Educational Design Series

Educational Electronic Kit Using Microcontrollers

The Educational Electronic MIDI Drum Kit

Detailed Product Brochure

ECMG

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Educational Design Series

Educational Electronic Hobby Kit Using Microcontrollers

The MIDI 8-Piece Electronic DrumKit

"It is truly amazing how real the drum sounds are coming from the speakers of the soundcard..."

"I was impressed at how easy this kit was to assemble and also how much I actually learned about the overall design process itself..."

"I really liked the ability to personalize the drumset to include only the sounds that I wanted to include in my kit. It kept my interest throughout the building of the kit and I learned a great deal..."

BENEFITS:

This educational electronic hobby kit institutes the most current national and state high school learning standards in the Science and Technology/Engineering Curriculum Frameworks. This educational electronic drum kit is based on actual project based courses taken on the university level in microcontrollers. It allows parents of electronic enthusiasts and electronic hobbyists themselves, a way of seeing the future potential in a career designing electronic devices using microcontrollers, and to spur their interest in further education in the various fields of electrical engineering.

Microcontrollers are found in a multitude of applications in the automotive, consumer communications, office automation and industrial control markets. For example, a modern car may have 50 or more microcontrollers controlling anti-lock brakes, keyless entry, air bags, burglar alarm systems and various vital engine functions. On the other hand a home is likely to have at least 30 and perhaps as many as 200 microcontrollers embedded in such popular household items as the washing machine and clothes dryer, security system, refrigerator, microwave oven, various electronic games, smoke detectors, and not to mention personal computers and their peripherals.

The instructional documentation contained in this electronics kit steps through the design process, and explains how algebra and physics, with the aid of software, are used in the design process to create an eight piece MIDI drum set that easily attaches to the gameport of a standard soundcard on almost any desktop PC. Assembly of the kit requires no soldering and the drum sounds created by the microcontroller can be customized to include eight drum and cymbal sounds from the current total of 48 drum and cymbal sounds created and recognized by the soundcard on a desktop PC.

TOPICS COVERED:

Electrical Engineering

• The MIDI protocol that communicates with the soundcard on a PC. Also included will be a general explanation of how serial communication works between peripherals and the PC and between PC's.

• The microcontroller that converts the data received from the 8 drum sensors into the MIDI protocol. Also included will be a discussion about other applications that these microcontrollers are used in and an explanation of how these microcontrollers fit into the world of electrical engineering and computer chips in general.

• A flow chart explanation of the software that is programmed into the microcontroller. Also included will be an explanation of what computer languages are used to program microcontrollers and how the overall process works.

• How to properly condition the inputs from the sensors to give the microcontroller a signal that it can process correctly.

• An explanation on how crystal oscillators work and why they are needed in electronic devices.

• An explanation of how the drum sensors (i.e. peizo sensors) work and why they produce a signal capable of being processed by a microcontroller when they are struck.

Math and Physics

• Number systems in general and a more in-depth discussion of the numbers systems used in computer hardware and programming.

• An explanation of the Math needed to calculate the values of the various components used in this electronics kit as an input to, an output of, and power source to the micro controller.

• An explanation of the Physics behind the various components used in this electronics kit and why they work the way they do.

KIT INCLUDES:

1. CD-ROM containing the software needed to play the drum sounds on your computer and the instructional documentation.
2. One - gameport cable used to connect the electronics kit to the soundcard of a PC.
3. One - 5V DC power supply used to power the electronics kit.
4. Directions on how to assemble the electronics kit.
5. All the parts necessary to assemble the electronics kit.
   - Breadboard (1)
   - Resistors (20)
   - Capacitors (5)
   - Diodes (9)
   - Opto-Isolator (1)
   - DB15 Gameport Connector (1)
   - 4Mhz Crystal Oscillator (1)
   - Peizo Sensors (i.e. Drum Pads) (8)
   - Jumper wire to connect the components together.
   - Drum sticks (2)
   - Pre-programmed PIC 16F877 Microcontroller (1)

The only component not supplied by this kit is a desktop PC with a soundcard.

Ordering and Pricing Information:

Our Educational Design Series electronic drum kit can be purchased by visiting our website at www.ecmg.net or by calling us directly at 419-831-0943.

Pricing is as follows:

1 - 10 Kits: ~~$199.99~~ $149 SALE PRICE

10+ Kits: ~~$189.99~~ $139 SALE PRICE

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Foreword

The purpose of this detailed product brochure is to demonstrate the value of our 8 Piece MIDI Drum Kit. Every kit we distribute contains a comprehensive User Guide and Reference Manual (UGRM) that is heads and shoulders above the competition. Our UGRM not only provides in-depth assembly directions along with step-by-step color photos, but as a bonus we have included the actual design process methodology used to create this kit. We hope you will find the background information and design process methodology as interesting as assembling the kit itself. Another distinct advantage of our 8 Piece MIDI Drum Kit is that most of the electronic kits on the market today use antiquated parts and technologies; whereas our kits use the most current parts and advances in the electronic design process.

Prospective Customers

This product can be used and applied in various ways depending on the type of customer you might be. Click on the links below to see how this electronics kit can specifically benefit you.

Educators

Parents

Students

Musicians

Hobbyists

The sample Instructional Documentation includes:

1. The Title page
2. The Contents page
3. Overview
4. Introduction
5. Chapter One: The Design Process: Identify the need or problem.
6. Chapter Two: The Design Process: Research the need or problem.
7. Chapter Five: Construct a prototype.
    a. First two pages of the assembly directions.

This sample documentation should give you a good idea as to the quality of this product and the instructional documentation included with it. It should also give you an idea of the flow and structure of the instructional documentation, and the ease and depth to which it explains the design process for microcontrolled electronic devices. Additionally, it gives a sample of the background information about basic electrical concepts and, which show*s* what the background information is like and how comprehensive it is.

Educators

This product is based on actual project based courses taught at the university level. This "8 Piece MIDI Drum Kit" is a great teaching tool for educators because it teaches about basic electrical and electronic concepts, the most current design process for microcontrolled electronic devices, and modern musical composition through the use of the MIDI protocol.

Educators can use this electronics kit to spark the natural interests and curiosity of their students inspiring them to seek further education in the areas of Science, Engineering, and possibly Musical Composition. This electronics kit will demonstrate much of what is currently possible in the fields of Science and Engineering and how an electronic device design gets from point A to point Z, as well as the various tools used in the design process.

University science departments all over the United States are moving toward a more project based curriculum. Because of this, Junior High and High schools that are attempting to respond to these changes will seek to supplement their school curriculum with these types of project based programs. This product allows the teacher to focus on teaching without having to be an expert in the field of electrical and electronic design. The instructional documentation includes everything that you will need to teach about the design process for this electronics kit including background electrical component and concept information as well as very detailed assembly directions.

Our product requires no soldering of parts, and it can be taken apart, reassembled, and reused for use in other classes. This electronics kit has much relevance for educators in today's marketplace. We at ECMG believe that most of the value of this product is contained in content of the instructional documentation and assembly directions. With this in mind ECMG has included in our product brochure, samples of the instructional documentation and assembly directions to demonstrate the quality of this product and the documentation that accompanies it.

[Table of Contents   Sample Documentation   How to Order]

Parents

This "8 Piece MIDI Drum Kit" can be used as a great teaching tool for parents who want to supplement their child's education with a project based program that is relevant, interesting and fun to both build and use.

Parents today find themselves in a peculiar situation when it comes to the education of their children, especially those whose children are attending Junior/High School and preparing for College. School curriculums of the past, though slowly changing for the better have at times inadequately educated students in the areas of Math and Science. Because of this, parents find themselves searching for ways to supplement the curriculum outside of school. It was with you in mind that ECMG created this educational electronic drum kit.

Parents can use this product to enhance their child's education by demonstrating the possibilities using Math and Science in electronic device design, by constructing this "8 Piece MIDI Electronic Drum Kit".

Building our product is also a great way to spend quality time with your child by constructing a state of the art electronic device that has much relevance in the areas of music, electronics and engineering. It is a great way to spur a child's curiosity in Math, Science, and Engineering. And it will help to prepare them for the project based curriculums currently being adopted by science departments in colleges all across the United States.

The need for math and science education among the junior high, high school and university level is increasing rapidly. University science departments are rapidly moving toward a project based curriculum focused on problem solving skills, and the design process.

Much of the value of this product is contained in the instructional documentation and assembly directions. With this in mind, ECMG has included in this sales brochure samples of the instructional documentation and assembly directions to show the quality of this product and the documentation that accompanies it.

[Table of Contents   Sample Documentation   How to Order]

Students

This product is ideal for students who attend or are looking to attend an electrical and/or computer engineering program. This product is based on actual project based courses taught at the college level. With this product you will learn the steps that are taken in the design process to create a realistic sounding "8 piece MIDI drum kit." The steps taught in this instructional documentation can be applied to the design of many of the electronic devices on the market today.

This product gives you all the pieces to the puzzle that are needed to understand the overall design process for microcontrolled electronic devices, and to understand the design process for this electronic drum kit in particular. Where as the college course would teach you specifically how to program the microcontroller by designing an electronic device in the lab. This product gives you the outlining structure to the electronic device design process without requiring you to know how to program the microcontroller chip. We give you a pre-programmed microcontroller which has 8 sounds programmed into the chip that you select.

Our product is basically training wheels for the higher level programming courses taught at the college engineering level. This kit's instructional documentation can give you a great head start toward college by teaching you the steps involved in the design process for microcontrolled electronic devices and how the product works along with background information describing the various electrical and electronic components used in this electronic drum kit.

This product can be used to play and record realistic sounding drum, and other unique musical sounds using the MIDI protocol. The MIDI protocol can be used in a variety of ways to both play, and compose music. The standard desktop PC with MIDI software available from the internet, can be used to compose all musical genres including classical music compositions. Complete symphonies can be composed by understanding how the MIDI protocol works and knowledgeable use of the various software packages available to compose music using the MIDI protocol.

This product can be used to form a base of knowledge from which you can further explore in more detail the topics outlined in the instructional documentation included with this drum kit. In the User Guide and Reference Manual, there are many links to get additional information about the various topics discussed in the documentation.

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Musician

This product can be used both by musicians who do not know how the MIDI protocol works, and by those who do. Both can gain insight into the MIDI protocol workings from the fundamental hardware and software perspective. This can add to your abilities when it comes to playing and composing MIDI sound files.

If, as a musician you are already familiar with the MIDI protocol, and already have a synthesizer that you are using, and do not require the soundcard of the standard PC to play the MIDI protocol, then the standard MIDI connector can be substituted in place of the (DB15) Gameport connector used to connect to the soundcard. This way you can connect this instrument into your already existing MIDI chain to the synthesizer of your choice.

There are currently 61 percussion instrument sounds to choose from for this drum kit, of which 8 can be chosen by you to be pre-programmed into the microchip. This way you can create a customized percussion instrument to suit your desires. The 61 percussion MIDI sound files are contained on our website and can be accessed by Clicking Here.

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[Table of Contents   Sample Documentation   How to Order]

Hobbyists

If you are a hobbyists or an electronic kit enthusiasts then this product is for you. Unlike other electronic kits on the market today, this electronic kit gives you information about comprehensive product functioning, the design process used to create the product, and background information about the various electrical and electronic components used in the design.

Many of the electronic kits on the market today do not include very detailed assembly directions. ECMG took many of the inadequacies perceived in the general electronic kit market and capitalized on them creating comprehensive instructional documentation and detailed assembly directions that set this product apart from the competition. Our assembly directions included with this kit contain high resolution digital images for each step in the assembly process along with detailed instructions explaining each step.

The product not only teaches about electronics and electronic device design, but can also be used to create a realistic sounding musical instrument. This product can be used to create a base of knowledge about the electronic device design process, how computers and peripherals communicate, and how modern musical instruments are designed. The instructional documentation contains many links to additional information on the internet that can be used to further expand your knowledge about the particular topics covered in the instructional documentation included with this product.

You can use this product to learn about the MIDI protocol and its many uses in the world of music. The MIDI protocol has recently become even more popular because today's current soundcard manufacturers are including sampled instrument sounds on their soundcard chips, which results in realistic sounding instruments. Because of this, gaming software developers and website designers are also using the MIDI protocol to play their sounds instead of normally recorded sound files. The MIDI protocol is being adapted in this way because of the sound file compression that is available as compared to the normally recorded sound files such as the *.wav* sound file format.

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Educational Design Series

Educational Electronic Kit Using Microcontrollers

The Educational Electronic MIDI DrumKit

User Guide and Reference Manual

SAMPLE DOCUMENTATION

This is not the complete Reference Manual documentation. This is a small sample to show the quality of the documentation that is contained with this electronic drum kit. In the complete version of the Reference Manual, the hypertext links underlined in black are links to further information to a particular topic. This sample documentation does not includes chapters 3, 4, most of 5, 6, 7 and 8. In place of chapters 3 and 4, an outline of the topics discussed is included for each chapter. An outline of chapters 6, 7 and 8 is not included in this sample documentation, these steps in the design process were not the primary focus of this product and therefore these chapters are lightly covered.

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User Guide and Reference Manual

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TRADEMARKS

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CONTENTS

There are two different approaches one can take when building our electronic kits:

- One could chronologically proceed through our documentation one chapter at a time, finally constructing the prototype in STEP 5 of our design process.

- Or, one could proceed directly to STEP 5, essentially bypassing STEPS 1-4, and go directly to constructing a working prototype by simply following the assembly directions contained in Chapter 5. Then starting from Chapter 1, read the rest of the chapters (STEPS 1-4) to find out exactly how our electronic kit works, and how it was designed.

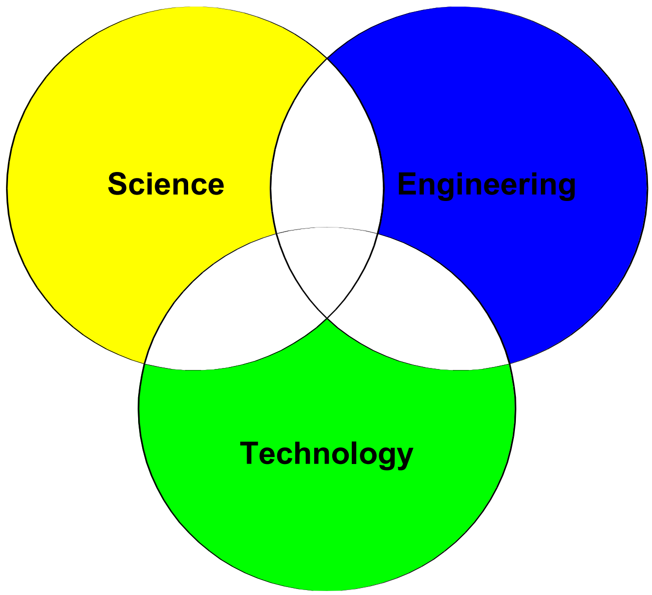
The purpose of our electronic kits is to explain the steps involved in the overall design process for microcontrolled electronic devices culminating in the construction of a working prototype in Step 5 of the overall design process. Our electronic kits should spur the interest of students and hobbyists of all ages, especially those eager to pursue further education or even a career in electrical and electronic engineering.

Our educational design series products can be used by educational providers to enhance the student's classroom experience in a variety of ways. For instance, those teaching on a Jr. High/High School/College level could easily use this kit to demonstrate the overall design process for many of the electronic devices on the market today. In an elementary school environment, our kit can be used as an electronic musical tool connected to the classroom computer that hopefully will inspire the natural inquisitiveness, curiosity of young minds. This electronic kit can even be used by parents to enhance their child's education at home, spending quality time together by going step-by-step through our design and assembly process.

The person who successfully goes through the design process and assembly of one of our kits, besides learning about the design process for microcontrollers as it currently exists, will also learn about the state of music composition in the 21st century by learning about the General MIDI protocol standard. It’s our companies firm belief that had Beethoven, lived in this century, he would probably be using the MIDI standard to aid in the writing and composition of his orchestra style music. Both the electronic hobbyists, and the music enthusiast can use this kit to insight into the design process for micro controlled musical instruments implementing the MIDI protocol standard.

The Relationship Among Science, Engineering, and Technology

Science seeks to understand the natural world, and often needs new tools to help discover the answers.



Engineers use scientific discoveries to design products and processes that meet society's needs.

Technologies (products and processes) are the results of engineered designs. They are created by technicians to solve societal needs and wants.

Engineering, Science and Technology

Understanding the relationship among science, engineering, and technology in the design process of electronic devices is critical to understand how these factors will effect the design process in the future. Engineers use both scientific discoveries about the world around them, and current technologies to create new products and processes that meet society's most current needs and demands. These societal needs, from the Electrical Engineering perspective, cover a wide array of topic areas and industries. Electrical Engineers seek to find solutions to problems in such topic areas as healthcare, automotive, flight, and communications just to name a few. Most of these solutions require microcontrolled electronic devices to solve a particular problem.

The overall market for microcontrollers is 15 times larger than that of the microprocessor (i.e. personal computer) market and is expected to increase exponentially in the next few years as everyday electronic devices begin to communicate with each other in new ways. Currently microcontrollers are used in most of the electronic devices on the market today. The understanding of microcontrollers is critical to the understanding of the electronic device design process as it currently exists in the 21st Century. The need for people in society to design these types of electronic devices will also increase for the foreseeable future. Currently there is a high demand for electrical engineers in the United States. The more society relies on electronic devices to assist in the productivity of their daily lives, the more workers in these fields will be needed in the future.

Engineers apply the theories and principles of science and mathematics to research and develop economical solutions to technical problems. Their work is the link between scientific discoveries and commercial applications. Engineers design products, machinery to build those products, factories in which those products are made, and the systems that ensure the quality of the product, and efficiency of the workforce and manufacturing process. Engineers design, plan, and supervise the construction of buildings, highways, and transit systems. They develop and implement improved ways to extract, process, and use raw materials such as petroleum and natural gas. They develop new materials that both improve the performance of products, and help implement advances in technology. They harness the power of the Sun, the Earth, atoms, and electricity for use in supplying the Nation's power needs, and they create millions of products using power. Engineering knowledge is applied in improving many things, including the quality of health care, a nations security and defense, the safety of food products, and the efficient operation of financial systems.

Engineers consider many factors when developing a new product. For example, in developing an industrial robot, engineers determine precisely what function the robot needs to perform; design and test the robot's components; fit the components together in an integrated plan; and evaluate the design's overall effectiveness, cost, reliability, and safety. This process applies to many different products, such as chemicals, computers, gas turbines, helicopters, and toys, just to name a few.

Engineers use computers to produce and analyze designs; to simulate and test how machines, structures, or systems operate; and to generate specifications for parts. Engineers also use computers to monitor product quality and control process efficiency. They spend a great deal of time writing reports and consulting with other engineers, as complex projects often require an interdisciplinary team of engineers to complete.

Educational requirements to become an engineer:
A bachelor's degree in engineering is generally required for entry-level engineering jobs. College graduates with a degree in a physical science or mathematics may occasionally qualify for some engineering jobs, especially those specialties in high demand. Most engineering degrees are granted in electrical, mechanical, or civil engineering. However, engineers trained in one branch may work in related branches. For example, many aerospace engineers have training in mechanical engineering. This flexibility allows employers to meet staffing needs in new technologies and specialties in which engineers are in short supply. It also allows engineers to shift to fields with better employment prospects, or to ones that match their interests more closely.

In addition to the standard engineering degree, many colleges offer degrees in engineering technology which are offered as either 2- or 4-year programs. These programs prepare students for practical design and production work, rather than jobs that require more theoretical and scientific knowledge. Graduates of 4-year technology programs may get jobs similar to those obtained by graduates with a bachelor's degree in engineering. Some employers regard technology program graduates as having skills between those of a technician and an engineer.

About 320 colleges and universities offer bachelor degree programs in engineering that are accredited by the Accreditation Board for Engineering and Technology (ABET), and about 250 colleges offer accredited bachelor's degree programs in engineering technology. ABET accreditation is based on an examination of an engineering program's student achievement, program improvement, faculty, curricular content, facilities, and institutional commitment. Although most institutions offer programs in the major branches of engineering, only a few offer some of the smaller specialties. Also, programs of the same title may vary in content. For example, some programs emphasize industrial practices preparing students for a job in industry, whereas others are more theoretical and better suited for students preparing for graduate work. Therefore, students should investigate curricula and check accreditations carefully before selecting a college. Admissions requirements for undergraduate engineering schools include a solid background in mathematics (algebra, geometry, trigonometry, and calculus), sciences (biology, chemistry, and physics), and courses in English, social studies, humanities, and computers.

Bachelor's degree programs in engineering are typically designed to last 4 years, but many students find that it takes between 4 and 5 years to complete their studies. In a typical 4-year college curriculum, the first 2 years are spent studying mathematics, basic sciences, introductory engineering, humanities, and social sciences. In the last 2 years, most courses are in engineering, usually with a concentration in one branch. For example, the last 2 years of an aerospace program might include such courses as fluid mechanics, heat transfer, applied aerodynamics, analytical mechanics, flight vehicle design, trajectory dynamics, and aerospace propulsion systems. Some programs offer a general engineering curriculum; students then specialize in graduate school or on the job.

Some engineering schools and 2-year colleges have agreements whereby the 2-year college provides the initial engineering education; and the engineering school automatically admits students for their last 2 years. Some colleges and universities offer 5-year master's degree programs. Some 5- or even 6-year cooperative plans combine classroom study and practical work, permitting students to gain valuable experience and finance part of their education.

Engineers should be creative, inquisitive, analytical, and detail-oriented. They should be able to work as part of a team and be able to communicate well, both orally and in writing. Beginning engineering graduates usually work under the supervision of experienced engineers, and in large companies, may also receive formal classroom or seminar-type training. As new engineers gain knowledge and experience, they are assigned more difficult projects with greater independence to develop designs, solve problems, and make decisions. Engineers may advance to become technical specialists or supervise a staff or team of engineers and technicians. Some eventually become engineering managers, or enter other managerial positions or sales jobs.

Technology is the compilation of all the created products and processes that engineers have designed over time. The new products and processes created by engineers using technology seek to make society more efficient and productive. By making people in society more efficient and productive, more of the problems that society confronts can be solved or at least diminished in capacity, especially those problems in society which can be solved through the use of science, engineering and technology.

Technology in an economic sense, is the relationship between inputs and outputs in a labor process. And the labor process is defined as the transformation of our natural surroundings using human labor with the intention of producing something useful. The technical change created through the use of technology can take on two different forms. The first form is laborsaving technical change, and the second form is capital saving technical change. Labor saving technical change gives us the ability to produce more stuff, ect. with less labor. And capital saving technical change gives us the ability to produce more things, ect with less capital resources required to produce the same amount of work or product. These technical changes increase the profit rate for employers, which usually generate higher wages for employees thereby raising the standard of living of all the people involved with creating and using these technical changes. The technology used in the design of electronic devices using microcontrollers has changed drastically over the last 10 years or so. Both new science, and the use of current technologies are creating a process that is more streamlined and easier for small design teams to produce complex designs cheaply. The synergy of high speed computing along with high quality simulation software packages makes the overall electronic device design process easier for one person to understand and command. This explosion in circuit design software and microcontroller programming software has made the prototyping of potential electronic devices much cheaper and has reduced, shortened the time it takes for electronic devices to make it from the concept stage of development to the production stage of development.

Science, from the microcontroller electronic design perspective seeks to understand the natural world in order to discover new ways to make electronic components smaller, faster and consume less power. These new discoveries of science are then used in the research and development phase of product development to produce products that use the newfound scientific discoveries. Engineers then take these new electrical components and create new, more efficient products using this new technology. Scientists in electrical engineering discover new fundamental ways by which electrical components function. These discoveries are then used to produce products that are smaller and more efficient than the same products made through an older method.

This process of finding new scientific discoveries and creating new products based on these new discoveries, is one that has existed for over 100 years in the electrical industry. The relationship among science, technology and engineering is often not easy to distinguish, and the three areas often, frequently overlap. This overlapping relationship often causes a blurring of the lines between science, engineering, and the technological products that are created through their efforts.

Some of the products created by using current technology help the engineering process become more efficient and productive. In the last four years software has been developed which aids the hardware development process by completely simulating hardware and software design on the personal computer (PC) prior to constructing a prototype and starting the manufacturing process. This drastically reduces the development time for products and has also enabled the development of complex products with relatively few engineering design team members. Software is currently being released that automatically creates assembly language code for a particular chip from the simulation block diagrams created in the conceptual stages of the design process. This automatic code creation, dramatically reduces the labor involved in the electronic device design process. Although it may be advertised as automatic code creation, one still has to be astute with both the higher level C language and the lower level assembly language that is specific to the type of computer chips used in a design, to properly debug the code in order to make the electronic device work correctly. It does not take the process of code creation totally out of the hands of the electronic device designer, but can with some designs convert system design block diagrams created in design simulation software into useable assembly language code. The labor process involved with code creation is diminished but not eliminated. Figure 1 on the next page shows a flow chart of a microcontrolled electronic device design process from the perspective of software development tools used in the design process.

The process involved on the software development side of electronic circuit design uses the software packages listed in figure 1 during different stages of the design process. These particular software packages were used in the design of this electronic kit. These software packages listed in figure 1 are by no means the only packages available on the market today, but they do control the largest market share among electronic device designers and are setting the future trends in software development which streamline the electronic circuit design process.

New synergistic developments between software implementation and computing power are making the design process for electronic devices easier and are resulting in a decreased time to market for the design of electronic devices. One design engineer using this new technology can accomplish in the same amount of time what used to take a design team of several engineers to accomplish. These recent computing and software developments and the future of electronic device design are moving in the direction of automatic code creation. In the near future there will be higher quality software that automatically takes a design from the block diagram representation of the system, generates the code necessary to implement that design on a programmable computer chip, and creates the circuit diagram needed to prototype the electronic device automatically.

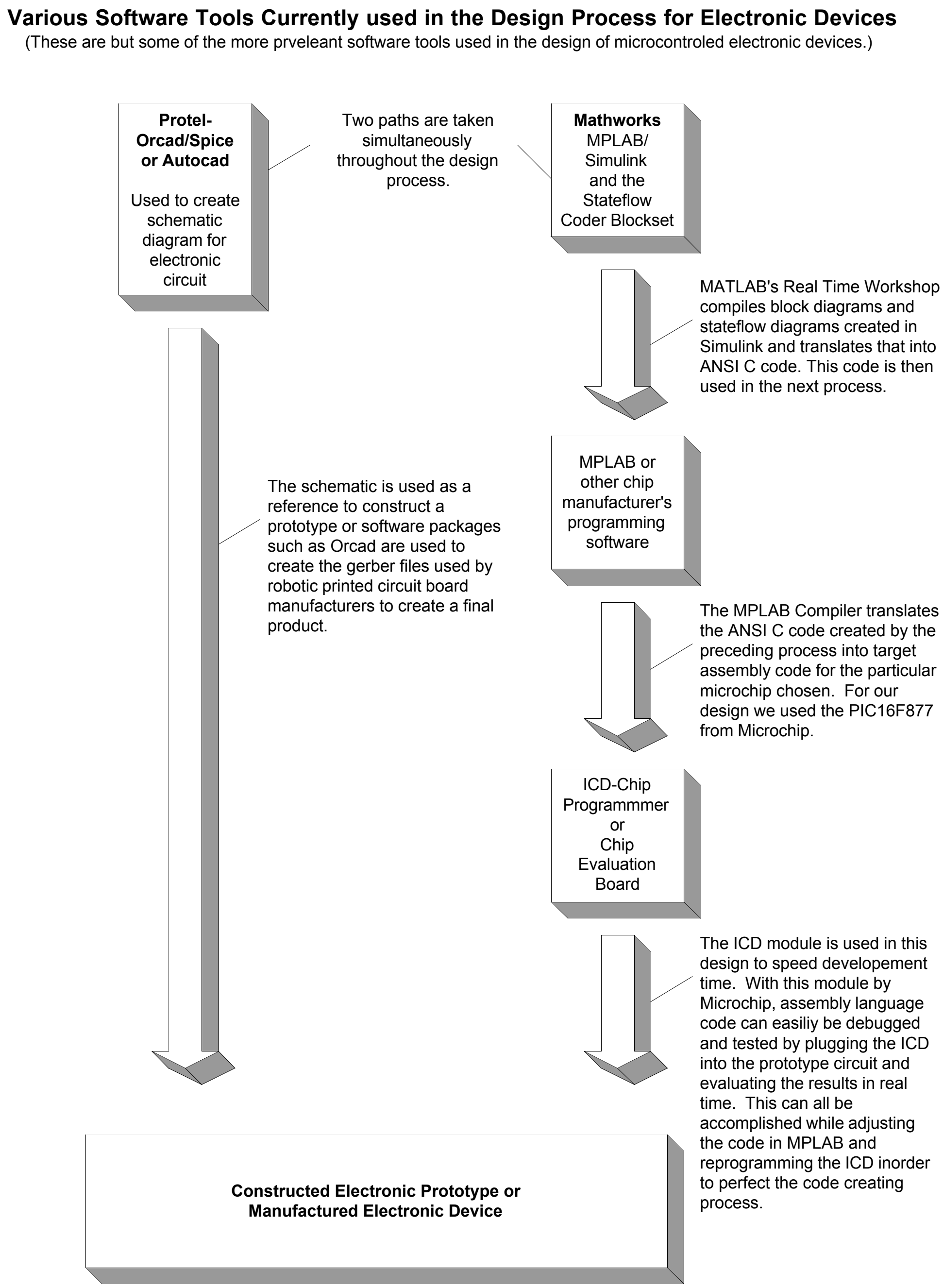
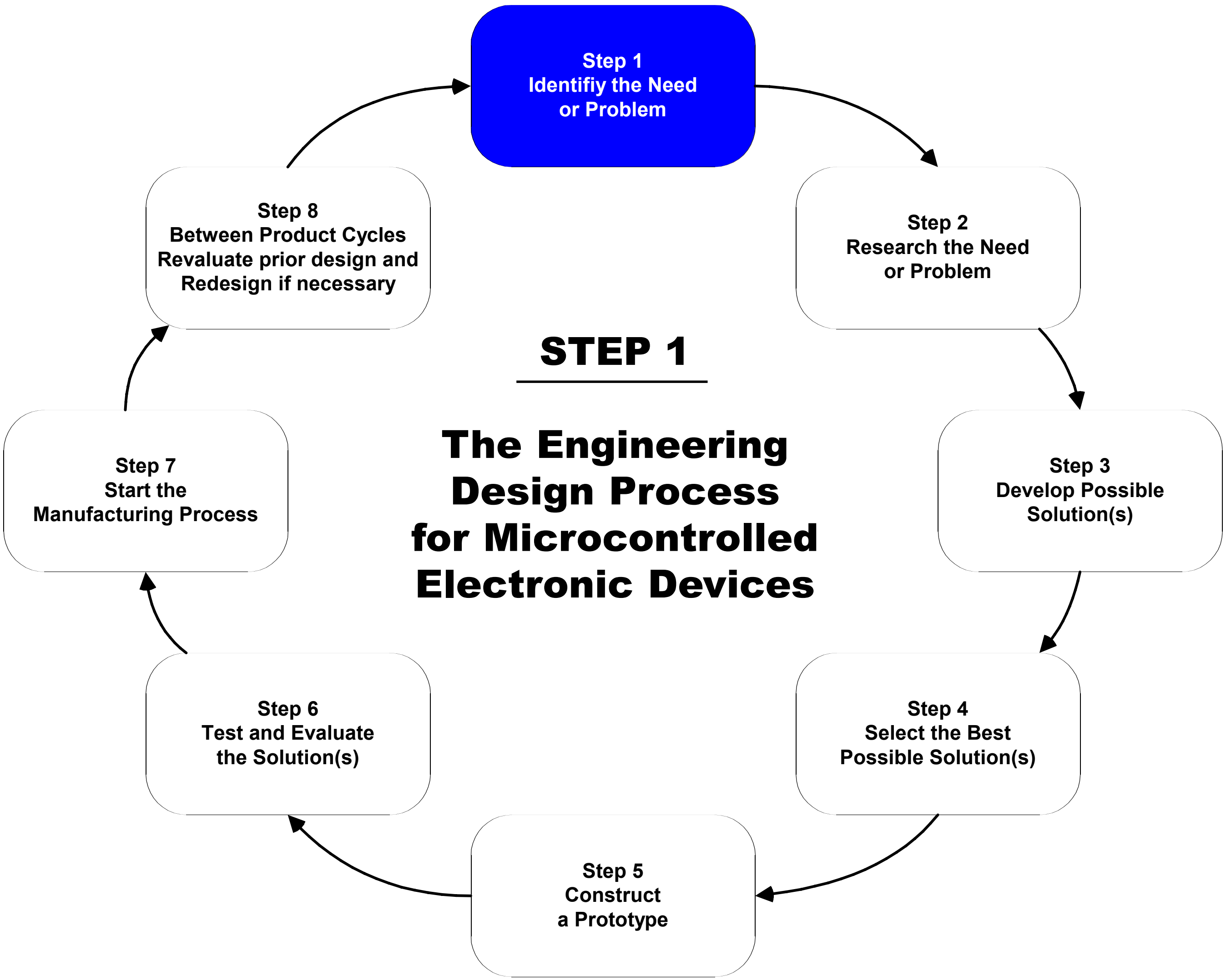


Figure 1

Mathworks, the creators of Matlab™ and Simulink™ a major provider of software and hardware simulation software, is currently moving in this direction and already has software that can generate assembly language code from block diagram representations. Another major hardware simulation software company Protel Inc. has recently acquired Tasking Inc. to bridge the gap between software development for the programming of computer chips, and the development of the electronic circuit boards where the chips reside. There is a whole host of mergers, acquisitions and partnerships occurring in this area as chip manufactures and electronic design simulation software providers' team up to create an all-in-one solution for the development of electronic device designs. Currently, there are many software development providers that aid in the design of electronic devices for the various stages in the design process. Some of major providers of simulation and development software are as follows: Mathworks, Protel, Orcad, Microchip, Motorola, and Texas Instruments.

Together science, engineering and technology are working to make the design process easier so that more people in our society may take part in the technical revolutions of the 21st Century. This cooperation among science, engineering and technology allows an engineer to focus on producing solutions to problems rather than being preoccupied with the tangential processes involved with the solution.


Step 1
Identifiy the Need
or Problem
Step 2
Research the Need
or Problem
Step 3
Develop Possible
Solution(s)
Step 4
Select the Best
Possible Solution(s)
Step 5
Construct
a Prototype
Step 6
Test and Evaluate
the Solution(s)
Step 7
Start the
Manufacturing Process
Step 8
Between Product Cycles
Revaluate prior design and
Redesign if necessary
STEP 1
The Engineering
Design Process
for Microcontrolled
Electronic Devices

Step 1. Identify the Need

The design process begins when there is a need perceived. Wherever there are people, there are problems requiring solutions. In some cases the designer may have to invent a product. An example might be an electronic healthcare device that can detect cancer at its earliest stages, or an electronic device that helps to eliminate traffic accidents. At other times the designer may change an existing design. For example, the brakes of an automobile were redesigned into anti-lock brakes out of the need to stop more quickly on slippery surfaces. This particular need had existed for many years but the technology at the time was not advanced enough to produce anti-lock breaks that were safe, reliable and economically practical. In this specific case, designers improved upon an existing product to make the product work better.

From computer chips that process millions of instructions every second, to radar systems that detect weather patterns days in advance, electrical and electronic engineers are responsible for a wide range of technologies. Electrical and electronics engineers design, develop, test, and supervise the manufacturing of electrical and electronic equipment. Some of this equipment includes power generating, controlling, and transmitting devices used by electric utilities; electric motors, machinery controls, lighting and wiring in buildings, automobiles and aircraft; and in radar and navigation systems, computer and office equipment, and broadcast and communications systems.

Electrical engineers specialize in different areas of the industry such as power generation, transmission, and distribution; communications; computer electronics; and electrical equipment manufacturing-or any subdivision of these areas-industrial robot control systems, or aviation electronics, for example. Electrical engineers design new products, write performance requirements, and develop maintenance schedules. They also test equipment, solve operating problems, and estimate the time and cost of engineering projects.

Electrical engineers held about 357,000 jobs in 1998, making it the largest branch of engineering. Most jobs were in engineering and business consulting firms, government agencies, and manufacturers of electrical and electronic equipment, industrial machinery, and professional and scientific instruments. Communications and utilities firms, manufacturers of aircraft and guided missiles, and computer and data processing services firms accounted for most of the remaining jobs. California, Texas, New York, and New Jersey-states with many large electronics firms-employ over one-third of all electrical and electronics engineers.

Electrical engineering graduates should have favorable job opportunities long into the future. The number of job openings resulting from employment growth, and the need to replace electrical engineers who transfer to other occupations or leave the labor force is expected to be in rough balance with the supply of graduates. Employment of electrical and electronics engineers is expected to grow between 21-35% for all engineering occupational categories through 2008, which is faster than average.

Projected job growth stems largely from increased demand for electrical and electronic products, including computers and communications equipment. The need for electronics manufacturers to invest heavily in research and development in order to remain competitive and maintain their scientific edge will provide openings for graduates who have learned the latest technologies. Opportunities for electronics engineers in defense-related firms should improve as aircraft and weapon systems are upgraded with improved navigation, control, guidance, and targeting systems. However, job growth is expected to be fastest in service industries, particularly consulting firms that provide electronic engineering expertise.

Median annual earnings of electrical engineers were $62,660 in 1998. The middle 50 percent earned between $47,080 and $80,160. The lowest 10 percent earned less than $38,470 and the highest 10 percent earned more than $91,490. Median annual earnings in the industries employing the largest numbers of electrical engineers in 1997 were:

Federal government : $68,000
Computer and office equipment: $67,100
Electronic components and accessories: $59,900
Communications equipment: $59,400
Engineering and architectural services: $58,900

According to a 1999 salary survey by the National Association of Colleges and Employers, bachelor's degree candidates in electrical and electronics engineering received starting offers averaging about $45,200 a year; master's degree candidates, $57,200; and Ph.D. candidates, $70,800.

The need to produce this educational electronic kit arose from the recent increased demand for electrical engineers in the marketplace. The need to encourage junior high and high school students to pursue further education at the collegiate level in electrical engineering has become an ever-important one. The demand for labor in this field has grown dramatically over the past few years and is expected to continue for the foreseeable future. At the same time school curriculum standards are changing to further promote engineering and technology on the junior high and high school level.

Also there is a growing trend to interface microcontrolled electronic devices with the PC in order to exploit the computing power, accessibility, and the software written for the PC. Software written for the personal computer can receive signals from microcontrolled electronic devices and manipulate them in such a way as to solve a problem or fill a particular need. Figure 2 on the following page illustrates the general connection diagram for microcontrolled peripheral devices interfacing with the PC.

This growing need for electrical engineers in the workplace, and the growing need to use technology in the workplace is putting pressure on teachers in schools across America to teach technology. The following paragraphs particularly stress this point and are taken from an article in Wired News dated June 30th, 2000 titled "The Need to Teach Teachers Tech". The article touches upon the need to supplement the classroom with educational material that allows the teacher to focus more on teaching and less on the actual technological subject being taught. The article begins with:

> "Computers aren't magic, but teachers are. Students are," Intel's CEO Craig Barrett said. That sentiment, combined with the surprise appearance of Education Secretary Richard Riley, the meeting of a federal commission on Web-based education, and the record turnout at the conference, marked a significant step for proponents of technology in education.
>
> "Having Riley here is a great legitimizing of technology," said Sue Collins, the general manager of bigchalk.com, and a member of the congressional Web-based education commission. "It shows that technology is a very legitimate part of what every teacher and every school ought to be doing."

But despite the attention from education bigwigs and national figures, problems with technology in education still loom, and no one yet has found a perfect solution, educators say.

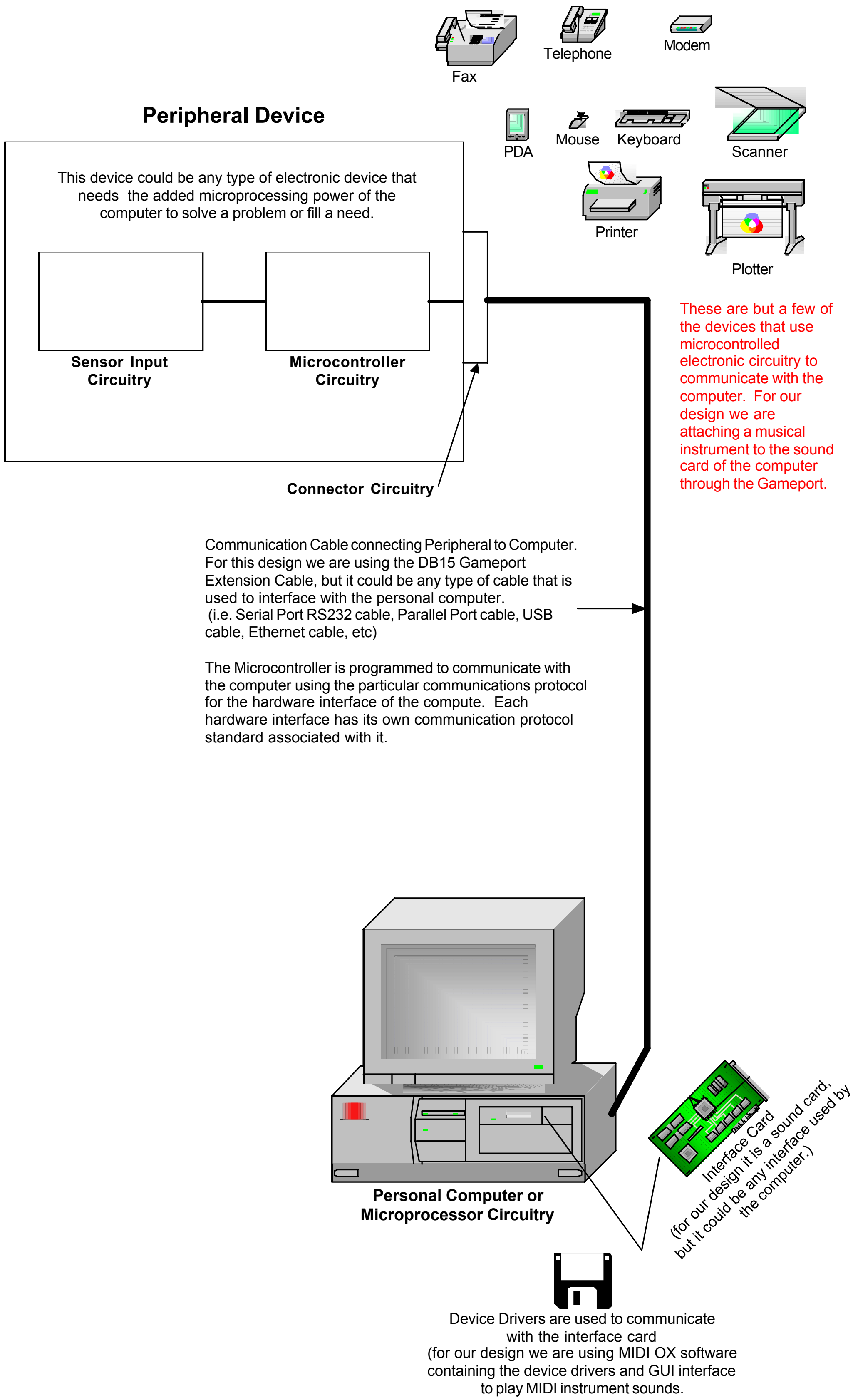


Figure 2

Intel's Barrett, said that while the United States has the highest number of connected schools and classrooms -- and has spent $40 billion in education technology so far -- there has been "little return on investment."

The number of engineers has not kept up with the demand, and desperate companies have turned to other countries to find qualified workers, sparking the heated debate over H-1B visas.

"We're not doing particularly great (in the education system)," Barrett said. "There seems to be a disconnect somewhere." To move forward, Barrett said, the focus must be on the

teachers first. At that conference he announced Intel's Teach to the Future program, a two-week course that will instruct 400,000 teachers around the world on how to integrate technology into their curriculum.

Educators agree that programs like that are needed.

"Teachers are really busy and they get overwhelmed," said Kathy Kugler, the technology coordinator for the Tukwila, Washington school district. "They need lots of support."

The International Society for Technology in Education developed the National Educational Technology Standards, which were also announced at the conference. According to NETS, teachers must be able to demonstrate skills and concepts in technology, and create lessonplans that use technology to enhance learning. They must use technology for their own professional development, and must demonstrate legal and ethical practices when doing so. Teachers should use resources that affirm diversity, and facilitate equal access to these tools for all students. To achieve these goals, educators will need support from the government, a topic which was also addressed at the conference.

The Web-based Education Commission, chaired by Senator Bob Kerrey (D-Nebraska), met in Atlanta this week, and members there emphasized the need for research and development, teacher training, and more funding.

This commission, in addition to the Glenn Commission -- which is studying more effective ways to boost science and math scores in the United States -- will make policy recommendations to Congress and Secretary Riley this fall.

Riley said the Department of Education will release a five-year education technology plan this fall. He also said that there are plans to form a "teacher corps," made up of technology-savvy teachers who can help train their colleagues.

And while the record attendance at NECC demonstrated that teachers are open to technology(,) and want to incorporate it into their curriculum, training them will take valuable time.

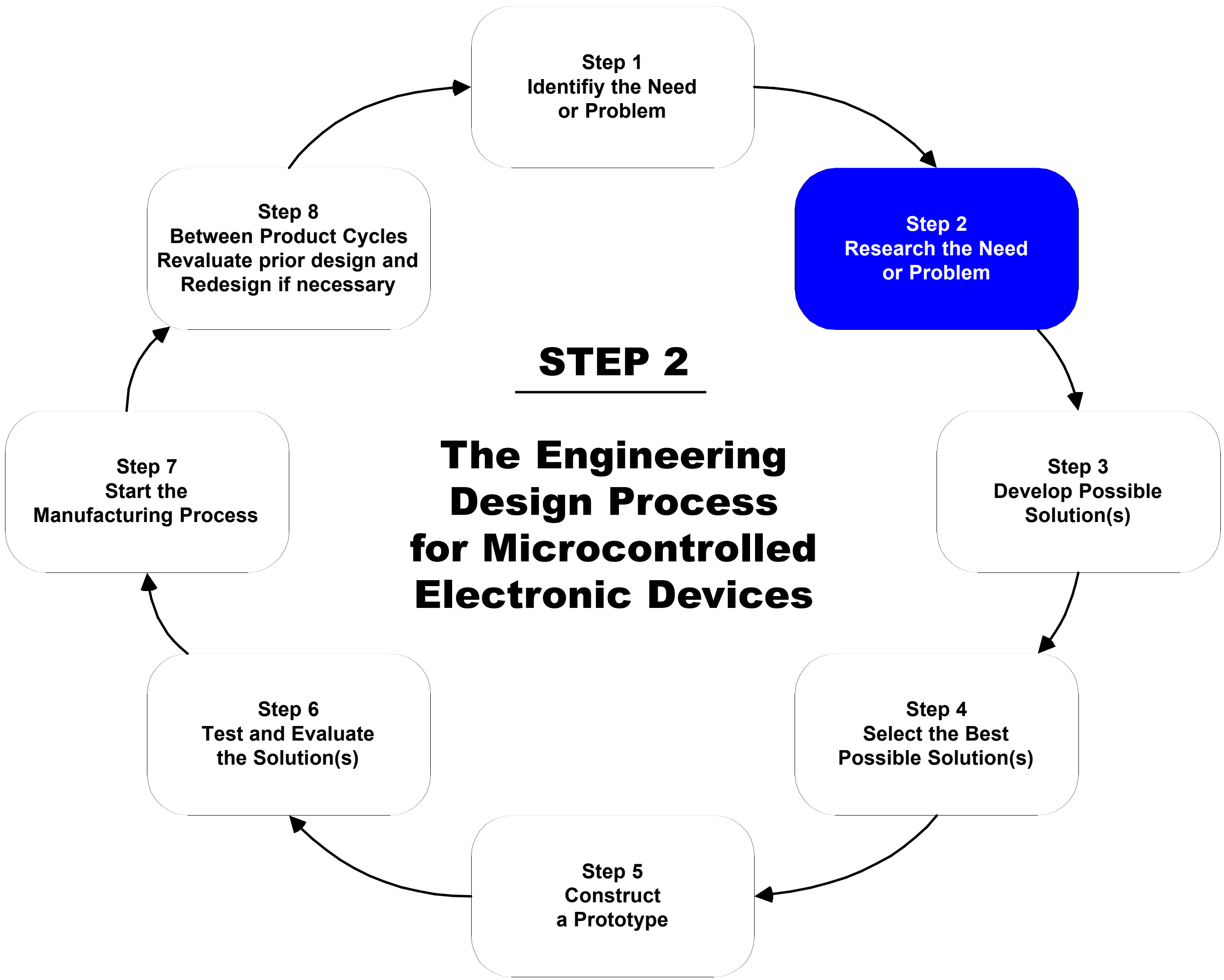
"(Teachers) are overwhelmed," said Marie Parrish, a second-grade teacher at Tukwila Elementary.

"They're overwhelmed with education reform and trying to meet standards," Kugler added.

But educators and policy makers agree that technology is not going to go away, and something must be done now.

"If timing is everything, let us seize the moment," said Atlanta Mayor Bill Campbell, another conference speaker.

All of the needs listed throughout this section are ones that we seek to solve through our educational design series: MIDI 8 piece electronic drum set. Throughout the next several steps in the design process we will see how these needs are met by going through the design process for microcontrolled electronic devices.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Step 2. Research the Need for possible solutions

Writing a clearly stated design brief is just one step of the design process. Now you must write down all the information you think you may need for a solution. Some factors to consider are the following:

FUNCTION: A functional object must solve the problem described in the design brief. The basic question to ask is: "What, exactly, is the use of the article?"

APPEARANCE: How will the object look? The shape, color, and texture should make the object attractive.

MATERIALS: What materials are available to you? You should think about the cost of these materials. Are they affordable? Do they have the right physical properties, such as strength, rigidity, color, and durability?

CONSTRUCTION: Will it be hard to make? Consider what methods you will need to cut, shape, form, join, and finish the material.

SAFETY: The object you design must be safe to use. It should not cause accidents.

The first factor to consider when solving a problem like this, is the function of the object. For the particular problem stated in Step 1, the object is to function as a tool to show students and hobbyist alike what is possible in the field of electronic design. The object is also to function, as a way for people to look inside the electrical engineering design process for microcontrollers. The object will also function in a way to keep people interested throughout the entire design process. And finally, the object is to function as a teaching tool that gives the hobbyist or student insight into the design process for microcontrollers by building an electronic kit which uses a pre-programmed microcontroller in the design. The teaching tool also is to demonstrate how electronic devices interface with the personal computer to create new products that leverage the effect of the microprocessor controlled computer and the microcontrolled electronic device. The electronic kit must also be easy to build, and must be able to be put together more than once.

The second factor to consider is the appearance of the object under consideration in Design Step1. The object should attract students and electronic hobbyists to the product by appearing fun and interesting. What they are building as an electronic kit should attract the interest of the potential customer. The size, shape and color of the object will depend on the type of electronic device that is designed.

The third factor to consider is the material that will be used in the design of the object. For this project, the materials that are used are a microcontroller and other common electrical and electronic components such as:resistors, capacitors, diodes, a crystal oscillator, an optoisolator, and a Schmitt trigger. These electrical components have all the right properties needed to build a wide variety of electronic devices. The electronic components used in this electronic kit must be highly reliable and possess the right physical characteristics for them together to produce the desired function of the object that we are looking for. The tools that were needed to design and construct this electronic device were:

1. An oscilloscope - used to analyze low frequency signals used as inputs to, and outputs from the microcontroller.
2. A Digital Multimeter - used to test the various resistor, capacitor values, along with the voltage levels across critical points in the circuit.
3. A computer used to write the program for the microcontroller, and used to simulate the design of the electronic device prior to prototyping.

The fourth factor to consider is how the object will be constructed. In our case, we are constructing an electronic device that will spur the interest of students and hobbyist into the design of electronic devices using microcontrollers. Constructing such a device must be mechanically simple, and must be able to be built more than once. The platform that will be used to build such a device is the solderless breadboard. Circuit components are pressed into this type of platform and can be pulled out if the project is to be used again. An extraction tool is used to pull the IC's (Integrated Circuits) from the solderless breadboard.

The design platform still needs a way to supply power to the circuit on the solderless breadboard. microcontrollers from Microchip use a supply of 5V DC (direct current voltage supply) to power the microcontroller and all other electrical components used in the circuit use a 5V DC power supply. A typical 5VDC wall transformer is used for this purpose. Wall transformers are commonly used to connect electronic devices to the 120V AC (alternating current) wall outlet power supply of homes and other types of buildings.

Once the electronic circuit design platform is confirmed, other methods are used to complete the design of the product. These methods will involve some basic math and science skills related to electrical and electronic engineering and will also involve knowledge of assembly language programming. For the documentation of this particular design we are not concerning ourselves with the actual programming of the microcontrollers, that topic is an entire subject area of its own usually taken on the college level. For this electronic kit we supply a pre-programmed microcontroller.

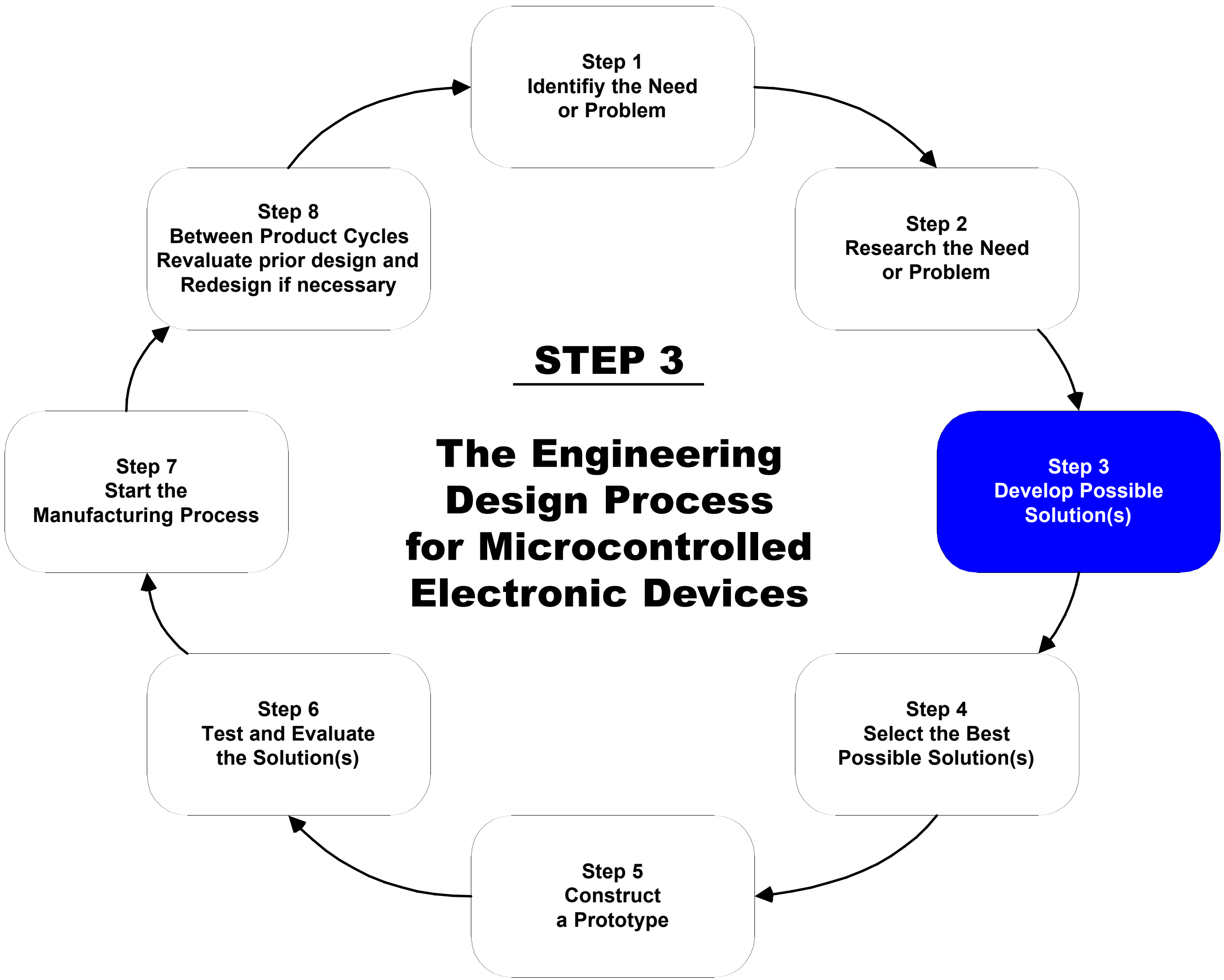
Basic math and science skills are used to properly choose the values of the various electrical and electronic components that are used to provide inputs to, and to control and direct outputs from the microcontroller. The knowledge of algebra and the physics of electrical components is used to design the Input/Output (I/O) circuitry. The microcontroller can accept certain types of input at the pins located on the computer chip. Some background information about microcontrollers and the algebra and physics associated with electrical components such as: resistors, diodes, capacitors, reset switches, oscillators, opto-isolator, Schmitt trigger and the speaker are listed on the next page. Click on the links located on the next page to get more information about the particular topic. Go through the background information to familiarize yourself with the basic concepts behind all the electrical and electronic components listed. All your knowledge of math and physics comes into play during this stage in the design process.

- Basic Electrical Concepts
- Number Systems
- The Microcontroller
- The Resistor
- The Diode
- The Capacitor
- The Reset Switch
- The Oscillator
- The Optoisolator
- The Schmitt Trigger
- The Speaker

The background information given here is critical for understanding how electronic devices work, and is critical in determining what physical constraints will be placed on the designer as solutions to the problems are prepared. By this step in the design process for this electronic device, we were well on our way to preparing some solutions and already had a few in mind. Interestingly, this kit came from a pool of possible solutions that were considered when we conceived this series of electronic kits. Because safety, and ease of assembly were primary concerns, it was determined that a solderless breadboard would be used along with a 5V DC wall transformer as a power supply to form the basic platform on which the circuit could be built. That much about the product we did know at this point in the design process. That may not be the case for the design of all electronic devices, but in this case the solution to the design platform was thought of immediately, and was the only real solution to the particular function that was desired from the product in the previous design step. This type of design platform (the solderless breadboard) is the only product on the market that allows for the prototyping of microcontrolled electronic devices without the need for a HOT soldering iron and solder.

The fifth factor to consider is product safety. The solderless breadboard as a design platform for the circuit makes the product safe as it possibly can be. The low voltage of the circuit and the fact that no soldering is required for the product makes the product safe from the possibility of unnecessary burns due to a hot soldering iron, or an electrical shock from higher voltages used in other types of circuit designs. The solderless breadboard as a design platform makes the product much safer to use.

In the next design step, we will build on the solutions considered thus far and decide exactly what type of electronic device will be designed to meet all of the functional requirements established in the previous step. We will do this by examining what the functional requirements are for the object, and then figure out how to meet those functional requirements within the physical constraints placed on the designer by the electrical and electronic components listed above. These components make up all of the electrical and electronic components used in this electronic device. Take as long as you need to understand the concepts listed above. It is very important to understand those concepts before proceeding to the next step.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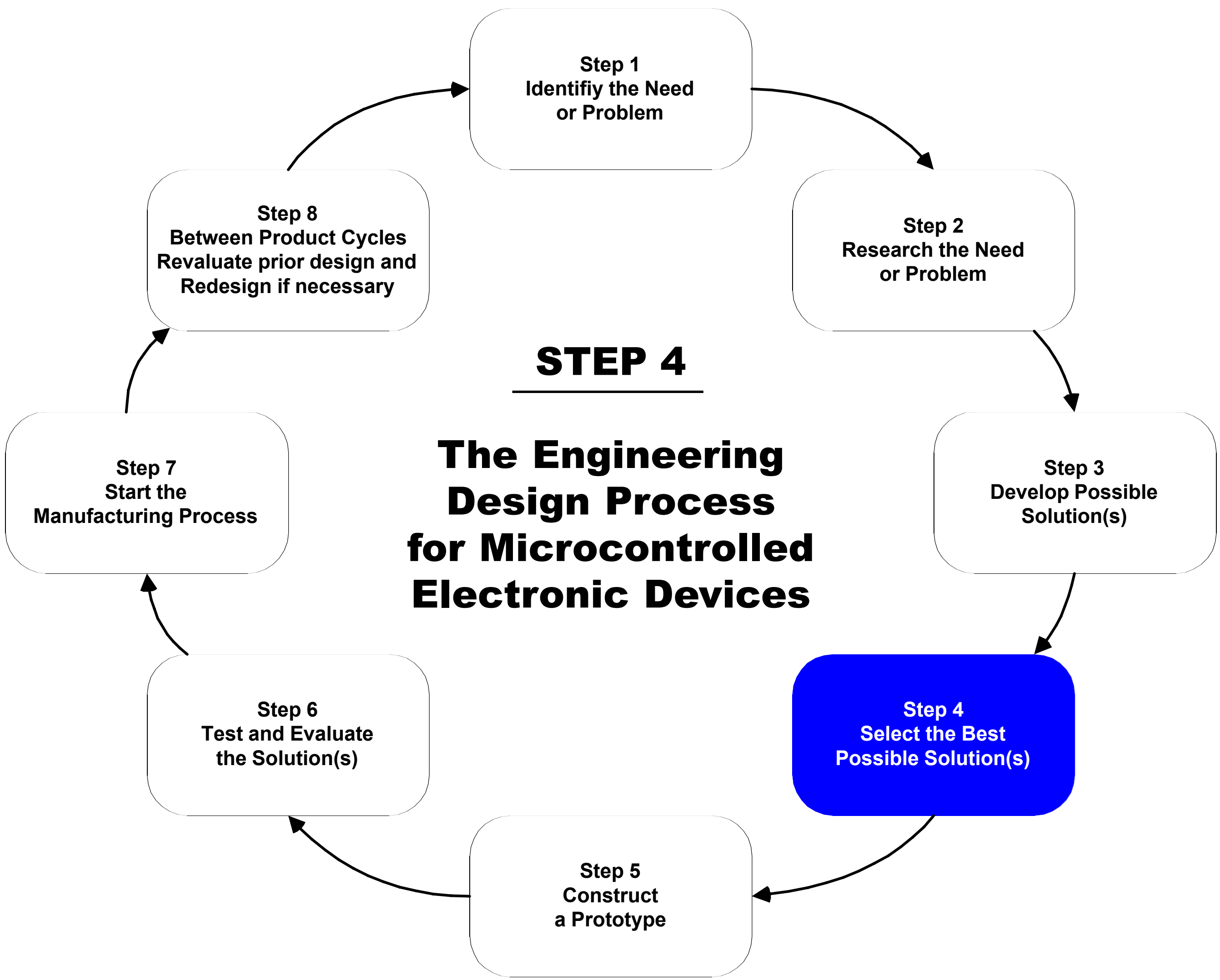
This sales brochure outlines just a small sample of the information contained in this text. Each step of the design process details the thoughts involved with that particular step while providing background information explaining how the electronic device functions and the various components used in its design.

Some of the topics discussed in this chapter are:

-The various ways that peripheral devices can communicate with the standard desktop PC.

-An explanation, explaining why the gameport connector was chosen as the communication path for our peripheral device to communicate with the PC over the other possible choices.

-A discussion about the soundcard's synthesizer, and the MIDI protocol.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Some of the topics discussed in this chapter are:

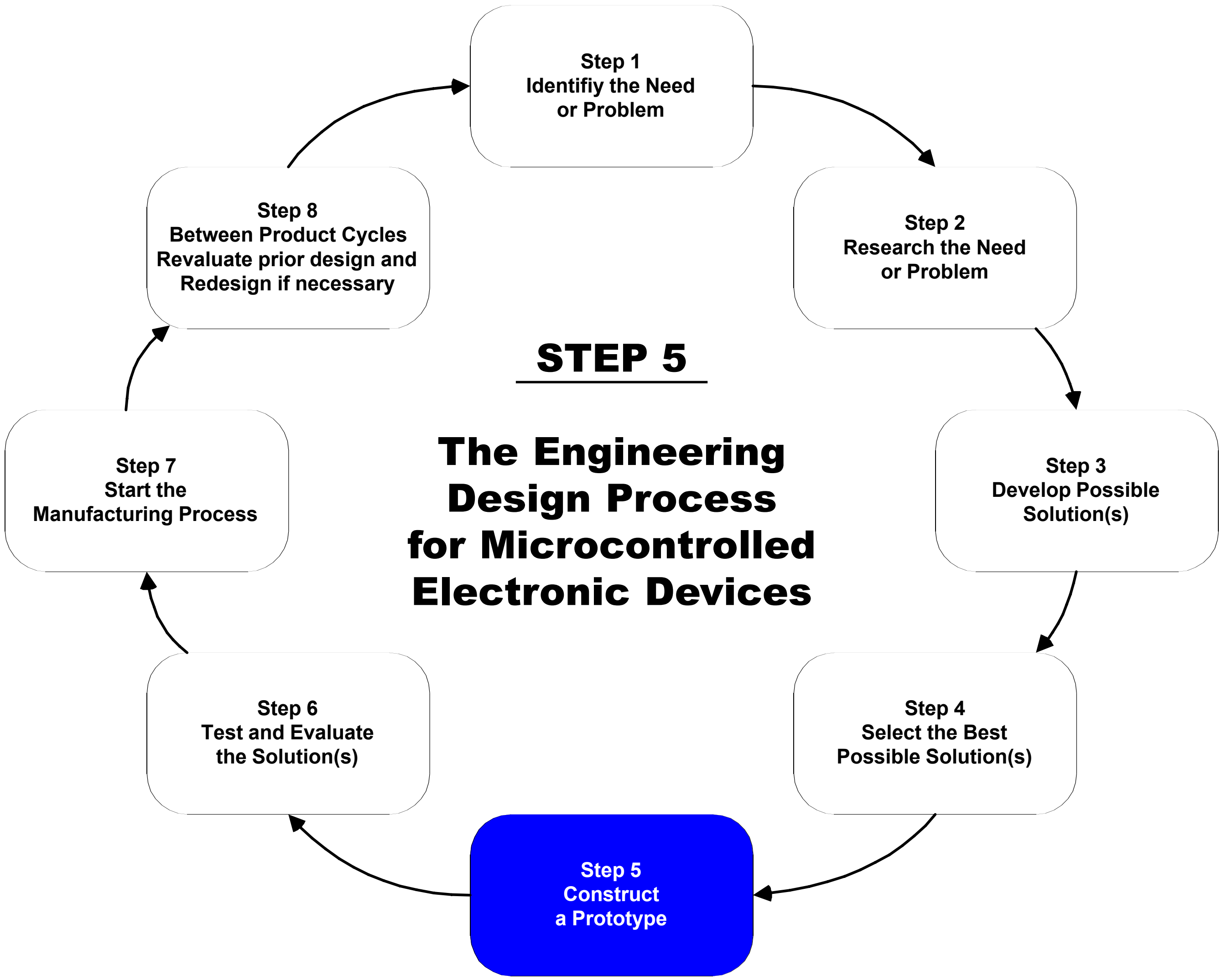
-An explanation of the process for selecting a microcontroller.

-The details of the specifications for the microcontroller chosen, and the reason it was chosen for this particular design.

-Gives background information about the microcontroller chosen for this design.

-Outlines the process for programming the microcontroller.

-Explanation about how the program works.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Step 5. Construct a Prototype

A model usually is either a full-size or a small-scale simulation of an object. Architects, engineers, and most designers use models as a way to represent their design solutions. The use of models is just one more step in the communication of an idea with the purpose of creating a product. It is much easier to understand an idea when presented in a three-dimensional form. A prototype is the first working version of the designer's solution. It is generally full-size, and often handmade.

***** Use the assembly directions to construct the prototype. Make sure to follow all the specially noted areas very closely. Any deviation from the prescribed installation could damage the components (i.e. Optoisolator, and microcontroller). Make sure to double-check all wiring at the specially noted points throughout the assembly process.**

The MIDI Electronic Drum Set Circuit Assembly Directions

As you go through these tasks, reference the circuit schematic to familiarize yourself with how drawn circuit schematics translate into actual circuit prototypes.

***** Special notice should be taken to eliminate the potential for static electrical discharges. If the area where this circuit is to be assembled is at a high potential for static electricity as is the case of carpeted floors, grounding oneself to discharge the potential static electricity is essential before handling any electrical and electronic components. Static electrical discharges through electronic components can cause component failure.**

Task #1:

Place the breadboard in front of you with row #1 of the breadboard appearing at the top, as shown in figure 1.

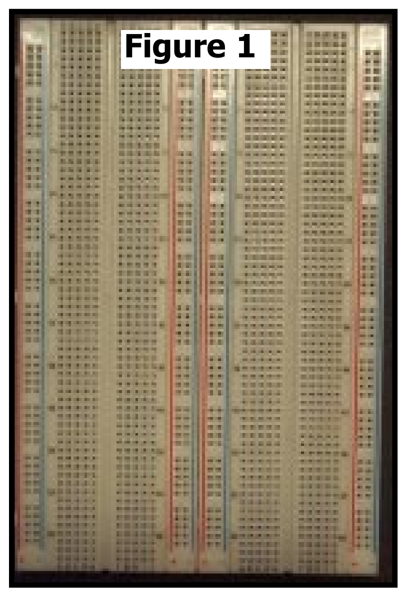


Figure 1

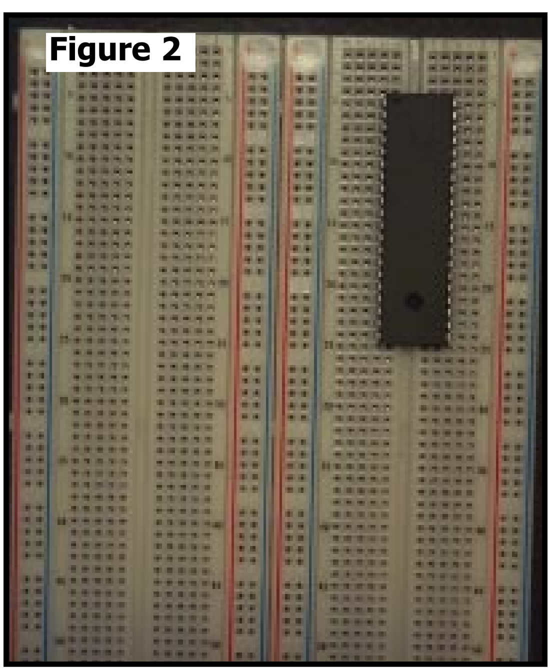


Figure 2

Task #2:

Install the PIC16F877 microcontroller onto the breadboard. First position the microcontroller so that the divot next to pin 1 on the surface of the microcontroller appears on top of the microcontroller as it is facing you. Then place the microcontroller with pin 1 positioned over hole ***d5*** on the breadboard and press the microcontroller pins into the holes of the breadboard, applying even pressure when inserting the microcontroller. Figure 2 shows how and where the microcontroller is to be placed onto the breadboard.

Task #3:

The next component to install is the optoisolator. The optoisolator is placed directly under the micro-controller. First position the chip so that the dark dot on the surface of the chip is in the top left corner as the chip is facing you. Then evenly press the optoisolator onto the breadboard so that pin 1 of the chip aligns with hole ***e30*** of the breadboard. Figure 3 shows how and where the optoisolator is to be placed on the breadboard.

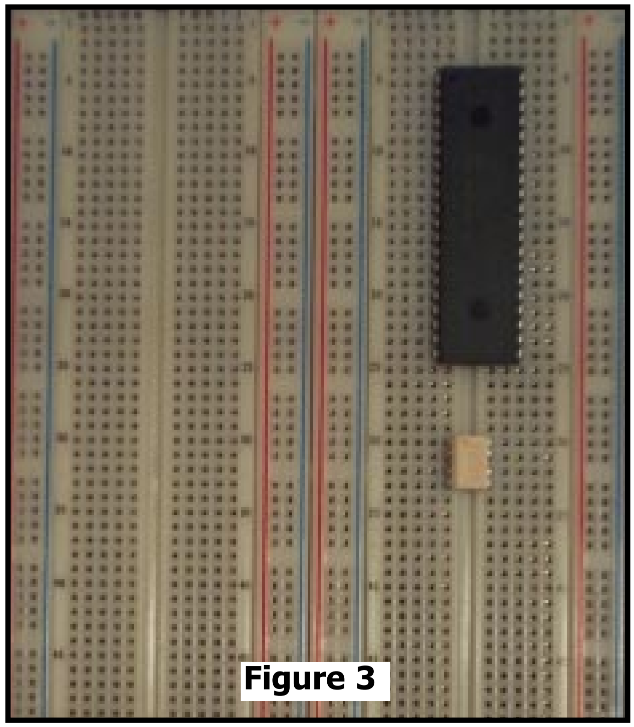


Figure 3

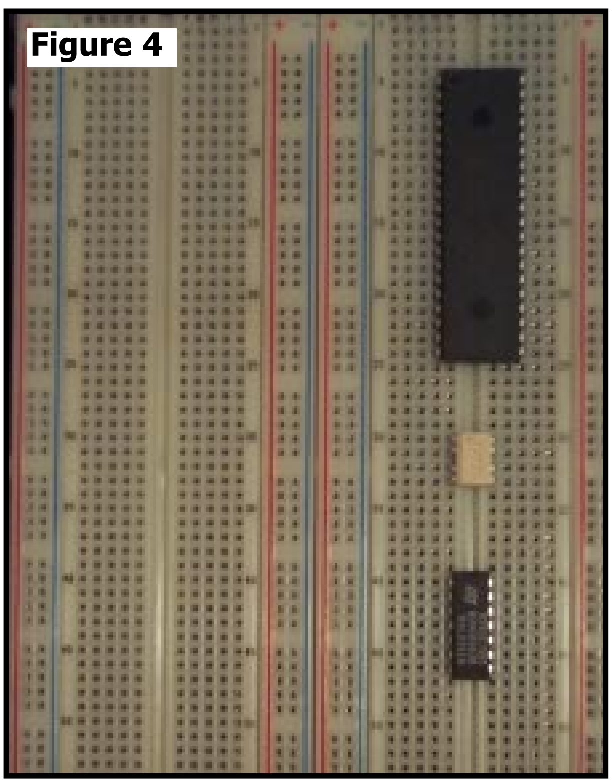


Figure 4

Task #4:

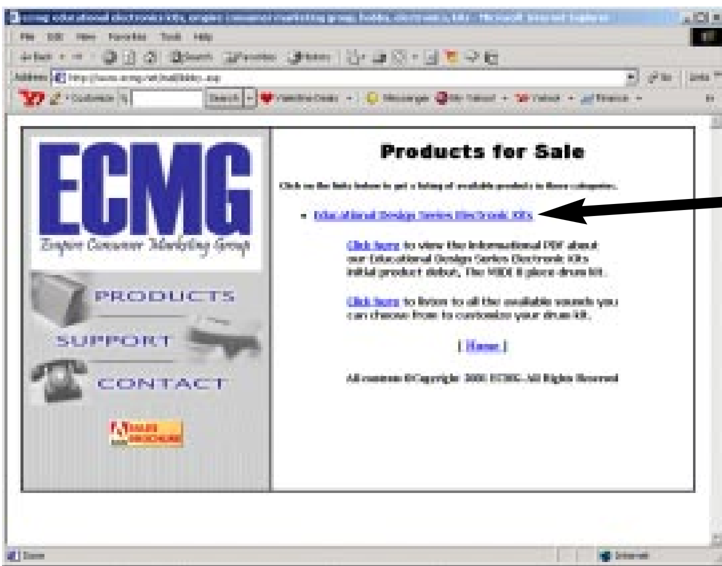
The next component to install is the Schmitt trigger 74HC14. The Schmitt trigger is placed directly under the optoisolator on the breadboard. First position the 74HC14 so that the half moon curved divot, located at the middle end on the surface of the chip, is positioned so that it appears on top. Then evenly press the Schmitt trigger onto the breadboard so that pin1 of the chip aligns with hole ***e40*** of the breadboard. Figure 4 shows how and where the Schmitt trigger is to be placed onto the breadboard.

Detailed Product Brochure

Ordering a drum kit from ECMG is easy and secure. Just follow the order process below that outlines how to use our secure shopping cart technology. Our shopping cart system utilizes 128 bit encryption and features secure online credit card processing to protect your valuable information.

STEP 1

Point your web browser to http://www.ecmg.net and click on the products button.



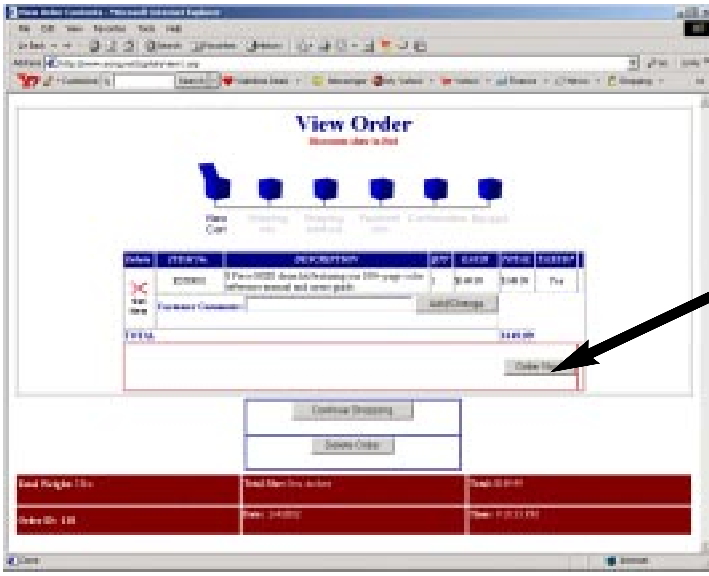
STEP 2

Click the "Educational Design Series Electronics Kits" link.

STEP 3

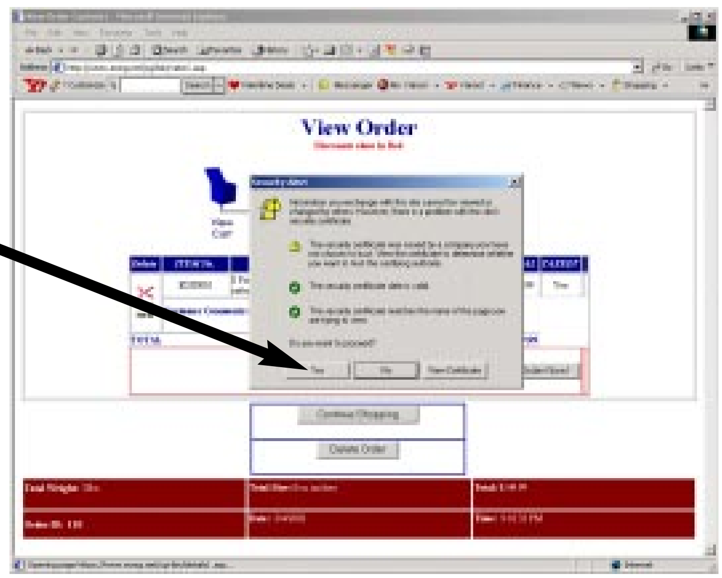
Add the number of drum kits you wish to purchase here and click the yellow button to add them to your shopping cart.

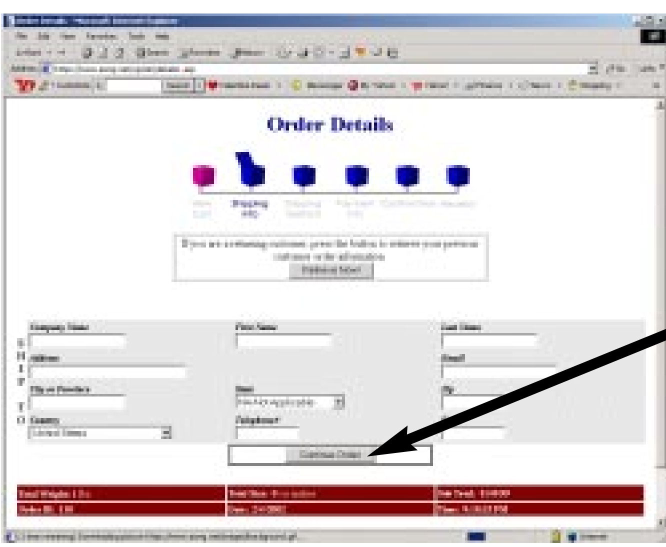
Detailed Product Brochure



STEP 4
Click the "Order Now" button.

STEP 5
Click "Yes" to accept our secure certificate.

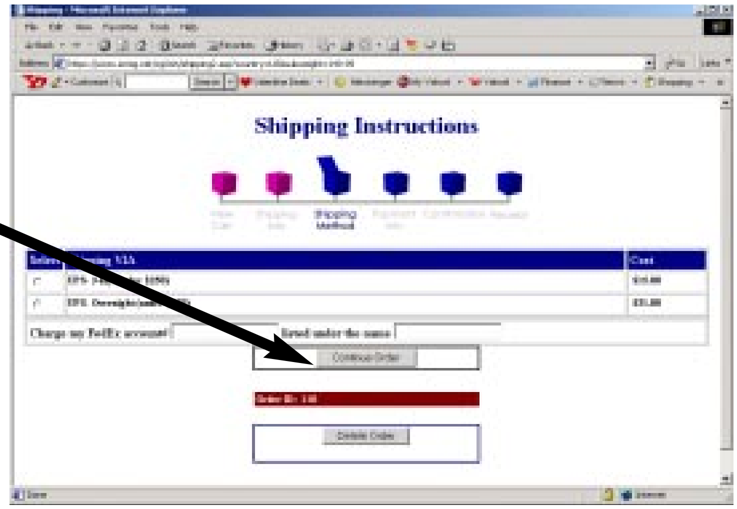




STEP 6
Fill out the necessary information for us to ship you your purchase, and then click the "Continue Order" button.

Detailed Product Brochure

STEP 7
Select your desired method of shipment, and then select the “Continue Order” button..



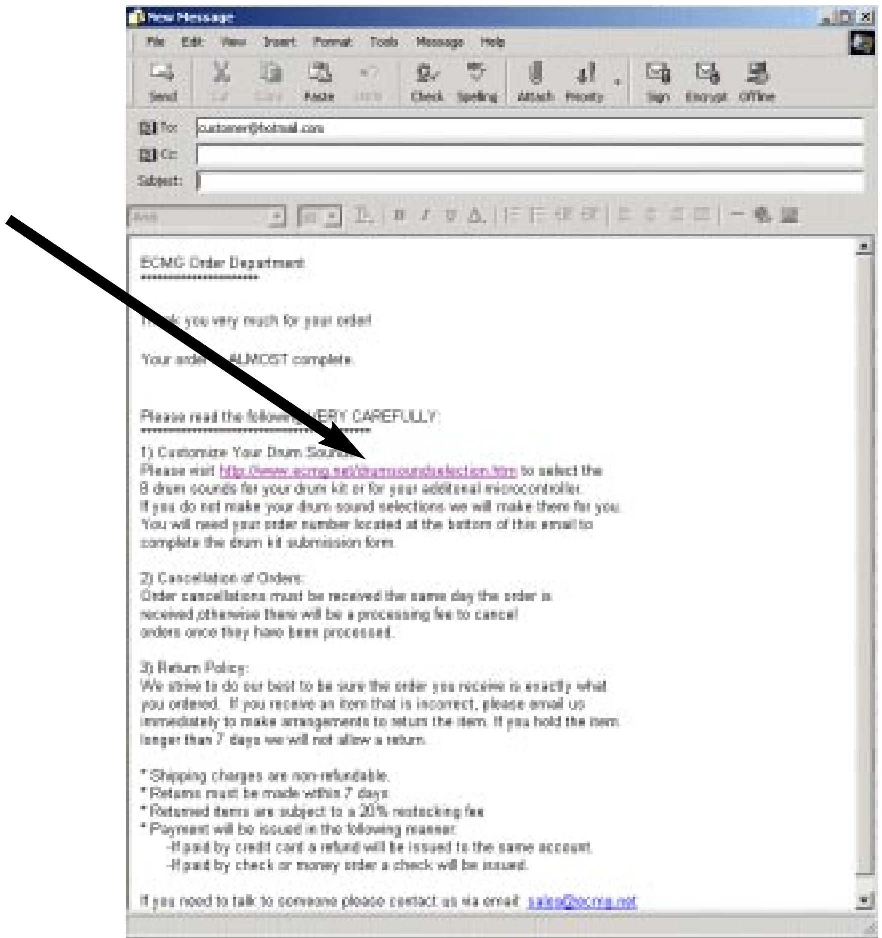
STEP 8
Choose the type of credit card you would like to use; then fill out the proper billing information to correctly verify your credit card, and then select the “Continue Order” button.

STEP 9
This is your order summary page. Please verify that all the information on the screen is correct, and then select the “Continue Order” button to have your credit card instantly processed through our 128 bit encrypted credit card gateway. After the successful processing of your order, you will have the option of having our shopping cart system email you a receipt.

A closed key notes that your browser’s encryption is working properly.

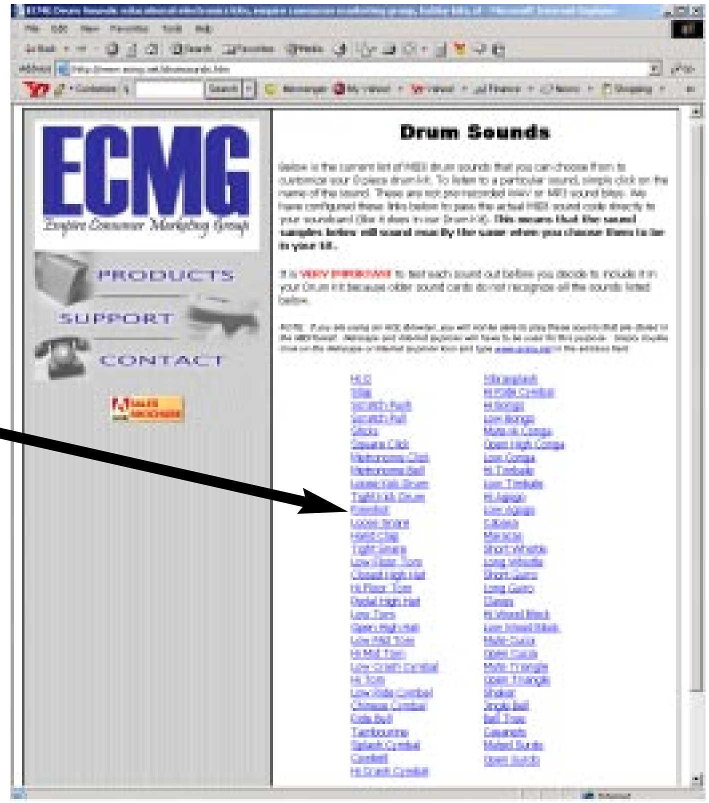
Once you have successfully completed your drum kit purchase you will be sent a receipt in your email mailbox. This email contains the final step in our order process. You will notice a link in the email receipt ECMG has sent you. This link takes you to a form on ECMG's website that will allow you to choose the 8 drum sounds which will be programmed into the microchip included with your kit.

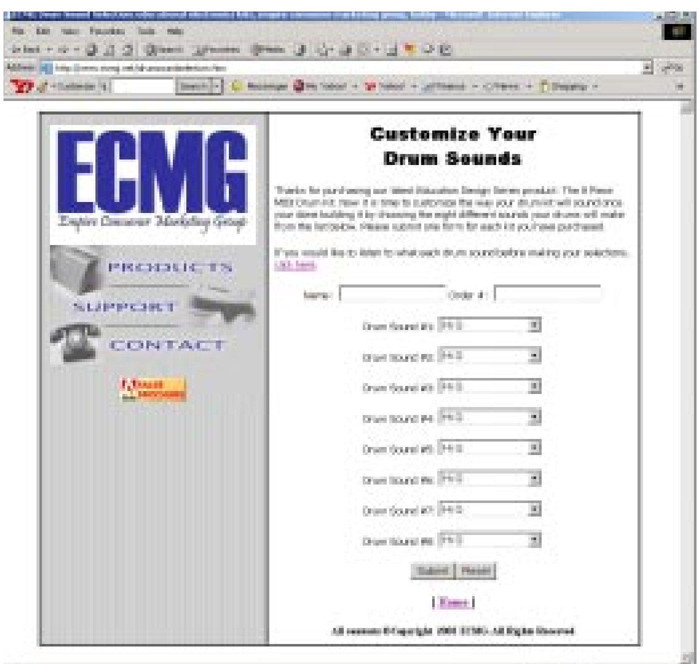
STEP 1
Click on the "Drum Sound Selection" link.



STEP 2
Open up another browser window and enter the following address http://www.ecmg.net/drumsounds.htm

This page provides all the current drum sounds that our kit supports. Since there are a variety of soundcards on the market, we recommend that you listen to each sound you would like to use for your kit BEFORE making your 8 choices. To listen to a particular sound simply click on the name of the sound.





STEP 3
Go back to the drum sound selection form you opened in step 1 and enter the 8 drum sounds using our pulldown menus. When you're finished selecting your 8 sounds, click the "Submit" button.

Detailed Product Brochure

ECMG is pleased to announce the official launch of their "Sales Referral Program". ECMG's "Sales Referral Program" allows everyone who refers a new customer to ECMG that purchases an 8 Piece MIDI Drum Kit, to recieve a FREE pre-programmed microcontroller chip ($25 Value). Having two microcontroller chips is like having two different sets of drums because each microcontroller chip can have up to 8 different sounds. Follow the 3 steps outlined below to refer someone TODAY !

STEP 1
Point your web browser to http://www.ecmg.net.

STEP 2
Click on the GREEN "Sales Referral Program" link.

STEP 3
Fill out the necessary fields on the form and hit the "Submit" button.