Intelligent Harmonic Device
RFP #350ECE1044
Globexx Corporation,
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THE UNIVERSITY of WISCONSIN MADISON

Introduction:

In response to the Request for Proposals issued by HarpoMarx Productions on April 5, 2004, Globexx offers the following solution for an Intelligent Harmonic Device. The proposed Intelligent Harmonic Device turns a harmonica into a MIDI input device without disrupting the normal function of the harmonica. Globexx presents the following solution that provides high reliability and flexibility, without high cost, inconvenience, or training.

This document provides:

- Overview of the Design and Operation of the Proposed IHD System
- Disclosure of Similar Competing Technologies and Relevant Patents
- Detailed Technical Specification
- Projected Cost Analysis for an Individual Unit
- Research and Development Schedule
- Detailed Customer Support and Maintenance Plan
- Projected Customer Support and Maintenance Plan Budget
- Qualifications
- Appendices

Design and Operation Overview:

The Intelligent Harmonic Device system is a remote device that interfaces to a microphone, such that a variety of harmonicas may be used with the device, ensuring that the device does not interfere with the user's playing style. The proposed system expects the user to have access to a microphone, which is not included in the package so that the user may select his or her preferred microphone. To accommodate a variety of microphones the device has multiple audio inputs, a 3-pin XLR and a standard quarter-inch audio jack. An additional input to the device is a MIDI input, which allows MIDI-thru capability. There are two outputs from the device, MIDI out, which can interface with personal computers or other MIDI devices, and an audio output, which provides audio-thru capability. An AC/DC converter is provided and an optional external battery-powered supply for outdoor use is available as well.

The microphone produces an analog representation of the harmonica's output, which the analog-to-digital converter, ADC, converts to a digital signal. The output from the ADC is then converted to an audio format (digitally represented notes) by the FPGA, which will perform this function as well as others. The FPGA then takes the digital audio signal and data from the other MIDI-thru input, if present, and combines them. The combined data is then output through the female MIDI output connector.

Full Disclosure of Competing or Similar Technologies:

Before development of this product commenced, extensive research was done to find out what technologies already existed. The purpose was to find out what had already been done to ensure Globexx's solution would be unique and to obtain ideas for the proposed system. The following are general descriptions of sample technologies and the associated links to the patents are included at the end of this document, when applicable.

The closest product to the IHD system was Yamaha's Polyphonic Breath Controlled Electronic Musical Instrument (PATENT #US5245130). This device uses a breath sensor, pressure sensing transducers, and a microphone to record the users input, which is inputted into a remote electronic controller, which converts it to MIDI data. This product differs from the proposed device because it does not incorporate a traditional harmonica into its design, and the sensors are attached to the device the user breathes into.

Another product that was closely related to the IHD system was the Electronic Harmonica for Controlling Sound Synthesizers (PATENT # US4984499). As the name suggests, a reedless harmonica was modified to produce electrical signals, which are then converted to digital signals. The digital output can then be used to control MIDI equipped sound synthesizers. This invention alters the traditional harmonica, while the IHD system does not and all the signal conversion takes place within the harmonica, while the proposed device does the signal conversion within a remote device.

There are more technologies that involve converting a variety of signals to a format that is MIDI compatible. For example, one device takes an input from a mouthpiece and converts inhales and exhales into a MIDI format. These will not be discussed, because they will not be in direct competition with the proposed IHD system.

Technical Requirements:

Technical Considerations:

Harmonicas and similar musical devices require a high level of interaction with its operator. Under that sole observation, any on-harmonica assembly is unacceptable and impractical for use by the general performer. Such a device would immediately present one or more of the following issues:

- Mechanical impedance: the device would not allow an easy grip or use of the harmonica. A musician's playing "style" could be impeded upon.
- Acoustical impedance: any internal device (mounted or non-permanent) could potentially cause the acoustical affect of the harmonica to be altered.
- Acoustic misrepresentation: the desired sound produced from a local device may or may not be the desired sound to be heard by the receiver.
- Far electrical interference: a small-unshielded electric attachment may electrically couple with surrounding devices, which are common in a studio.
- Near electrical interference: the use of harmonica microphones would distort or couple with an on-harmonica electric device.
- Fitting restrictions: harmonicas come in a variety of forms; an on-harmonica device would have to be adaptable to a variety of sizes.

Recognizing these restrictions, the only viable proposal was an off-device solution. The proposed device does not interfere with the user in any practical way; it only requires a microphone input, a device most musicians are very comfortable with.

Regulatory Considerations:

Any product using digital technology emits radio noise and interference that can affect police, ambulance and fire communications, radio and television broadcasting, and air traffic control operations. Therefore, the Federal Communications Commission rules were investigated and taken into account when designing and developing the IHD system.

The certification of the design and production of this device is pending tests making sure it meets the standards of the FCC Regulations, and any alterations or modifications must be registered with the FCC and are subject to FCC control. Any changes made by the purchaser or user without first contacting the manufacturer will be subject to penalty under FCC regulations.

This device use DC power and therefore the use of non-shielded cables will not result in interference with radio communications. In order for this equipment to comply with part 15 of the FCC Rules, this device is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

If this equipment does cause harmful interference to radio or television reception or computer operation, which can be determined by turning the equipment off and on, the operator must attempt to eliminate the interference by (1) increasing the separation between the equipment that it is affecting (2) relocating the equipment into a power source that is located on a different circuit than that of the devices being affected by this equipment or (3) consulting the dealer or an experienced technician for assistance.

All material, equipment, and supplies fully comply or exceed all of the federal and state of Wisconsin OSHA guidelines or regulations.

Design Theory:

The Fourier transform is the heart of signal processing. It is used to decompose an analog signal into is frequency components. The FPGA in the proposed design contains an implementation of the Fourier transform called a fast Fourier transform. The Fast Fourier Transform, FFT, is a 'radix-2' algorithm, designed for digital implementation. It accurately implements a Discrete Fourier Transform, DFT. Mathematically, the Discrete Fourier Transform is as follows:

$$F(n) = \sum_{k=0}^{N-1} f(n) e^{\frac{-2\pi i n k}{N}}$$

$f(x)$: analog signal

k : harmonic number (the kth harmonic)

$F(k)$: the amplitude at 'k'

N : number of samples

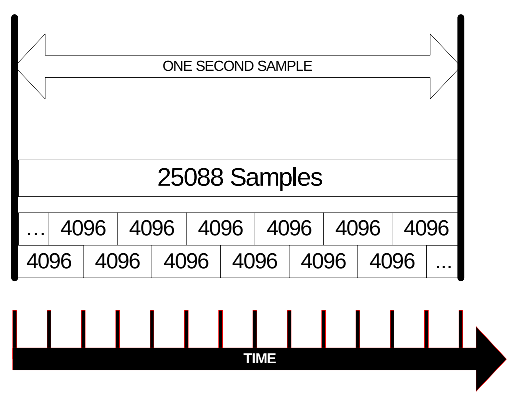
Both transforms, digital and mathematical, output both an imaginary and a real component; we are only concerned about the real components. Since the human ear hears logarithmically and the FFT operates linearly, the transform length must be considerably long for lower-frequency resolution. For instance, in order to obtain the desired permission, we must sample at 25088 Hz and use a transform length of 4096 samples. Using the following equation, we are able to obtain the ‘bin’ size of the frequency components.

$$\Delta f = \frac{f_{Nyquist}}{N_{samples}} = \frac{f_{sampling}}{2 \cdot N_{samples}} = \left(\frac{25088}{2 \cdot 4096} \right) \approx 3[Hz]$$

This frequency allows the transform to cover almost all possible MIDI frequencies except for the eight lowest. This lower four octaves cannot be covered due to the limited size of our transform. The transform could be expanded, but at the cost of delaying the signal. Regardless, these frequencies are below even the most expensive microphone frequency ranges, this is not a concern. Moreover, harmonica frequencies are well above these lower octaves.

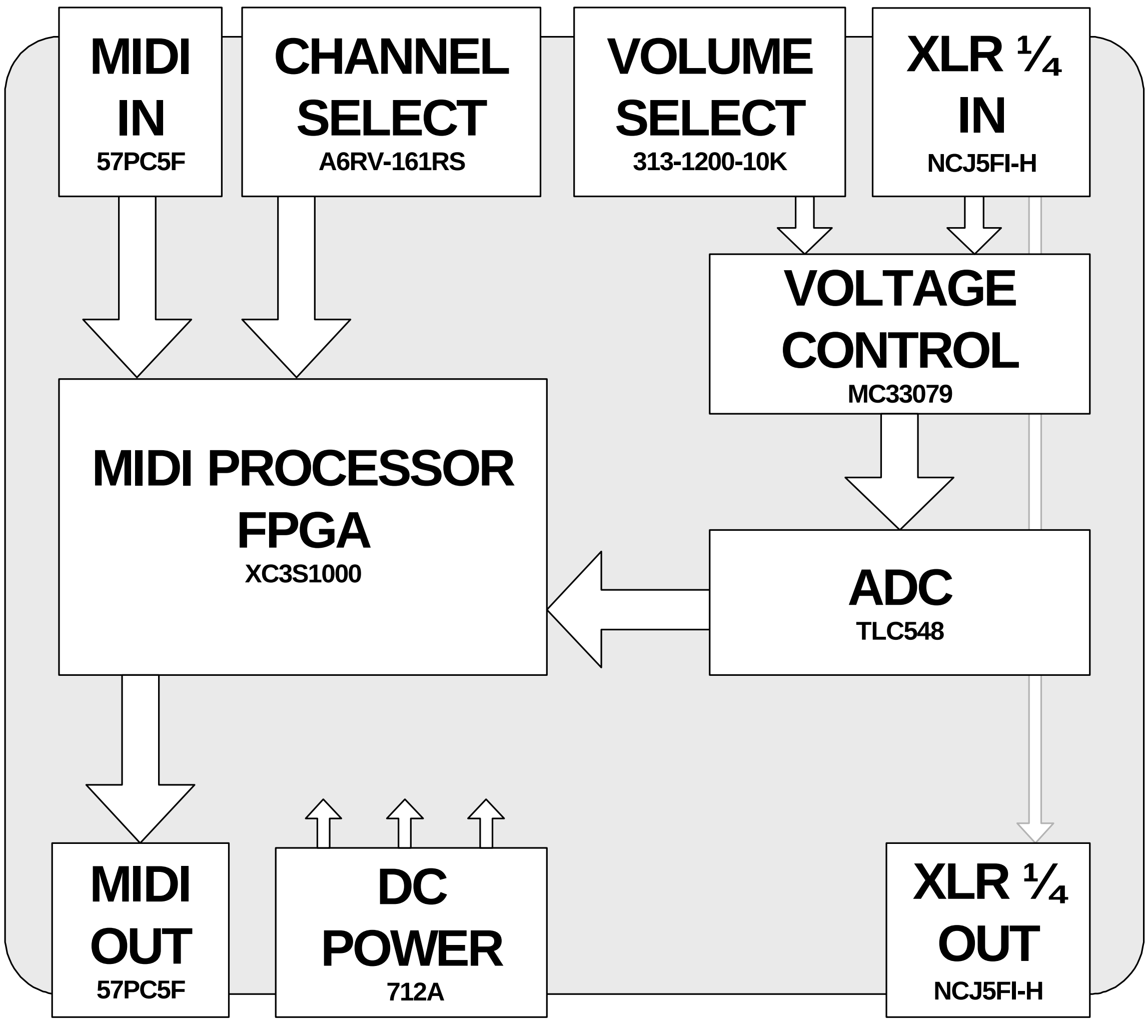
Obviously the notes on higher octaves encompass hundreds of bins. In order to accurately classify a note in these ranges, a sum of their bins must be performed. Since the coefficients are outputted from the FFT in a consecutive order, this operation is not a timing constraint for the design. Until recently, the size, speed, and cost of implementing a wide-range FFT has prevented such devices from being created. Fortunately, with the onset of cheaper, configurable chipsets such as the Spartan-3, these types of devices can now be designed.

The ideal computational delay of the transform is the time it takes to acquire all 4096 samples. However, this delay is considerable, lasting approximately 163 milliseconds; a complex song using a harmonica may have notes alternating faster than that period. The proposed device therefore computes two transforms which are 2048 samples out of phase (as shown above). This allows note sets to be broadcast at 80 milliseconds, an acceptable rate.



Detailed Technical Specification:

This section gives a detailed description of the components that were briefly discussed previously. Below is a top-down layout of the device and how it appears on the printed circuit board.

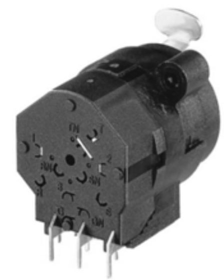


The Analog Audio Input Connector – Part Number NCJ5FI-H:

Neutrik™ NCJ5FI-H

External View

PCB Mount



The output of any standard microphone is analog; the signal is a direct representation of reflected sound waves from the microphone device. As where microphone technology is generally transparent to the musician, how the microphone interfaces is not. For example, there are several different analog connectors for audio:

- XLR (3-pin)
- XLR (5-pin)
- Phone (1/8 Inch)
- Phone (1/4 Inch)

However, for single instruments or single sound sources, XLR (3-pin) and phone (1/4 Inch) are the most common input connectors used by professionals. Therefore, these are the supported interfaces. In many applications, one may find separate connectors for these two interfaces to a single input device. Since the sound circuit can interpret only one set of the signals, the most practical solution is to use a combination jack, which can only receive one cable at any given time.

The combo connector manufactured by Neutrik™, the NCJ5FI-H, is shown above. This model is designed specifically for horizontal mounting on a printed circuit board. Two of these are used in the proposed design: one for analog audio input and one for audio output (audio thru). Audio thru is not a requirement for the proposed design, but useful in the case where a musician must send the signal to multiple devices. If audio thru was not included, the musician would have to buy a separate device to split the signal, and the signal would be degraded as a result. Another advantage to the combination port is that the device inadvertently functions as a ¼ inch to XLR or XLR to ¼ inch converter.

Knob, Potentiometer, Op-Amp – Part Numbers P670S-09-S6, 313-1200-10K, MC33079D:

The analog signal from the microphone does not have the voltage range required by the ADC. This voltage, which must be linearly conditioned to preserve the signal's 'information', may differ between microphones. These restraints are easily rectified with a basic gain circuit. The variety of input ranges is controlled via the use of a potentiometer, which takes the form of a volume control on exterior of the device. The basic gain circuit is constructed of an op amp, the potentiometer, and a separate combination of the resistors, which is not specified.

A rotary potentiometer by Alpha™ electronics, the 313-1200-

10K, is used by the proposed device to alter the input of voltage ranges. It offers low conductor capacitance and has a logarithmic response from zero to ten thousand ohms. This response is an audio response and is desired for such applications. The operational amp chosen is a quad-op amp with low voltage noise, the MC33079 by STMicroelectronics™. Low noise is important because the input voltage range is very narrow and therefore susceptible to noise.

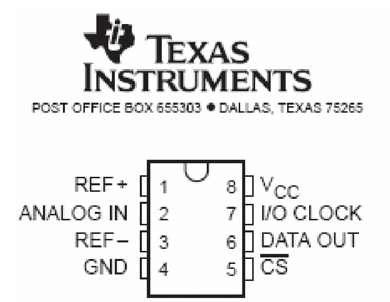
The potentiometer shaft is sleeved by the Rean™ control knob. This piece is also used by the MIDI channel selector switch discussed later. The piece was selected for its durable design, low cost, and size (which must match that of the components it sleeves).

Clock:

The Spartan 3 Family of FPGAs features multiple on-chip digital clock managers, which can eliminate the need for external clocking. The device makes use of the digital clock managers of the XC3S1000 in order to control the clocks for the FPGA, the ADC, and the MIDI control.

Analog to Digital Converter - Part Number TLC548:

MIDI is a purely digital interface, so the first step in conversion to MIDI is digitizing the analog data. To do this, the proposed device used a standard analog to digital converter. The device does not support stereo audio so the ADC need only support one channel. Moreover, the FPGA used can parallelize the converted data so an ADC with a serial output is appropriate. Also, MIDI only supports 128 intensity values, so the output of the ADC does not need to be more than 8-bits.



Part: TLC548

The proposed device uses Texas Instruments' TLC548, an affordable 8-bit ADC. It uses switched-capacitor successive approximation to perform the conversion, a reliable analog to digital transformation. The TLC548 has a wide voltage supply range, allowing it to be powered at the same voltage as the FPGA (3.3 volts). This is important because no voltage conversion must be done to signals running between the FPGA and the ADC. The TLC548 also has very few pins, reducing routing and consequently lowering the cost of PCB production.

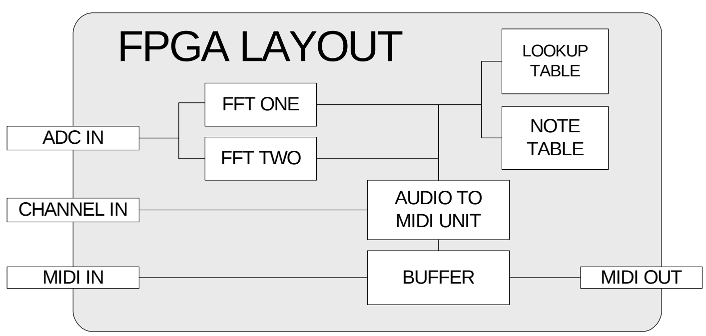
Field Programmable Gate Array (FPGA) - Part Number XC3S1000:

In order to convert the digital signal that is generated from the Analog to Digital converter into MIDI format, we chose to use the FPGA from Xilinx (see attached data sheets). The soon to be released Spartan-3 Family of FPGAs are specifically designed to meet the needs of high volume electronic applications at low cost, which is precisely what we are looking for. Xilinx is also a well-known vendor in the FPGA market, and has an excellent track record with service and support. This is essential since the FPGA performs the most crucial functions of our system. The selected FPGA handles the following functions:

- The Fast Fourier Transform, which takes the digital signal from the ADC and converts it to an audio representation (digital notes).
- Conversion of digital audio representation to MIDI format
- Construction of MIDI data
- Buffering incoming MIDI thru data, construction of MIDI out data
- Storing information about current notes, including ON/OFF, and volume levels to reduce MIDI channel utilization

The Fast Fourier Transform is provided as a core from Xilinx. This drop in module is compatible with the Spartan 3 Family of FPGAs and can compute both forward and inverse Fourier Transforms at selectable bit precisions. We chose to use the FFT core from Xilinx since it is a free module that is optimized to work for Xilinx products. This saves us the time and resources of writing our own FFT. We are using 4,096 samples in each transform to provide maximum granularity of audio frequency representation. Since MIDI audio has a maximum speed of 11 KHz we are able to provide this level of granularity while still maintaining real-time audio processing. Implementation of the FFT using 4,096 samples requires a total of 2,776 slices or 694 Combinational Logic Blocks. Two of these are used to sample at half – periods, increasing data resolution.

Globexx will write the remainder of the functions provided by the FPGA. The first of these functions, the MIDI conversion and construction unit, takes the output of the FFT and transform it into a MIDI message. This function needs to use a lookup table to convert the FFT output to the respective audio signals, and then construct a MIDI message (see Appendix II). The implementation of the conversion and construction unit should require a total of 400 slices, or 100 Combinational Logic Blocks. The FPGA also stores the state of all possible notes in order to reduce bandwidth on the MIDI channel. There are 128 possible notes (96 are accounted for), and each note requires 8 bits of volume information. This information is stored inside the FPGA to eliminate the need for an external memory. This memory allows the device to offer polyphonic output, which means that more than one note can be represented at a time. A total of 1,024 bits of memory must be stored, and approximately 50 combinational logic blocks are required for data conversion. The final function is the MIDI thru buffer and MIDI output unit. This buffers incoming MIDI data and manage the insertion of new MIDI data into the MIDI stream. We have decided to store a half second of MIDI data to ensure no MIDI signals are dropped. This requires 16,896

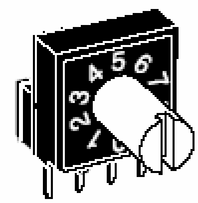


bits of storage. This unit requires approximately 100 combinational logic blocks to correctly buffer and output the data.

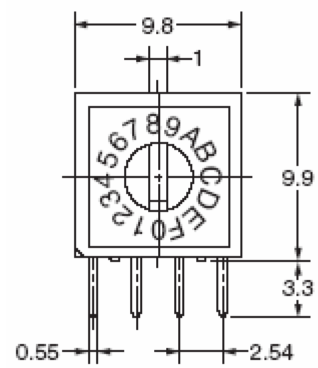
The total amount of required combinational logic blocks for the FPGA implementation is 1,638 blocks. Within the Spartan 3 Family of FPGAs the XC3S1000 provides 1,920 combinational logic blocks, 1 million gates, 17,280 logic cells, 432Kbits of RAM and 175 differential Input/Output lines. The choice of the XC3S1000 FPGA allows for implementation of current features and additional room for future enhancements.

Channel Select Switch – Part Number A6RV-161RS:

A6RV-161RS



MIDI communicates by sending messages, which are prefixed by its channel. The channel ID has a value between 0 and 15 (0x0000 and 0x1111 in binary). This identifier is critical in systems with more than a few components so that messages between components are not confused. There is no method of automation to channel detection since MIDI devices have no built-in broadcast messages to sync devices. The user must be able to select the desired channel for any device. The proposed design uses an external switch for this functionality.



The OMRON hexadecimal coded rotary switch is shown to the right. The switch, the A6R-161RS was chosen for several reasons:

- The switch protrudes from the front of the device; the interface to the board is at a right angle to the PCB.
- Since the device encodes the active switch value, it uses much less space compared to a switch with 16 separate outputs. This makes the switch small and compact.
- The hexadecimal output value can be fed directly into the FPGA and used as the channel identifier since it uses the exact same encoding the MIDI channel message requires.
- There are only a limited amount of pins available on the FPGA; using 16 pins solely for the channel selector increases the needed FGPA pin amount.
- The encoded value also reduces the potential cost of lead routing on the PCB.
- The slotted rotary pieces allow easy interfacing via an external knob.

Switchcraft
Consistently Excellent Since 1946℠

Part: 57PC5F

MIDI Input / Output Connectors – Part Number 57PC5F:

Two MIDI connectors are required in the proposed system to support the daisy chaining of MIDI devices. It is also very important for these connectors to have very low capacitive properties. Both input and output connectors are female; which is typical of most MIDI systems. (In general, this is due to the fact the male end is most easily damaged so it should be part of the cheaper component, the connecting cable).

A very attractive and durable DIN receptacle, Switchcraft's 57PC5F suites the design's needs perfectly. The 57PC5F has a right angle mount, which makes PCB mounting very simple.

DC Power Supply – Part Numbers T48052500A00G, 712A:

The proposed system is a completely digital system. Due to the nature of digital electronics, only a non-oscillating power source can be used.

The locality of an internal transformer gives way to electrical interference. Running a high voltage AC cable parallel to the input and output lines also introduces EMI through coupling. Moreover, an electrical surge could negatively affect the power supply; it would require less labor to replace an external device. Due to these reasons, an external DC transformer is the most practical choice.

The proposed device uses the T48052500A000G, by AULT™. The supply is 5-volt AC/DC adapter running at a maximum of 2.5 amps. This provides 12.5 watts of power to the system, which is adequate, considering there are no mechanical devices (such as a fan for cooling, etc).

The power receptacle recommended for use with this adapter from the 712A from SwitchCraft™. It is right angle mountable and can be attached to the PCB easily.

T48052500A000G AULT

Part T48052500A00G

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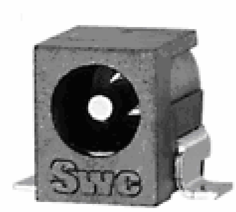
Part: 712A



Optional Battery-Powered Module – Part Number PST-DC292:

In addition to the standard AC-DC power module described above, Globexx also provides an option for a battery-powered module. This option would be especially attractive to performers who may not have access to AC power at the location of their performance. This is accomplished by utilizing a source of two 6 V lantern batteries connected in series to form a 12 V DC source. The source is then fed through a DC-

DC converter, which takes the 12 VDC in and outputs 5 VDC with maximum amperage of 3 Amps out, which easily meets the requirements for the MIDI-Harmonica device. The converter to be used is the PowerStream™ model PST-DC292. This device was originally manufactured for the intent of use with a cigarette lighter jack, but by contacting the company we can purchase the part without the plug. The device has the same 5 V output as the AC power supply and can be plugged into the same power receptacle as the AC input device.

Project Unit Cost:

Below is the cost per unit broken down by component. The total price is given with and without the optional battery power supply. The other category includes components such as resistors and capacitors, which are needed to support the larger components. These figures represent the vendor prices for these components, and do not factor in the cost of labor and other production costs. Estimated production costs including customer service support and labor costs are provided in Appendix III.

Part Description	1000 units	10,000 units	100,000 units
NCJ5FI x 2	2.26	2.26	2.26
TLC548	1.20	1.20	1.20
XC3S1000	24.00	19.00	15.00
A6R-161RS	2.69	2.69	2.69
T48052500A000G	2.21	2.07	1.93
712A	4.14	3.76	3.45
P670S-09-S6	0.30	0.27	0.25
313-1200-10K x 2	0.95	0.92	0.89
MC33079D	0.61	0.56	0.51
Other	1.00	1.00	1.00
Casing	15.13	8.64	3.91
Total	**59.28**	**47.04**	**37.63**
PST-DC292	14.65	13.12	11.09
Battery Casing	21.22	12.34	4.67
Total w/ Option	**96.25**	**75.13**	**58.05**

Research and Development Schedule:

The main components of the device are the analog-to-digital converter and the FPGA. Smaller components include a potentiometer, for volume control; an op-amp, for gain adjustment; a switch (16 bit/channel selector), for selecting the MIDI output channel; and an internal battery. The analog-to-digital converter is pre-manufactured to ensure quality and reliability. The FPGA functions are the most complex. The FPGA has to handle the Fourier transform, interpret the channel setting of the device, and combine the MIDI input with the audio input into a MIDI out signal.

Approximately sixty hours were invested in part selection. This involved figuring out the best approach to the project. The MIDI specifications also needed to be completely understood, to ensure that the solution met the RFP. Another factor that needed to be accounted for was to make sure that the product complied with all FCC standards. Globexx wants to offer the most flexible solution at an affordable cost to the manufacturer and the consumer; therefore many price comparisons were performed. Also, as the solution became more defined, previous parts that were selected were found to be insufficient.

The most time consuming part of the development process will be programming the FPGA. The Xilinx Spartan-3 was not only selected for price, but also because of the designers' familiarity with the Xilinx toolkit. This will greatly facilitate the design process. Due to the complex functions the FPGA needs to carry out, Globexx projects that one hundred and sixty hours will be spent designing the FPGA. Designing the printed circuit board should be fairly simple because there are not that many parts. Twenty-five hours is a generous time estimate for this step in the design process.

The debugging step of the design process is always the most tedious and is usually the longest phase. Even if great care was taken in the previous stages of the development cycle, unforeseen snags and small errors can lead to hours of work. Hence, a conservative time estimate for this phase is three hundred hours.

After the digital hardware has been tested using a prototyping board, the product must be assembled with the power supply. A pre-fabricated power supply is used, so most of the development time was accounted for in the part research phase. The assembly of the unit will most likely take fifteen hours. After the assembly, the unit as a whole must be tested to ensure that it complies with FCC Regulations, which are discussed later. Time to obtain FCC approval cannot be exactly estimated, so sixty hours were allotted for the researching of the regulations, and completing the FCC approval process.

Overall, the time estimate for the research development is six hundred and twenty hours. This does not include time waiting for components from vendors. For example, the casing, which was purchased from SI2M, Integrated Solutions for the Mold Industry, had a delivery time of two weeks. Also, at the time of this proposal, the Spartan-3 was not available for purchase, but the specifications and predicted costs were available. So the development process would not be able to commence until the Spartan-3 was available. Alternative FPGAs were researched and it was found that for the gate capacity that the product required, no other FPGA came close to meeting the capacity for the price.

The above calculations take into account the actual hours worked. When the time for waiting for parts to be delivered, waiting for FCC approval, finding a development site, which for the size of this device could be a simple office, and other scheduling issues, the time estimated from proposal approval to a prototype is six months.

Research and Development Budget:

Analog Engineer – $53,500-$58,850 / Year (includes salary and benefits)

Responsibilities

- System Design including passive and active filter design
- Analog Circuit Design (Analog/Digital interfacing)
- Power Supply Design (battery charging, power regulation, power management)
- Data acquisition system design (Analog to Digital conversion, filter design)
- Board-Level Component Selection (3 Layer Printed Circuit Board) Circuit Design
- Schematic Capture and System Integration
- Design and Product Review
- Customer Support and Troubleshooting

Computer/Digital Engineer - $56,710-$62,060 / Year (includes salary and benefits)

Responsibilities

- Prepare Instruction Manuals
- Troubleshoot manufacturing problems
- Verilog design/Verification Flows
- Design, develop, simulate, test, modify hardware system
- Optimizing circuit design and manufacturing processes
- Design and Product Review
- Oversee Digital Manufacturing of Product
- Customer Support and Troubleshooting

Equipment:

Computers, Software, Telecom Devices $5,000/ Year
Office Supplies, Fax, Printer, Copy Machine Rental

Office Rental Space Downtown Madison $1,200/ Month
Including parking

Research and Development	1 Year Cost	5 Year Cost (includes inflation and raises)
Engineering	$ 121,000	$ 668,104 (high end estimate)
Equipment	$ 5,000	$ 27,000
Office Rental	$ 14,400	$ 78,000
Total Cost	**$ 127,000**	**$ 773,104**

Customer Support and Maintenance Plan:

In accordance with the specifications, Globexx will provide a full customer support and maintenance plan for the IHD system. The product will also be under warranty for one year after the date of purchase (see Appendix IV). The warranty will only be valid if the product has not been modified. The customer support plan will always be available, and maintenance will be available after the warranty expires, but at the expense of the user.

The customer support plan will entail e-mail and phone support as well as a website. The website will contain links to MIDI specifications, microphone descriptions, harmonica sites, and other pertinent information. It will also provide users with a forum that allows them to post questions, comments, concerns and reply to other postings. The website will also inform customers of new products, product updates, and changes in company policies. The e-mail support will first send an acknowledgement e-mail to the customer informing them that their inquiry will be addressed within two business days. Because of the increasing popularity of e-mail, phone support will only be offered Monday thru Friday between 9AM and 4PM E.S.T. If customers find that these hours are not sufficient, this policy may be amended.

The maintenance plan provides repair or replacement at no cost to the customer within the first year, which includes reimbursement for shipping and handling. Consumers will ship the defective unit to the manufacturer, and the manufactures will either replace the defect parts, or if the damage is extensive, it will replace the entire unit. After sending their unit to the manufacturer, the customer can expect to receive an e-mail or phone confirmation that the manufacturer has received the unit and an initial assessment. The initial assessment will determine how long it will take to repair the unit. The turn around time should be no longer than twenty business days, which is dependent on the extent of the damage and the location of the user.

Customer Service/Maintenance Plan Budget:

Customer Service for the MIDI-Harmonica Device will be provided via an Internet website as well as an 800 number. The website will be set up through a host connection created through Site-Maker.com and will start as the Starter Package for a cost of $19.95 per month. There will be a policy in place, just in case the monthly traffic limit was exceeded, that would prevent the site from shutting down by allowing Globexx to pay an extra charge for the excess traffic. Globexx will review the site traffic on a monthly basis to determine if it is more cost effective to upgrade to a higher package. Globexx will have technicians at the manufacturing facility that will respond to any customer service phone calls or emails sent regarding the repair or service of the MIDI-Harmonica Device. The number of technicians available will depend on the projected number of devices to be sold. For 1,000 units, there will be one technician. For 10,000 units, there will be 2 technicians. For 100,000 units, there will be 4 technicians. The technicians will be paid an annual salary of $38,000 each.

The cost per unit for the technicians is shown in the chart below. (Data includes cost of phone number and Internet.)

Units	1,000	10,000	100,000
Cost Per Unit of Technician	**$53.59**	**$10.63**	**$2.12**

There will also be a 1-800 number and a facsimile number available for customer support. The numbers will be set up through FreedomVOICE Systems as the Freedom Lite package for $9.95/mo with the dedicated fax option for an additional $5.00/mo.

Qualifications:

Bryan Berns:

Bryan Berns is a senior majoring in Electrical Engineering and Computer Science at the University of Wisconsin - Madison. He specialized in electromagnetic waves and took several high level courses in computer engineering. His experience in EM allows Bryan to foresee interference issues with circuitry in a variety of environments. In his four years of undergraduate studies, he worked in several team projects which included very detailed designs, extensive documentation, and meticulous implementation. One team project in particular involved developing a complex multi-threaded processor with a XILINX Virtex chip on a XESS prototyping board. Other relevant coursework includes acoustical engineering and image processing, in which Bryan studied theories behind data compaction and encoding using such tools as Fourier and cosine transforms. This broad range of education has enabled him to approach design projects from multiple directions. Bryan has also worked in a customer service based environment for six years, allowing him to view potential ideas from a consumer's perspective.

Francisco Godinez:

Francisco Godinez is a student at the University of Wisconsin-Madison. He expects to obtain his BS in Electrical Engineering in addition to his BA in Engineering Math and Sciences obtained from Lakeland College in Sheboygan, WI. He has expertise in power electronics having interned with the Department of Defense and a local electrical component distributor.

While at the University of Wisconsin, under the direction of Professor Hitchon, he and another student developed a very inexpensive way to design printed circuit boards. He has also been elected to leadership positions while attending college. His time management and leadership skills will be an asset to assisting our team to maximize our efficiency.

Francisco has worked in sales as an assistant manager for over five years where he maintained a strong focus on customer satisfaction. He brings a tremendous amount of experience and understanding of the importance of high customer service. His insights will an asset to ensure that we develop a strong relationship with our customers. He is also very proficient in reading and writing in Spanish which will help our company expand its customer base.

Amanda Lum:

Amanda is a senior at the University of Wisconsin, Madison, who is graduating in May 2004. Last semester she completed her senior design course, Embedded Microprocessor System Design. A team of three was required to propose, design, and build a prototype of a project based around the Texas Instruments DSP prototyping board. Over the course of the project, Amanda learned how to research parts, decipher datasheets, deal with vendors, and other phases of the design process. The FPGA used in the project was a Xilinx product, which is the same manufacturer as the Spartan-3. This is advantageous, because she is already familiar with the design tools associated with the FPGA. The project also exposed the teams to the unexpected snags that can occur during product development, which allows her to make appropriate cost and time estimates, as well as understanding the importance of documentation, meeting deadlines, and dealing with setbacks. The class also helped Amanda learn about team dynamics and how to work with a variety of people.

Kevin Resch:

Kevin is currently a senior in his final semester at UW-Madison majoring in electrical engineering with an emphasis in power and machines. He recently received a 2004 Grainger Outstanding Power Engineering Student Award. His background in power allowed the group to select the appropriate power conversion modules and assure that reasonable protection measures were taken in the design of the device to minimize part loss due to improper voltages being applied. He has worked as a co-op student in the preventive maintenance field and has a construction background.

William Stube II:

William Stube is a senior, majoring in Computer Engineering at the University of Wisconsin - Madison. In the past five years, his education has focused on the digital design process in all aspects from assembly programming to gate level design. William has also applied this education in team design projects including gate level processor design, and most recently product realization. The product realization process was performed for a senior design course, Embedded Microprocessor System Design. A team of three individuals used a Texas Instrument Digital Signal Processor to design and implement a functional product. This project required part research and procurement, verilog design work with a Xilinx Spartan FPGA, and meeting difficult time constraints. This experience assisted William in making valid time and cost estimates, and to bring his skills in the area of FPGA design to the company. His familiarity with Xilinx products and design tools will allow for work on the FPGA to proceed quickly, with little time spent learning tools.

APPENDIX I

SIGNATURE AFFIDAVIT

The undersigned, by submitting this proposal, hereby agree to all the terms, conditions, and specifications required in this Request for Proposal, and declare that the attached proposal is in conformity therewith.

In signing this proposal, we also certify that we have not, either directly or indirectly, entered into any agreement or participated in any collusion with other vendors or with any outside person or agency except as disclosed herein; that this proposal has been independently arrived at without collusion with any other vendor or with any outside person or agency except as disclosed herein; that no attempt has been made to induce any other vendor to alter a proposal in any way; that this proposal has not been knowingly disclosed to any other vendor or competitor prior to submission; and that the above statement is accurate under penalty of appropriate academic and legal sanctions.

The undersigned also understand and agree that in submitting this Proposal they are placing the proposed technology, including any copyright, trademark, patent, or other intellectual property rights attached thereto, under the jurisdiction of the University of Wisconsin System, and that said property will be handled thereafter in accordance with the laws of the State of Wisconsin and the regulations of the University of Wisconsin System. They agree to hold the HarpoMarks Productions, the project evaluator, and the University of Wisconsin System harmless for any errors of judgment or execution which may occur in the handling of said property, and they understand and agree that neither HarpoMarks Productions, the project evaluator, nor the University of Wisconsin System are under any obligation to develop, market, promote, license, or manufacture the said property now or in the future.

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____________________________ ______________________
Bryan Berns Date

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____________________________ ______________________
Francisco Godinez Date

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arlum@wisc.edu

Amanda Lum	Date

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Kevin Resch	Date

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wlstube@wisc.edu

William Stube II	Date

APPENDIX II

References:

1. FFT to MIDI Representation Lookup Table

MIDI NOTE	FREQUENCY (HZ)	COEFFICIENTS RANGE	MIDI NOTE	FREQUENCY (HZ)	COEFFICIENTS RANGE	MIDI NOTE	FREQUENCY (HZ)	COEFFICIENTS RANGE
0	8.18	3 - 3	43	98	32 - 33	86	1174.66	384 - 395
1	8.66	3 - 3	44	103.824	33 - 35	87	1244.54	395 - 418
2	9.18	3 - 3	45	110	35 - 37	88	1318.53	418 - 443
3	9.72	3 - 3	46	116.544	37 - 39	89	1396.86	443 - 470
4	10.30	3 - 3	47	123.472	39 - 42	90	1479.94	470 - 498
5	10.91	3 - 4	48	130.816	42 - 44	91	1568.00	498 - 527
6	11.56	4 - 4	49	138.592	44 - 47	92	1661.18	527 - 559
7	12.25	4 - 4	50	146.832	47 - 49	93	1760.00	559 - 592
8	12.98	4 - 4	51	155.568	49 - 52	94	1864.70	592 - 627
9	13.75	4 - 5	52	164.816	52 - 55	95	1975.55	627 - 664
10	14.57	5 - 5	53	174.608	55 - 59	96	2093.06	664 - 704
11	15.43	5 - 5	54	184.992	59 - 62	97	2217.47	704 - 746
12	16.35	5 - 5	55	196	62 - 66	98	2349.31	746 - 790
13	17.32	5 - 6	56	207.648	66 - 70	99	2489.09	790 - 837
14	18.35	6 - 6	57	220	70 - 74	100	2637.06	837 - 887
15	19.45	6 - 7	58	233.088	74 - 78	101	2793.73	887 - 939
16	20.60	7 - 7	59	246.944	78 - 83	102	2959.87	939 - 995
17	21.83	7 - 7	60	261.632	83 - 88	103	3136.00	995 - 1054
18	23.12	7 - 8	61	277.184	88 - 93	104	3322.37	1054 - 1117
19	24.50	8 - 8	62	293.664	93 - 99	105	3520.00	1117 - 1184
20	25.96	8 - 9	63	311.136	99 - 105	106	3729.41	1184 - 1254
21	27.50	9 - 9	64	329.632	105 - 111	107	3951.10	1254 - 1329
22	29.14	9 - 10	65	349.216	111 - 117	108	4186.11	1329 - 1408
23	30.87	10 - 10	66	369.984	117 - 124	109	4434.94	1408 - 1491
24	32.70	10 - 11	67	392	124 - 132	110	4698.62	1491 - 1580
25	34.65	11 - 12	68	415.296	132 - 140	111	4978.18	1580 - 1674
26	36.71	12 - 12	69	440	140 - 148	112	5274.11	1674 - 1773
27	38.89	12 - 13	70	466.176	148 - 157	113	5587.46	1773 - 1879
28	41.20	13 - 14	71	493.888	157 - 166	114	5919.74	1879 - 1990
29	43.65	14 - 15	72	523.264	166 - 176	115	6272.00	1990 - 2109
30	46.25	15 - 16	73	554.368	176 - 186	116	6644.74	2109 - 2234
31	49.00	16 - 16	74	587.328	186 - 197	117	7040.00	2234 - 2367
32	51.91	16 - 17	75	622.272	197 - 209	118	7458.82	2367 - 2508
33	55.00	17 - 18	76	659.264	209 - 222	119	7902.21	2508 - 2657
34	58.27	18 - 20	77	698.432	222 - 235	120	8372.22	2657 - 2815
35	61.74	20 - 21	78	739.968	235 - 249	121	8869.89	2815 - 2982
36	65.41	21 - 22	79	784	249 - 264	122	9397.25	2982 - 3160
37	69.30	22 - 23	80	830.592	264 - 279	123	9956.35	3160 - 3348
38	73.42	23 - 25	81	880	279 - 296	124	10548.22	3348 - 3547
39	77.78	25 - 26	82	932.352	296 - 313	125	11174.91	3547 - 3757
40	82.41	26 - 28	83	987.776	313 - 332	126	11839.49	3757 3981
41	87.30	28 - 29	84	1046.528	332 - 352	127	12544.00	3981 4096
42	92.50	29 - 30	85	1108.736	352 - 362			

APPENDIX III: Estimated Costs

Total Worker Compensation (including benefits, FICA, 401K			
Personnel	Cost/Hour	Cost/Year	
Engineer	$25.65	$38,000	
Technician	$25.65	$38,000	
Assembly Worker	$12.15	$18,000	
Square Feet Needed for Work			
Industrial Engineer	36		
Worker	100		
Technician	60		
Equipment Costs			
Benches/Tools	$1000	1 per assembler	
Computer	$800	1 per engineer/tech	
Office Desk	$350	1 per engineer/tech	
Units	1,000	10,000	100,000
Units/hr assembled	1	1.25	1.5
Total Hours Needed	1000	8000	66667
Hours per year (5year contract)	200	1600	13333.4
Total Assemblers Needed	1	1	7
Total Engineers Needed	1	1	1
Total Technicians Needed	1	2	4
Total Labor Costs	$268,650	$353,700	$1,066,504.05
Labor Costs/Unit	**$268.65**	**$35.37**	**$10.67**
Total Cost of Technician	$51,300	$102,600	$205,200
Cost of Technician Workspace	$240	$480	$960
Cost of Technician Supplies	$1,150	$2,300	$4,600
Technician Costs/Unit	**$53.59**	**$10.63**	**$2.12**
Total Supply Prices	$2,150	$5,150	$12,150
Supply Prices/Unit	**$2.15**	**$0.52**	**$0.12**
Office Space Rental (Assuming $4/sq. ft.)			
Total Square Footage	136	436	1136
Cost of Rental Unit	$2,720	$8,2720	$22,720
Rental Cost/Unit	**$2.72**	**$0.87**	**$0.23**
Website and 800 number			
Hosting Service	$1,197	$1,197	$1,197
800 Number and Fax	$897	$897	$897
Service/Unit	**$0.90**	**$0.09**	**$0.01**

Total Cost/Unit	**$327.11**	**$47.38**	**$13.13**

Up to about ten thousand units, it would be much more cost effective to outsource. Assuming the cost to outsource is roughly twice the cost of doing the manufacturing and customer support internally, the following costs are valid.

Units	1,000	10,000	100,000
Total Labor Costs	$136,640	$427,340	$1,997,548
Total Cost/Unit	$136.64	$42.73	$19.98

Units	1,000	10,000	100,000
Component Costs	$59.28	$47.04	$37.63
Research and Development Costs	$43.33	$4.33	$0.43
Customer Service Costs	$54.49	$10.72	$2.13
Labor Costs (In house production)	$268.65	$35.37	$10.67
Labor Costs (Outsourced production)	$136.64	$42.73	$19.98
Total Costs	**$293.74**	**$97.43**	**$50.86**

APPENDIX IV

Customer Warranty for MIDI-Harmonica Device

For a period of one (1) full year from the date of purchase of the Intelligent Harmonic Device, Globexx® Corporation guarantees this product to be free from defects in workmanship or materials. If such a defect is found, Globexx® Corporation will do one of the following:

1. **Repair** the product or parts that are found to be defective.
2. **Replace** the entire product with a new Intelligent Harmonic Device at no cost to the consumer.
3. **Refund** the depreciated value of the Intelligent Harmonic Device. (Depreciated values will be determined by our insurance company.)

Globexx® Corporation reserves the right to choose which of the three options it will pursue on a claim-by-claim basis.

Altering the Intelligent Harmonic Device in any way from the original form will void the expressed warranty. Altering or removing the serial number will also cause this warranty to be invalidated. Acts of God and cosmetic damage are not covered. Any abuse beyond normal wear and tear will also cause the warranty to be voided. Globexx® Corporation's liability is limited to the repair, replacement or refund of the product as specified and does not extend to damages, physical or emotional, caused by using this product. Globexx® Corporation is not liable for product use beyond that specified in the user's manual provided.

To submit a warranty claim, please call our representative at 1-800-GLOBEXX, or send your malfunctioning product in its original packaging or packaging of equal protection as well as a check for $10.00 to cover shipping and handling expenses (not applicable to California) to:

GLOBEXX Corporation
15201 Maple Systems Road
Madison, WI 53726

Be sure to include a proof of purchase, your name, address and telephone number, and an explanation of the problem.

THIS WARRANTY PROVIDES SPECIFIC LEGAL RIGHTS AND YOU MAY HAVE OTHER RIGHTS IN ADDITION TO THESE DEPENDING ON THE STATE IN WHICH YOU RESIDE.

CAUTION!

TO PREVENT FIRE OR SHOCK HAZZARD, DO NOT REMOVE COVER. DO NOT USE THIS PLUG WITH AN EXTENSION CORD, RECEPTACLE OR OTHER OUTLET UNLESS THE BLADES CAN BE FULLY INSERTED TO PREVENT BLADE EXPOSURE. TO PREVENT FIRE OR SHOCK HAZARD, DO NOT EXPOSE THIS APPLIANCE TO RAIN OR MOISTURE.
NO USER-SERVICEABLE PARTS INSIDE. REFER SERVICING TO QUALIFIED SERVICE PERSONNEL.

IMPORTANT SAFETY INSTRUCTIONS

The lightning flash with the arrowhead symbol within an equilateral triangle is intended to alert the user to the presence of "dangerous voltage" inside the product that may constitute a risk of electric shock.

The exclamation point within an equilateral triangle is intended to alert the user to the presence of important operating and maintenance instructions in the literature accompanying the product.

1) Read Instructions – Read all the safety and operating instructions before operating this product.
2) Keep These Instructions – Retain safety and operating instructions for future reference.
3) Heed Warnings – Adhere to all warnings on the product and in the operating instructions.
4) Follow Instructions – Follow all operating and use instructions
5) Cleaning – Unplug this product from wall source or battery supply before cleaning. Use a damp cloth for cleaning. Clean only the outside of the product.
6) Attachments – Do not use attachments that are not recommended by the product manufacture; they may be hazardous.
7) Water and Moisture – Do not use this product near water.
8) Accessories - Do not place this product on an unstable cart or stand. The product may fall causing bodily injury and damage to the product. A product and cart combination should be moved with care. Quick stops, excessive force, and uneven surfaces may cause the product and cart to overturn.
9) Ventilation – Do not block any ventilation openings. Install with accordance with the manufacturer's instructions.
10) Power Sources – Operate this product only from the type of power source indicated on the label. If you are not sure of the type of power supply to your home, consult your dealer or local utility company. Protect the power cord from being walked on or pinched particularly at plugs, convenience receptacles, and the point where they are plugged into the device.
11) Lightning – Unplug the unit from the wall outlet for added protection during a lightning storm and when it is left unattended and unused for long periods of time. This will prevent damage to the product due to lightning and power line surges.
12) Overloading – Do not overload the wall outlets or extension cords. This may result in a fire or electric shock.
13) Inserting Objects into Unit – Never push objects of any kind into this product through any openings: they may touch dangerous voltage points or short out parts that could result in fire or electric shock.
14) Servicing – Do not attempt to repair or service this product yourself. Opening or removing covers may expose you to dangerous voltage and other hazards. Refer all servicing to qualified service personnel.
15) Damage Requiring Service – Unplug this product from the wall outlet and refer servicing to qualified service personnel under the following conditions: the power supply cord or plug is damaged, liquid has been spilled or objects have fallen into the device, the device has been exposed to rain or moisture, does not operate normally, or has been dropped.
16) Replacement Parts – When replacement parts are needed, be sure that the service technician has used replacement parts specified by the manufacturer. Unauthorized substitutions may result in fire, electric shock, and or other hazards.
17) Safety Check – Upon completion of any service repairs to this product ask the service technician to perform safety checks to determine that the product is in proper operating condition.
18) Heat – This product should not be placed near any heat sources such as radiators, heat registers, stoves, or other devices that produce heat.

NO POSTAGE
NECESSARY
IF MAILED
IN THE
UNITED STATES

BUSINESS REPLY MAIL
FIRST CLASS MAIL PERMIT NO
POSTAGE WILL BE PAID BY ADDRESSEE

How often will this device be used:

☐ Everyday ☐ 4-6 days/week ☐ 1-3 days/week ☐ Less than 1 day/week ☐ rarely

Did you purchase this device for:

☐ Business use ☐ Personal Entertainment ☐ Family Use ☐ Educational Use

Is the owners manual easy to understand? ☐ Yes ☐ No

ADDITIONAL QUESTIONS

Marital Status:

☐ Married ☐ Single ☐ Divorced/Separated/Widowed

Household Income: (in thousands of dollars)

☐ Under 30 ☐ 30-49 ☐ 50-74 ☐ 75-99 ☐ 100+

Home Ownership Status:

☐ Own Home ☐ Rent ☐ Live with others ☐ Dorm ☐ Other _______________

Dwelling Type:

☐ Single Family Home (owned) ☐ Apartment ☐ Condominium

☐ Duplex/Townhouse ☐ Other

GLOBEXX®
OWNER REGISTRATION CARD
MIDI-HARMONICA DEVICE

PLEASE FILL OUT THIS REGISTRATION AND MAIL IMMEDIATELY!

Thank you for purchasing this Globexx® MIDI-HARMONICA DEVICE. Please fill out and mail this card to register your purchase. Proper registration will enable us to send you periodic mailings about new products, newly released software, and other announcements. Registering your product will also allow us to contact you in the unlikely event that you need adjustments or modifications. Thank You!

CONTACT INFORMATION

☐ Mr. ☐ Mrs. ☐ Ms. ☐ Miss

First Name: ___________________________________ Last Name: ______________________

Street Address: _________________________________ Apt: ____________________________

City: ____ State: ____________

Zip: __________

Home Phone: _________________________________

Email: ___________________________

Date of Purchase: ________/_____/__________

DEMOGRAPHICS

What year were you born? 19_____ Gender: ______________________

Occupation:

☐ Professional ☐ Technical ☐ Homemaker

☐ Managerial Administrative ☐ Sales/Service ☐ Student

☐ Administrative ☐ Factory/Farm Worker ☐ Retired

☐ Clerical ☐ Teacher/Educator

☐ Other___________

☐ Medical/Legal ☐ Business Owner

Which Instruments Do you play:

☐ Harmonica ☐ Piano ☐ Organ ☐ Violin ☐ Guitar

☐ Drum

Did you purchase this product for yourself or did you get this as a gift:

☐ Bought for Self ☐ Received as Gift

If gift whom did you receive it from:

☐ Parent ☐ Spouse ☐ Friend ☐ Other _________

PRODUCT PURCHASE PREFERENCE

Source of Product Purchase:

☐ Harmonicastore.com ☐ Harmonica-Shop.com ☐ Musiciansfriend.com

☐ Best Buy ☐ Circuit City ☐ Ultimate Electronics ☐ Other ______________

When did you decide to purchase this product:

☐ GLOBEXX Brand ☐ Product features ☐ New Technology ☐ Relative/Friend

☐ Salesperson ☐ In-store Display ☐ In-store Flyer ☐ Website/Internet

☐ Magazine ☐ Catalog

What are the most important features for a MIDI device: (Please check only three)

☐ Sound Quality ☐ Ease of use ☐ Unique features ☐ Style Appearance

☐ GLOBEXX brand reputation ☐ Price vs. Value ☐ Previous GLOBEXX experience