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Javelin Stamp Manual

Version 1.0

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Internet Javelin Stamp Discussion List

We maintain a Javelin Stamp discussion list for people interested in Javelin Stamps. Many people subscribe to the list, and all questions and answers to the list are distributed to all subscribers. It's a fun, fast, and free way to discuss Javelin Stamp issues. To subscribe to the Javelin Stamps List, visit the Tech Support section of the Parallax, Inc website. This manual is valid with the following software and firmware versions: Javelin Stamp IDE v2.0, Javelin Stamp firmware v$50

The information herein will usually apply to newer versions but may not apply to older versions. New software can be obtained free on our ftp and web site (ftp.parallaxinc.com, www.parallaxinc.com). If you have any questions about what you need to upgrade your product, please contact Parallax.

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e-mail	General	info@parallaxinc.com
	Sales	sales@parallaxinc.com
	Technical	javelintech@parallaxinc.com

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Manual Organization

This manual was written under the assumption that the reader's level of experience could be anywhere between beginner and advanced embedded Java™ aficionado. We recommend that you start from the beginning and work your way through this manual sequentially, especially if you are new to both circuits and Java. Make sure to try all the examples and understand how they work before moving on to the next. For those of you who do not fall at either end of the spectrum, below is a condensed table of contents with comments regarding the intended audience and uses of each chapter.

Preface

General information - discusses Javelin Stamp's features, this manual's format and conventions, resources and acknowledgements.

1: Introduction

General information - about the Javelin, its uses, equipment it can be used with, specifications, software, etc.

2: Javelin Quick Start

Recommended for all – includes step by step instructions for software installation, hardware setup, trouble shooting, a couple of example programs, an example circuit, and a software tour.

3: Beginners Guide to Embedded Java™ Programming

Recommended for Java newcomers and BASIC Stamp users - if you've never programmed in Java before, read this, and try the examples!

4: Application Examples – Circuits and Programs

Recommended for embedded newcomers and BASIC Stamp users – provides good examples for BASIC Stamp users to make the transition to Java based hardware design, and helps those new to circuit based programming projects get their feet wet.

5: Using the Javelin Stamp IDE

Recommended for all – the Javelin Stamp IDE is a powerful tool with many useful features.

6: Javelin Stamp Programmers Reference

If you are a Java programmer, pay close attention to the differences between Java for the Javelin and Java on your PC. For beginners, this is a good way to learn programming in Java.

7: Working with Objects

Recommended if you are still learning Java – by this point, if you were new to Java at the beginning of this manual, you are now well into the learning curve.

8: Object Reference

Recommended for all – whether you are an experienced Java programmer or you just finished Chapter 7, this chapter explains the Java library classes available for use with the Javelin.

9: Javelin Stamp Hardware Reference

Recommended for all – explains all the hardware related library classes and methods. If it has to do with a VP, a peripheral or an external circuit, the information is here.

10: Technical Details

Appendix material.

Java Programmers – READ THIS

The Javelin Stamp is a small yet powerful controller that makes use of a subset of Java 1.2. The Javelin Stamp has firmware enhancements (called Virtual Peripherals or VPs) that emulate, or virtualize, hardware devices such as UARTs, timers, A/D converters, D/A converters, and more. These VP's have been painstakingly optimized, and they take the form of native methods that make it easy to interface with just about any circuit or peripheral device. Many of these firmware features are similar to those that lead the BASIC Stamp's popularity, and others have long been on BASIC Stamp users' wish lists.

The flip side of the Virtual Peripheral firmware features is that they have been incorporated into the Javelin Stamp at the expense of Java purity. You will find the experience of developing applications with the Javelin Stamp uniquiely different from developing applications on a PC. To get to the rewards of a rapid prototype of your product design or project with minimal stumbling, we recommend above all that you try the many programming and circuit examples in this text. Before getting started on the examples, take a few minutes to review the reading list below. It will acquaint you with the scope of Javelin Stamp projects and help you avoid some of the programming pitfalls you might otherwise encounter.

Suggested reading for Java Programmers:

BASIC Stamp Enthusiasts – READ THIS

As with the Java Programmers who were addressed in the previous section, programming the Javalin Stamp is also likely to be very different from what you, the BASIC Stamp Enthusiast, are expecting. This manual has LOTS of example programs and circuits to help you transition from PBASIC to the Java subset used to program the Javelin Stamp. Especially if you are unfamiliar with Java, we strongly recommend that you work through the examples in this text sequentially. The majority of this manual's organization was established with you in mind, so, if you have not already done so, please take a look at the Manual Orginazation section at the beginning of this preface. If you are like the rest of us at Parallax, you probably can't wait to get started, so have fun with Chapter 2: Javelin Quick Start.

Manual Conventions

Below is a list of typographical conventions used in this manual:

`Monospaced` is used for:

- Words that are part of the language syntax when they are part of a sentence.
- Fragments of programs. The code snippet below is an excerpt from a program, but it cannot be run on its own. It has to appear in either a complete program or a complete class file, both of which are discussed next:

```
System.out.println("Not a complete program.");
```

A gray box is used for:

- Complete programs that can be entered into the Javelin Stamp IDE and executed on a Javelin Stamp, for example:

```
import examples.manual_v1_0.*;
public class CompleteProgram{
  public static void main() {
  CompleteClassFile example = new CompleteClassFile();
    System.out.println("Now, it's in a complete program.");
    example.displaySameMessageAgain();
  }
}
```

- Complete class files that can be instantiated by other programs. Here is an example:

```
package examples.manual_v1_0;
public class CompleteClassFile {
  public static void displaySameMessageAgain() {
    System.out.println("Now, it's in a complete class file");
  }
}
```

Resources and Technical Support

The inside cover of this manual has three sections pertaining to resources:

- Internet Access
- Internet Javelin Stamp Discussion List
- Contacting Parallax

> Follow the Tech Support link at *www.javelinstamp.com* for the latest in tech support contact info, discussion group links, manual errata, answers to frequently asked questions, and more!

Free Downloads from www.javalinstamp.com

You can always get the latest revisions and updates of the following from www.javalinstamp.com:

- Javelin Stamp Manual
- Javelin Stamp IDE
- Application Notes
- Library Files

Acknowledgements

Chris Waters and Celsius Research provided the Javelin Stamp firmware and reference design. This manual was developed using information and research provided by Al Williams Consulting. Each and every employee at Parallax has made some contribution to the Javelin Stamp project, so as always, thanks to the entire Parallax staff.

The Javelin Stamp and Its Features

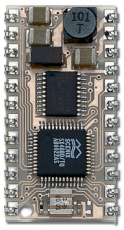

Figure 1.1 Javelin (top view)

The Javelin Stamp is a single board computer that's designed to function as an easy-to-use programmable brain for electronic products and projects. As shown in Figure 1.1, it's about the size and shape of a commemorative postage stamp. It is programmed using software on a PC and a subset of Sun Microsystems Java® programming language. After the program is downloaded to the Javelin, it can run the program without any further help from the PC. The Javelin can be programmed and re-programmed up to one million times.

We hope you enjoy working with your new Javelin Stamp as much as we have while preparing this manual. The Javelin Stamp is somewhat of a departure from Parallax's BASIC Stamps. Most notably, the Javelin is programmed using a subset of the Java programming language. Some of the other features that set the Javelin apart from BASIC Stamps are:

- The instruction codes for the Javelin are fetched and executed from a parallel SRAM instead of a serial EEPROM.
- The Javelin has 32k of RAM/program memory with a flat architecture. No more program banks, and no more tight squeezes with variable space.
- The Javelin has built in Virtual Peripherals (VPs) that take care of serial communication, pulse width modulation and tracking time in the background.
- Serial communication is buffered as a background process. When writing programs, all you have to do is periodically check the buffer.
- The Javelin Stamp Integrated Development Environment (Javelin Stamp IDE) software is a significant departure from a simple Editor and messages window combination. When used with the Javelin connected to a PC by a serial cable, this software can be used as a highly integrated in-circuit debugging system that allows you to run code, set breakpoints and view variable values, memory usage, I/O pin states and more. There is also no need for emulators; the Javelin can be placed directly into the circuit and debugged there.
- Delta-sigma A/D conversion.
- D/A conversion is accomplished in the background as a continuous pulse train delivered by an I/O pin. The pulse width modulation VP can also be used for generating pulse trains, frequencies, and D/A conversions in the background while your foreground code is free to perform other tasks

Those of you who appreciate the simplicity and ease of use of the BASIC Stamps need not worry; the Javelin Stamp has many features that BASIC Stamp users have come to depend on in their projects and designs. Here is a list of features built into the Javelin with BASIC Stamp users in mind:

- Synchronous serial communication (shiftIn/shiftOut)
- The ability to both send and measure discrete pulses (pulseIn/pulseOut)
- Frequency counting (count)
- Simple and intuitive methods for reading from and writing to I/O pins
- Measurement of RC charge and discharge times (rcTime)

BASIC Stamps have been used for everything from lessons in basic computer programming and electronics, all the way up to aerospace subsystem designs. We expect to see the Javelin used in a similar manner. However, by making use of the Javelin's new features, it can be used to tackle some more demanding designs that used to require larger processors.

Programming Language - Java™ for the Javelin Stamp

The Javelin's programming language supports many of the Java languages most useful features:

- Object Orientation - Inheritance, method overloading, polymorphism and static initializers.
- Exceptions - Try-catch-finally blocks and the ability to catch exceptions with a super-class.
- Strings – Programmed using many familiar Java commands.
- Custom Library Support - For many popular peripherals such as LCDs, temperature, AD, communication ICs, and common Internet protocols such as ARP, UDP, and PPP.

Java Differences	There are some differences between writing applications for your PC using Java 1.2 and the subset of Java used by the Javelin. Experienced Java programmers should consult the Summary of Java Differences section in Chapter 10.

Javelin Stamp Integrated Development Environment

Javelin Stamp Integrated Development Environment (Javelin Stamp IDE) offers the features that you would commonly expect from a source-level debugger:

- Multiple breakpoints
- Stack backtrace
- Inspection of all variables and objects, both static and dynamically allocated
- Single-step, run, stop, reset
- Built-in bi-directional serial message terminal for **`System.out.println()`** and **`Terminal.getChar()`** type debugging

The Javelin Stamp IDE is introduced in Chapter 2, and then discussed in more detail in Chapter 5. This IDE makes real-time debugging so easy that a PC emulator is completely unnecessary. It is just as easy to develop and debug on the Javelin module itself.

Virtual Peripherals

The Javelin Stamp firmware supports a variety of Virtual Peripherals (VPs). The VPs are separated into two separate categories, foreground and background. The background processes allow you to create UARTs, pulse trains, and a timer. Once created, background VP objects run independently from the program. Since time-sensitive tasks are taken care of by the VPs in the background, designs that used to be difficult become easy. For example, serial communication does not stop just because the Javelin is measuring the duration of an incoming pulse. The programmer simply needs to periodically check the serial buffer in the foreground code. Below is a list of background and foreground VPs.

Background VPs

- UART (Full duplex, HW flow control, buffered)
- PWM
- 32-bit Timer
- 1-bit DAC
- Delta/Sigma ADC

Foreground VPs

- Pulse count
- Pulse width measurement
- Pulse generation
- RC Timer
- SPI master

> *These Virtual Peripherals are built into the Javelin Stamp's firmware. Although you can write library classes that make use of these VPs, the VPs themselves cannot be modified or rewritten.*

How the Javelin Stamp Works

The Javelin Stamp's hardware architecture is shown in Figure 1.2. Programming and debugging is done via communication with the serial port. The COM circuit takes care of the voltage conversions necessary for a TTL device to talk with an RS232 port. The Java interpreter processes all serial port/COM circuit information. Whether it's byte codes, debugging data or serial messages, the interpreter processes the data and decides what to do with it.

When a program is downloaded, the interpreter buffers the program bytecodes and writes them to the EEPROM. Upon reset (or a power interruption), all the Javelin Stamp's I/O pins are set to input. The interpreter copies the bytecodes to the SRAM, then starts fetching bytecodes from the SRAM and executing them. The bytecode instructions can be executed very rapidly because all data is transmitted along parallel data busses instead of synchronous serial lines. A typical fetch and execute cycle involves a couple of read/write cycles. During a read/write cycle, the interpreter loads some of the 15 bit address information into an address

latch and writes the other portion directly to the SRAM. When the SRAM address is set, then the data is read or written by the interpreter as needed.

The Javelin's internal voltage regulation is done using a switching regulator. The switching regulator runs cooler and is significantly more efficient than a linear regulator. It accepts voltages between 6 and 24 V, and makes 5 V available for the Javelin Stamp with a total current budget of 150 mA. The passive components including the input and output capacitors, switching diode and inductor are on the top side, and the switching IC is on the bottom side of the board next to the EEPROM. The switching IC monitors the output voltage and adjusts the switching duty cycle to the passive components to maintain a constant 5 V output.

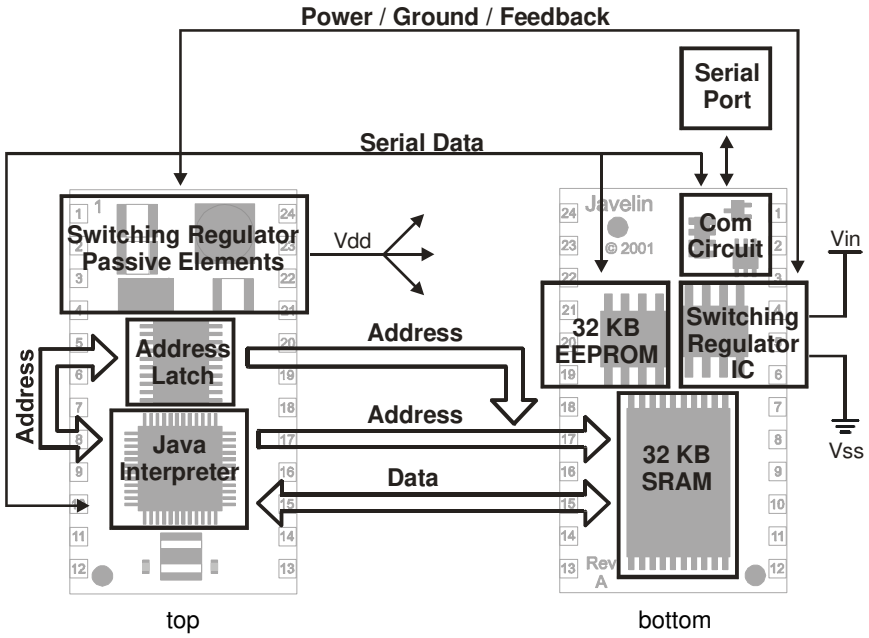

Figure 1.2
Javelin Block Diagram

Javelin Stamp Hardware

Table 1.1 shows the Javelin Stamp's specifications. Note that the onboard voltage regulator can accept between 6 and 24 V_{DC} and output up to 150 mA of current. Since the Javelin consumes approximately 60 mA, you have 90 mA available for other uses. Keep in mind that if you are utilizing the full 60 mA of total I/O pin source/sink that only 30 mA is left over for powering peripheral devices using the Javelin's Vdd pin. On the other hand, if all the I/O pins are being used for input, 90 mA can be used drawn from the Javelin's voltage regulator output (Vdd) for peripherals. If in doubt, use an external 5 V regulator for your peripherals.

Table 1.1: Javelin Hardware Specifications

Attribute	Value
Module Footprint	24-pin DIP module
Package Measurements (LxWxH)	1.2”x0.6”x0.4” (3.0x1.5x1.0 cm)
Operating Environment	0º - 70º C (32º - 158º F)
Microcontroller	Ubicom SX48AC
RAM	32 kilobytes
EEPROM	32 kilobytes
Number of I/O pins	16
Voltage Supply	6 – 24 VDC (unregulated) - or - 5 VDC (regulated)
Voltage regulator current output	$0 < I_{out} < 180$ mA
Current Consumption	60 mA / 13 mA nap
Sink/Source Current per I/O	30 mA / 30 mA
Sink/Source Current per module	60 mA / 60 mA per 8 I/O pins
Sink/Source Current per Bank Pins (0 – 7) and (8 - 15)	30 mA / 30 mA
Windows Editor/Debugger	Javelin Stamp IDE

Equipment and System Requirements

To run the IDE and program the Javelin, you will need an IBM PC or compatible computer with the following:

- Windows 95, 98, ME, 2000, or XP.
- A CDROM or Internet connection.
- An available 9-pin serial port
  Or – A USB port with an approved USB to serial adaptor. See www.javelinstamp.com for information on products that have been tested and approved.
  Or – A 25-pin serial port with a 25 to 9-pin adaptor.

The Javelin Stamp Starter Kit is discussed in detail in the following section: *Useful Hardware*. If you do not have a Javelin Stamp Starter kit, you will need to acquire at least the following.

- Recommended DC Power Supply: 7.5 VDC, 1000 mA 2.1 mm, center-positive
  Acceptable battery/DC Power Supply values range between 6 and 24 VDC. Minimum output current rating depends on voltage. A 6 V supply can have an output current rating as low as 100 mA while higher voltage supplies may need higher output current ratings.
- Serial programming cable