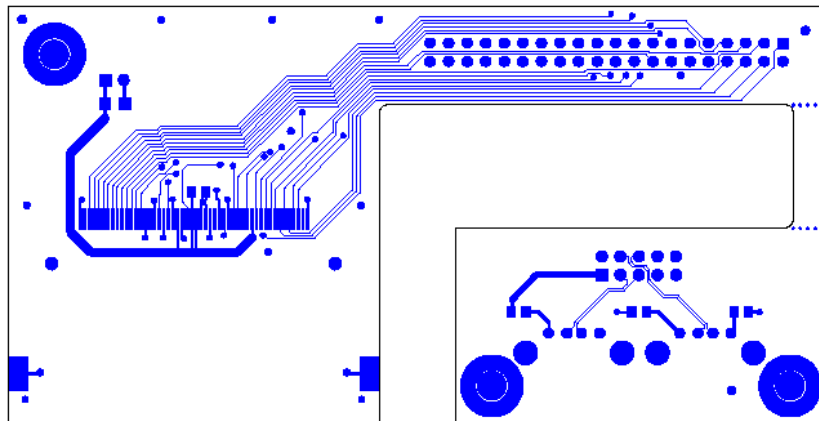


Fig 3.4 - ITCF top view with USB snap-off board.

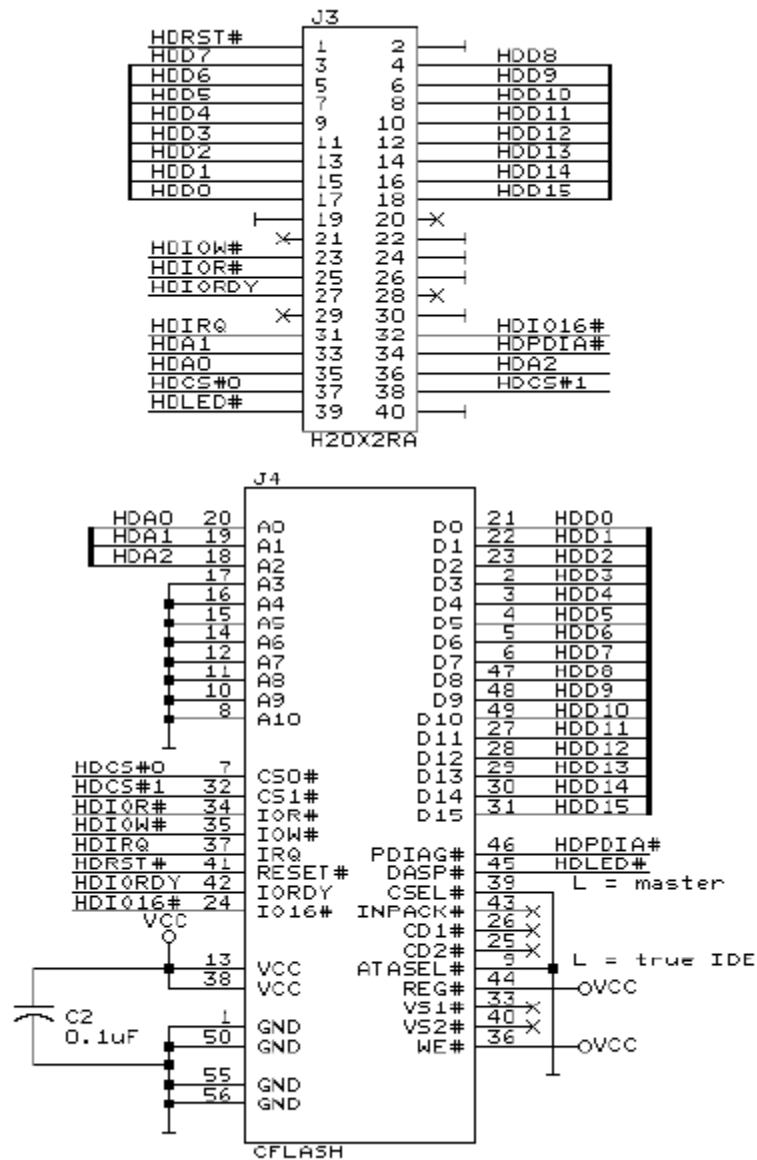


Fig 3.5 - ITCF schematic

Fig 3.1 shows the CF adapter “daughterboard” for EPIA-800.

Fig. 3.2 shows the CFDISK 1C, 40pin IDE.

Fig. 3.3 shows the CFDISK 2D, 44 pin adapter, Laptop drive replacement.

Fig. 3.4 shows the top layout of this Mini-ITX Compact Flash adapter along with a snap-off USB mini-board.



Fig 3.5 shows a typical Compact Flash to IDE adapter implementation. Please note that this implementation does not permit hot swapping. This particular implementation is set to act as a Master device and it can plug in either IDE0 or IDE1. C2 is used for power filtering, 0.1 $\mu$ F.

For a complete set of schematics and PCB layout, please contact [andrewb@ituner.com](mailto:andrewb@ituner.com).

### **Concluding Comments**

This article has provided useful information for developing a car PC application. In the world of mass-produced mainboards, the VIA mini-ITX platform is the most suited car PC computing platform. I personally love the mini-ITX products. For years, until VIA come up with the mini-ITX boards, I have been looking for the ideal small PC board that is reasonably priced and not underpowered. I can only hope that VIA will come up with more mini-ITX and nano-ITX boards in the future. Not knowing anything about the nano-ITX form factor (announced at CE-Bit 2003) I visit almost every day <http://www.mini-itx.com> to keep up with the latest mini-ITX projects, news and rumors.

### **Acknowledgments**

VIA Technologies EPIA-M Operating Guidelines.  
National Semiconductor's [power.national.com](http://power.national.com) web site  
[Mini-itx.com](http://Mini-itx.com) web site  
[Mini-box.com](http://Mini-box.com) web site

### **Resources**

Forums: <http://www.epia-forums.com>  
Auto forums: <http://www.epia-forums.com/auto>  
Via's web site: <http://www.via.com.tw>  
Mini-ITX resources: <http://www.mini-itx.com>