Proposal for
USB I/O Board

Prepared for
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Executive Summary

Fast Forward Technologies proposes to create a USB controlled input/output module that is cost effective and user friendly.

The system will be based on USB 1.1 communications standard. This standard supports up to 127 devices on a single bus. Each object on the bus can transmit at a maximum of 1.5Mb/s. The I/O end of the module will carry custom made solid state relays to enable an industrial DC interface.

Customers will be able to plug the I/O module into the USB port of the computer and start programming using the created API. This is particularly useful to people who are using learning system, and the low cost and convenience will prove especially attractive to teaching institutions. The application will provide students with the opportunity to work on industrial projects and create control software in C++ or other computer based programming languages, without blowing the institution’s budget. Additionally, the USB bus provides a faster speed than older serial port based systems.

The prototype I/O board will contain 16 input ports and 16 output ports. All of the ports will work on an externally powered 24V bus.
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1.0 Introduction

The USB I/O module proposed by Fast Forward Technologies is the next evolutionary step in computer interfaced I/O boards. Common I/O boards on today’s market are generally comprised of a card inside the computer or external cards attached to the serial port of a computer. Some USB based I/O boards do exist, but tend to be incomplete, complex and expensive (Appendix B). For the many applications that do not require extremely high sampling rates, there is a need for cost-effective and user-friendly USB I/O.

This is the pilot project for Fast Forward Technologies. Product development will evolve from the initial platform of a university project. The USB IO module will become the prototype for a large line of I/O modules by and for Fast Forward Technologies.

The module is designed to replace Festo’s “Easy Port” serial I/O board. The increased sampling rates and the convenience of the USB module will exchange optical expansion for the old “Easy Port’s” antiquated serial interface.
1.1 Project Overview

Development of the prototype will be accomplished in five distinct phases:

**Phase I: Hardware design** - the design of the hardware in schematic form.

**Phase II: PCB Design** – the design of a mass production PCB (most likely with surface-mount technology).

**Phase III: Firmware design** – the programming of the client USB-enabled microcontroller.

**Phase IV: Windows Driver** – the design and creation of a windows driver for the device.

**Phase V: API program** – Creation of a standard library of communications functions.

1.2 Scope

This project will be limited to the development of the 32 digital IO USB controlled module. Additional modules and options will be developed and treated as separate projects and will be completed as such.

The module will be designed and manufactured as a prototype. Standardization tests will not be included in the scope of this project. The module will be designed for production; however, production itself is not within the scope of this project. Both standardization and production of the module will have separate project assignments through Fast Forward Technologies.

The software development will include completion of the standard API and windows driver. All other software development will be done through "bendit Innovative Interfaces GmbH" and will be classified as a separate project.

The scope of this project also includes reports, documents, schematics and specifications relevant to the development of the prototype.
2.0 Technical Plan

2.1 Hardware

The USB module hardware will conform to the USB and CE standards. CSA and ISO specifications will also be considered in the design.

The hardware will be based on combination surface-mount and through-hole technology, as a dual layer PCB. A microcontroller will be used to translate over the USB bus. All inputs and outputs will be optically isolated from the USB port to eliminate ground loop problems. All I/O will be externally powered by and operate at 24 volts. The 24volts can be supplied by the device itself or by a separately purchased power source. The benefits of having a device power its own I/O is the elimination of isolation problems and a subsequently more durable system. Most industrial electronics are built in this manner.

The module PCB will have the form of the current Festo “Easy Port”. This will allow Festo to use their existing cases.

2.2 Software

The largest part of the project is software development. Both firmware and driver creation are integral to the project and will require the most man hours.

The driver will be developed using the Windows USB DDK. If the DDK developed driver is not completed by August, a third party demo program will be used to create a temporary driver for the sake of demonstration. This will not serve as replacement to the DDK developed driver, but as a tool to demonstrate the hardware system before the expected completion of the DDK driver.

The API library will consist of functions that communicate with the driver. The API functions will have a generic header file that will allow customers to use the library functions without having to learn the driver systems.

The firmware on the microcontroller will facilitate the sampling and multiplexing of data and will communicate it to the computer via the USB standard.
3.0 Management Plan

3.1 Time Line

The time line has been broken up by three milestones:

**Milestone I**: To complete the schematics and hardware design, and create a working prototype based on a bread board.
*Date: May 31 2002*

To achieve this goal the following tasks must be completed:
- Finalize a component list
- Create schematics
- Research current specifications for the “Easy Port”

**Milestone II**: Create firmware and basic Driver
*Date: July 5, 2002*

To achieve this goal the following tasks must be completed:
- Research driver creation with the Windows DDK
- Research firmware creation
- Create firmware
- Create driver
- Trouble shoot connectivity

**Milestone III**: Create standard API, production PCB, and demonstration materials
*Date: July 25th*

To achieve this goal the following tasks must be completed:
- A standard set of functions for the library must be written
- CE standards will be researched
- USB standards will be researched
- PCB board will be designed and simulated
- A small batch of PCB boards will be made
- Poster presentation will be created
- Demonstration software will be created
- Documentation will be completed

For a better understanding further information on tasks and deadlines, please see of the times allotted for each task see Appendix A.
3.2 Project Benefits

This prototype will be completed with the following parameters in mind. The result will be an inexpensive, user friendly device to fill a currently lacking niche in the USB market. The prototype will have the following advantages over its competitors:

- **Cost effective.** The module will provide a more economical IO solution to schools and small companies that cannot afford PLCs.
- **Plug and Play.** The module will be a windows plug and play device. The driver will be automatically loaded by Windows. There will be no settings and speed controls as the computer will automatically adjust for that.
- **Easy Expansion.** With the USB bus, up to 127 devices can be added. The devices do not all have to be the same. A scanner, digital camera, printer and five IO modules can all be on the same bus. Hubs will be required depending on the computer.
- **Data Speeds.** The exact data collection speeds are not known currently, however they will be substantially higher than serial was able to produce.
- **Multiple devices & Multiple programs.** With the way that USB interacts with windows, programs will be able to open multiple devices, or even share devices.

3.3 Marketing Information

The module is designed to be sold to a distributor who will provide their own case and certification. The target retail price is $150USD. The cost to the distributor will vary with the quantity of units requested. Table 3.1 shows the target pricing for distributors.

<table>
<thead>
<tr>
<th># of Modules</th>
<th>Price/Module</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>$90USD</td>
</tr>
<tr>
<td>1000</td>
<td>$85USD</td>
</tr>
<tr>
<td>10000</td>
<td>$80USD</td>
</tr>
</tbody>
</table>

Table 3.1: Target Pricing for Distributors

Products similar to the proposed prototype do exist on the market. However, of the current products that were researched the lowest cost product is $360USD and it provides only eight inputs and eight outputs. Other more complicated products cost over well over $1000. For a list of websites for competing products please see “Appendix B”.

The initial target market would be engineering groups with limited funding. This would include, but not be limited to schools, small engineering firms,
software firms, and back yard engineers. The module can be used to control pneumatics, hydraulics, and other industrial devices and therefore is suitable for many applications.

3.4 Costs

Current projections are for individual boards. Specification of some components has not been finalized. By July, the software will be complete and the PCB parts, pricing, and layout will be finalized. Table 3.2 provides a breakdown for the estimated pricing at a production of 1000 units.

**Table 3.2**: Estimated Price Breakdown for 1000 Units

<table>
<thead>
<tr>
<th>Component</th>
<th>Price CDN</th>
<th>Source of info</th>
<th>Possible error</th>
</tr>
</thead>
<tbody>
<tr>
<td>PCB Manufacture</td>
<td>$5</td>
<td>Educated Guess</td>
<td>±$3</td>
</tr>
<tr>
<td>Assembly</td>
<td>$10</td>
<td>Educated Guess</td>
<td>±$5</td>
</tr>
<tr>
<td>Components</td>
<td>$37</td>
<td>Digikey</td>
<td>+$5 and -$9</td>
</tr>
<tr>
<td>Packaging and documents</td>
<td>$5</td>
<td>Educated Guess</td>
<td>±$2</td>
</tr>
<tr>
<td>Prototype costs</td>
<td>$1</td>
<td>Educated Guess</td>
<td>±$0.50</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>$58</strong></td>
<td>--------------------</td>
<td>+$15.50 and -$19.50</td>
</tr>
<tr>
<td><strong>USD Total</strong></td>
<td><strong>$38</strong></td>
<td>--------------------</td>
<td></td>
</tr>
</tbody>
</table>

Price estimations were made by both Jon Knoll, the circuit designer, and John Dunfield of IDC. Table 3.2 indicates that the total cost to manufacture the board is $38USD. The proposed selling price is $80USD. Subsequently, *Fast Forward* will be selling the product for just over twice the cost. If the cost increases by more than $3 then it is likely that the suggested sales price will increase accordingly.

*Excluded from this price list are any applicable tariffs and duty.*
Appendix A
<table>
<thead>
<tr>
<th>Month</th>
<th>May</th>
<th>June</th>
<th>July</th>
<th>August</th>
</tr>
</thead>
<tbody>
<tr>
<td>Week</td>
<td>#1</td>
<td>#2</td>
<td>#3</td>
<td>#4</td>
</tr>
<tr>
<td>Days</td>
<td>13to19</td>
<td>20to26</td>
<td>27to2</td>
<td>3to9</td>
</tr>
</tbody>
</table>

### Jon’s Tasks
- Circuit Design
- Testing Demo Firmware
- Writing Firmware
- PCB Design
- PCB Order
- Touch ups and buffer
- Prototype board creation

### Dave’s Tasks
- Circuit pricing
- Prototype Component Purchase
- Initial Paper work
- Third party driver creation
- DDK Driver Creation
- Webpage creation
- Library creation
- Final report and poster
- Negotiations with distributors

### Scheduled Tasks

### Completed tasks

### Canceled tasks
Appendix B
Below are some competing products located through web searches, and notes made by Fast Forward on specific findings:


- Nice complete USB IO modules, I have emailed for pricing but I found the same product on another website for about $600 and up.
- They have nice products but I am looking to provide a lower cost solution.


- A nice USB module, however the sampling times and casing indicate that the price will be much higher. I have not checked for pricing.

http://www.measurementcomputing.com/cbicatalog/cbiproduct.asp?dept%5Fid=344&pf%5Fid=1462&mscssid=26BM5SQS3XJ78G23ELADFBF57SGHFVFE

- Higher Price at 299$ US
- Mechanical Relays
- 120V switching
- only 16 IO

http://www.contecusa.com/products/product_search.cfm

- A contec rep once told me that they have USB IO cards… But I cannot find them

http://www.instrument.com/pci/udas.asp

- Only for use with their data input systems
- Higher price

http://www.iotech.com/catalog/daq/persdaq.html

- High priced, not just the card but 25$ for a 1 meter USB cable (good thing they have a lease program!)

http://www.sealevel.com/catalog/8203.htm

- This is TTL based. It is also slightly more expensive then what I propose.

http://www.sealevel.com/catalog/8206.htm

- This is very close to what I’m proposing. I will offer more IO. And hopefully a cheaper price.
- This does not have indicator lights.
- 16 inputs and 16 outputs come in separate packages. You have to buy two boxes to get both 16 in and 16 out.
Here is one of the more valuable sites for searching IO boards.
http://www.bbdsoft.com/iocard_digital.html

There are lots of systems out there but most are very expensive, while Fast Forward Technologies aim is to provide a quality module at a low retail price.