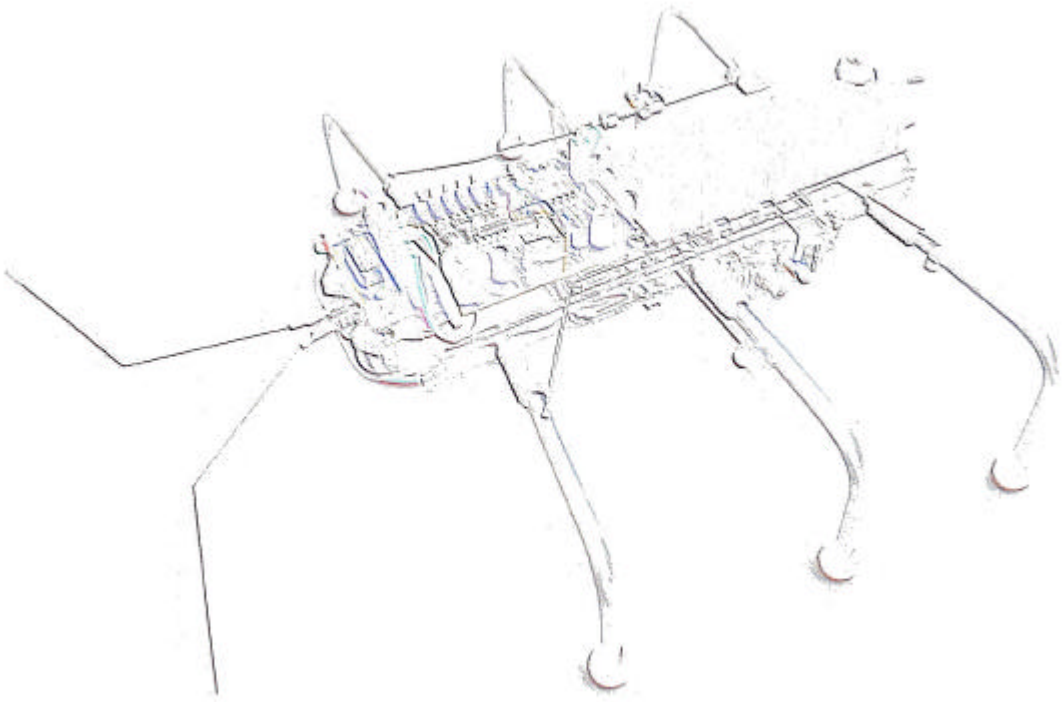
Cricket the Robot

Documentation



By Henry Arnold

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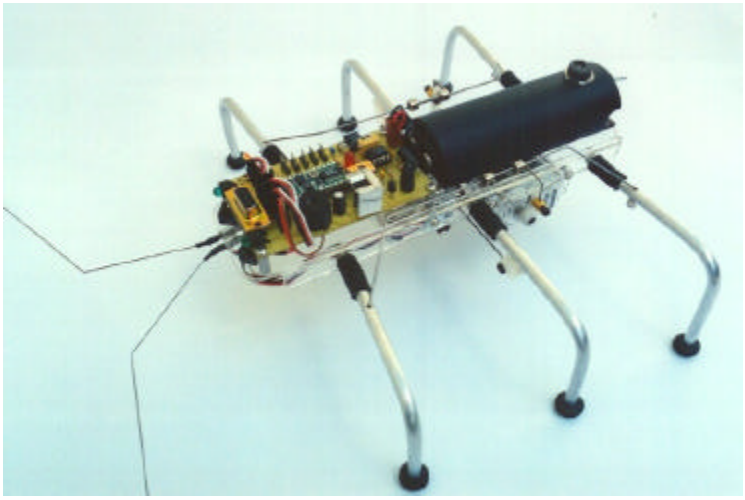
Cricket the Robot

Congratulations on the purchase of your Cricket Robot. Cricket is a unique handmade robot. Although he may look like a toy, you will find that, as you become familiar with his features that he is powerful programmable robot. Cricket comes with the following features and accessories:

- Stamp II Controller w/ Basic Programmable Memory
- Bi-directional Infrared Communication
- 3 Cirrus Servos to control six aluminum legs
- 3 LEDs for visual effect (2 eyes, one extra)
- Small speaker for various sounds
- 5 extra I/O ports w/ connectors
- 2 Bump Feelers
- Nickel Cadmium Battery pack with charger
- Sony Type Remote Control
- Download Cable and Software (From Parallax)
- Documentation



Cricket comes preprogrammed and ready to go. As you become more familiar with his capabilities you can easily modify his control program to add or change his behaviors. Programming Cricket requires your own IBM PC along with the supplied software and download cable. The Appendix contains documentation for the Stamp II command set.

Overview

Cricket is a six-legged walking robot, which uses three motors to make the six legs walk in a tri-gate fashion. Cricket can walk forward, backward, and turn right and left. Cricket can also make sounds, flash LEDs, and detect obstacles with its feelers. A Parallax Stamp II Controller controls all robot functions. The Stamp controller can be easily programmed in Basic. In addition to the standard features of Basic, the Stamp controller has extended commands that allow it to perform functions like making sounds, blinking lights, and controlling motors. The Basic program is written on an IBM compatible PC and then is downloaded through the PC's serial communication port.

Getting Started

Cricket's batteries were charged before he was shipped to you but they may have discharged. A quick one-hour charge will allow Cricket to operate for a short time. Normally the batteries should be charged over night. Place Cricket on a level service and flip the toggle switch on the end of his battery pack. Cricket will make a series of chirping sounds, bring all his legs into a neutral position, pause for one second and then begin walking. While walking around, Cricket will make chirping sounds at random times, he will blink his LED eyes, and the red LED pulse when he takes a step. He will also make a series of sounds whenever his antennae touch an object. When Cricket detects an obstacle with his antennae, he will back up three steps and then turn away from the obstruction and keep wandering around. Cricket will continue to walk around until his battery becomes weak.

You can tell the battery is weak when the robot starts to act erratically. Charging the battery for a few hours will restore Cricket's health.

Using the Remote Control

In addition to Cricket's ability to wander around on his own, he will also respond to user commands from the supplied Sony Remote Control. The remote control will override whatever Cricket is doing and execute the following functions:

Sony Remote Control

- Volume Up — Cricket turns right.
- Volume Down — Cricket turns left
- Channel Up — Cricket moves more quickly forward
- Channel Down — Cricket backs up
- Rewind — Same as left antenna hit
- Fast Forward — Same as right antenna hit
- Stop — Cricket stops and centers legs
- Pause — Cricket stops
- Keys 0-9 — Cricket makes different interesting sounds

The sound keys 0-9 are fun to play with because Cricket can make a continuous stream of chirps while you hold one of these keys down. Pushing the Pause button will cause Cricket to stop until another key is pressed. Pushing Stop causes Cricket to stop and center his legs. The action keys right, left, forward, and backward cause Cricket to move more quickly than his normal walk. **VERY IMPORTANT!** If the remote fails to work, it may need to be reset to the Sony TV and VCR codes. The codes are 002 for TV and 004 for VCR.

Press and hold the code search button until the LED lights.
Press the TV or VCR button, (the LED will blink).
Then key in the three-digit code (002 for TV, 004 for VCR)

Charging Cricket's Battery

Cricket has a 9-volt nickel-cadmium pack mounted on his plastic body with Velcro fasteners. The battery pack also contains the on-off switch, charging connector and controller power cable. After about an hour of operation, Cricket's battery will run down. He will either chirp constantly or walk erratically. To charge the battery, simply place the power switch in the off position and plug the charger into the connector below the switch. You may do this with the battery installed on Cricket but in the off position (down). An exhausted battery will take several hours to charge. Do not leave the battery for prolonged periods of time. Eight to ten hours should be more than enough to charge the battery. The battery pack can be removed from Cricket's chassis if desired by releasing the power connector and gently removing the pack from the Velcro fastener.

Software and Download Cable

Cricket's Stamp II controller can be programmed by writing a program on an IBM compatible PC and the downloading the program through a serial port into the serial connector on Cricket's controller PC board. This process will be explained in detail later and is also explained in detail in the supplied *Parallax STAMP Programming Manual*. Any download will erase the current program in memory, which will render Cricket's memory erased. The supplied floppy has the source program that Cricket is delivered with if you need to restore operation to the original control program.

Documentation
This documentation is a preliminary copy, which will be updated periodically. This initial copy is enough to get started. Future releases will provide more details regarding the technical aspects of Cricket's capabilities and operation. This documentation is also available online at http://home.earthlink.net/~henryarnold.

Crickets Features and Behavior

The following paragraphs give a brief overview of how Cricket is able to walk, make sounds, and execute his various behaviors and features.

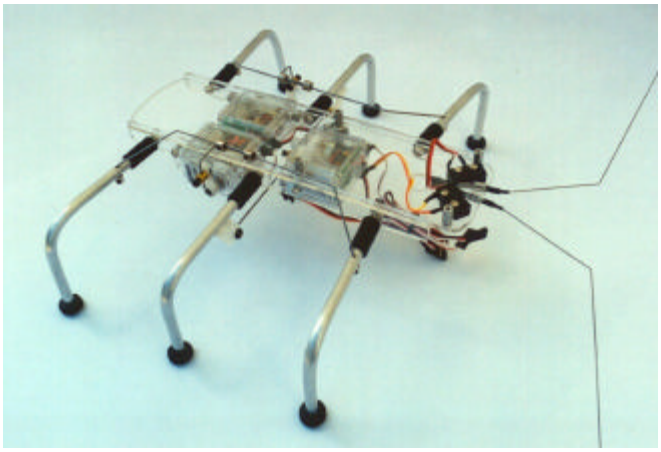
How Does Cricket Walk?
By now you have watched Cricket walk around and may be curious as to how he walks. Cricket's tri-gate walk is one of the most efficient ways to implement a walking robot with a minimum number of motors. The right and left servo motors move the right and left pairs of legs forward and backward. In order for this leg movement to move the robot forward, the center legs rock the robot to one side so the legs can move forward without touching the ground. When the legs are touching the ground a backward movement pulls the robot forward one step. This stepping alternates from one side to the other causing the robot to walk forward. Walking backward is the same as forward except that the legs are off the ground when being moved backward and touching the ground when being pulled forward. Watch the robot for awhile and you will begin to see how it works. Cricket executes a turn by stepping forward with one side while the other side steps backwards.

Obstacle Avoidance
Cricket's Stamp II controller is constantly monitoring his feeler switches to detect a closure. When Cricket bumps into an object with his feelers he stops, makes a noise, backs up three steps, turns either right or left three steps, and then continues moving forward. The feeler that was hit determines whether the robot turns right or left. If the right feeler is hit, the robot will turn left away from the obstacle on the right. If the left feeler is hit, the robot will turn right away from the obstacle on the left.

Random Noises
You may notice that Cricket chirps from time to time but not always. Sometimes he will chirp three or four times in a row. This random chirping is part of the Basic program. For every step the robot takes he looks up a random number between 0 and 65535. If the number is less than 58000, Cricket stays quiet, but if the number is between 58001 and 65535 Cricket makes a chirp sound. This chirp is as close to a real cricket as I could achieve. If you would like to hear this sound, press key "3" on the remote control. Try holding the key down.

Flashing LED Eyes and Red LED
Cricket has three LEDs, which are merely for looks, two green eyes and a "heartbeat" red LED. After Cricket is powered up, the green LED eyes will light and randomly turn on and off. The red LED toggles on and off during each step Cricket takes. These LEDs are all under the Basic program control and are not just blinking on their own.

Remote Control
The square silver module on the controller board is a Sharp infrared module, which responds to the Sony Remote Control by directing Cricket to actions other than his normal autonomous behavior. During each step Cricket takes, he also checks for any remote control commands received. The Sharp Infrared module receives the remote control signal and a special decoder chip turns the information into commands that the Stamp II can understand. Cricket is programmed to understand quite a few of the remote keys. Future software releases will most likely implement other keys as command inputs.

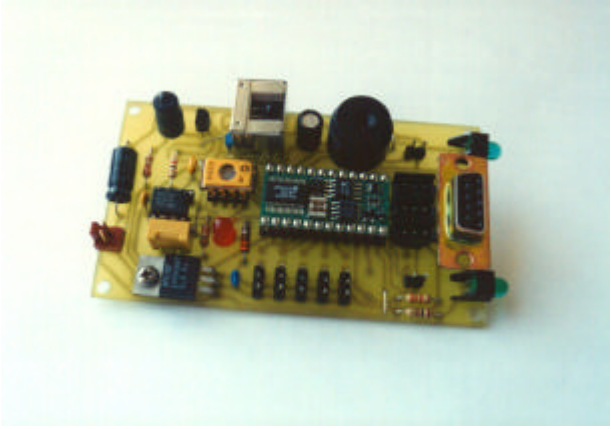


Component Descriptions
The following paragraphs explain each of the robot components.

Chassis
Cricket is constructed on a Lexan chassis. Motors, controller, switches, and the battery pack are all mounted on this chassis. This chassis is strong but not unbreakable. Be careful about putting to much pressure on this part.

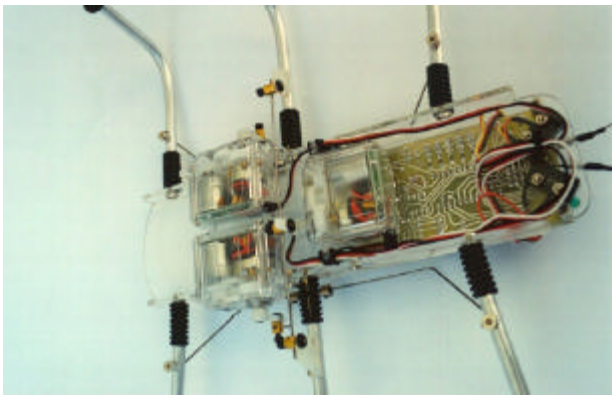
Aluminum Legs and Control Wires
Crickets legs are made from aluminum tubing with a simple 90-degree bend. A hinged standoff makes the leg joint. Center legs are jointed to bend up and down while front and back legs are jointed to move backwards and forwards. The legs have control wires that transfer the rotary motion of the servos into linear forward and backward motion or up and down motion. Most of the components that make up Crickets legs are model airplane parts. The center legs are actuated by horns screwed to the underside and the front and back legs have small holes with the control wire going through.

Parallax Stamp II Controller
The Stamp controller is mounted on a small circuit board along with the connectors that go to the motors, feeler switches, and batteries. A 9-pin connector on the front edge of the circuit board allows the Basic programs to be downloaded into the Stamp. There is a small speaker for sounds and LEDs that can be blinked. The battery pack powers the Stamp directly while a 5-volt regulator supplies power for the motors. The Stamp has its own 5-volt regulator, which also supplies power to the infrared circuitry and the remote control decoder. The bluish LED is the infrared emitter, which is not used in the current control



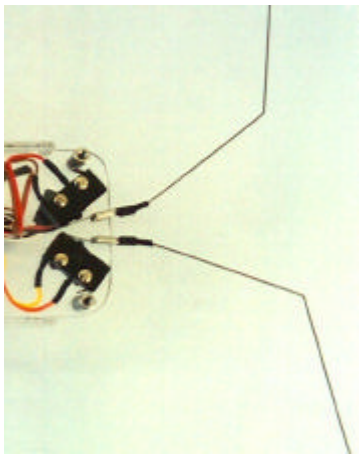
program. Cricket can transmit infrared commands from this LED using SEROUT commands of the Stamp. The variable trimpot controls the frequency of the carrier for Cricket's transmission of infrared. The silver can is the Sharp IR receiver mentioned earlier. The large device with the heat sink is the servo 5-volt regulator. This regulator supplies power for the Servo motors and does get hot during normal operation. The Appendix has the schematic and parts layout for Cricket's controller board.

Servo Motors



Cricket uses three motors. These motors are hobby servomotors used for model airplanes and cars. Each motor has three wires that supply 6 volts (red), ground (black), and the special controller signal (white). The controller signal is a special stream of pulses supplied by the Stamp controller. These pulses tell the motor what position to go to. Normally a radio control receiver in a model airplane or car would supply this special signal but for Cricket, the Stamp controller generates these signals. The motor on the right side moves the right front and rear legs forwards and backwards. The motor on the left side moves the left front and rear legs forwards and backwards. The center motor pulls on the right and left center legs to make the robot lean from one side to the other. The connectors are marked "R", "C", and "L" and correspond to the right, center and left connectors found on the controller board.

Feeler Wires and Switches



Once the Cricket robot starts walking around it doesn't take long before he will run into something. Without a way to detect an obstacle the robot would get stuck. For this reason, Cricket has long feelers much like a real cricket has. These feelers are connected to small switches, which turn on, when the feeler is pushed. The Stamp controller checks the switches and if they are closed, the robot backs up and turns away from the obstacle. The feelers are removable and are quite flexible. If they ever come off, they can easily be reattached by pushing the small connector onto the metal lever on the switch.

Battery Pack and Charger

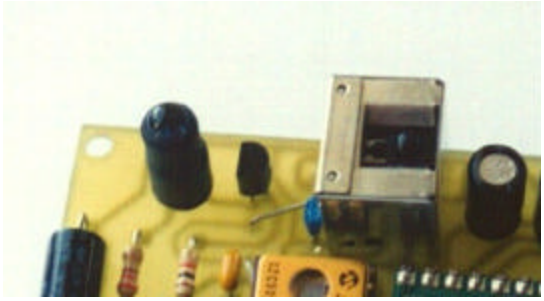
Cricket has one rechargeable battery. The 7.2-volt nickel-cadmium battery drives the Stamp controller and the motors. The battery will last about 1 -2 hours per recharge. The power enters the controller board through a polarized connector at the front of the battery pack. The switch at the rear of the battery pack has two positions, on, and off which is also the charge position. The up position is on and down is off. The connector at the rear of the battery is the charging pack connection.

Speaker and Sound Generation

The Stamp II controller has a wonderful ability to make sounds of various frequencies and duration using the command FREQOUT. The Cricket program makes extensive use of this command and a

small speaker to generate many different sound effects. I would be an interesting experiment to modify some of the FREQOUT commands in the Cricket program and see how it effects Cricket's voice.

Infrared Receive and Transmit



The remote control uses infrared to communicate with Cricket. The silver can on the controller board is a Sharp IR receiver, which can detect the remote signals. The detected signal is converted into a command by a special decoder IC, which takes Sony remote commands and converts them to simple serial ASCII characters. Cricket also has the ability to transmit infrared data through an infrared LED. This bluish looking LED is driven by a circuit, which provides the necessary 40 kHz modulation to transmit commands. This feature has no current implementation in software but has been placed in hardware so that in the future one Cricket could talk to another Cricket using infrared.

Light Emitting Diodes

Two green LEDs give Cricket the appearance of having eyes. These eyes are on most of the time but do blink off occasionally under program control. The green LEDs are ganged together, so they may not be controlled individually. The red LED provide a kind of Cricket heartbeat because in turns on and off at periodic rate. This LED is also under program control.

Download Connector, Cable and Software

The download cable allows the Basic program to be downloaded into the Cricket's Stamp memory. The program will not be lost when power is turned off. Cricket is shipped with the standard program with all described features. Keep in mind that downloading a user program will erase the standard one. The standard Cricket program (Cricket.BS2) can be found on the supplied floppy disk if the user wants to download it into Cricket's memory. To download a new program, you need to connect one end of the cable to the robot and the other end to the Com1 port of your PC.

Extra Connectors

Five extra connectors are available to connect other devices or servos to the Cricket controller board. These connectors have a current limit resistor suitable for driving the hobby type servos and also have 5-volts and ground available.

Troubleshooting

Cricket has been constructed carefully and durably but like anything else, he may break or exhibit some kind of problem. Here are some things to check if Cricket starts looking ill.

- Low Battery – During my testing of Cricket, I found that a low battery exhibits all kinds of funny behavior. Cricket will start chirping constantly and stop walking when the battery is low. This occurs because the microprocessor and circuitry on the Stamp controller can detect a brownout situation and will keep trying to reset it self to recover. This causes the initial turn on chirping to keep happening with no movement of the legs.

- Remote Doesn't Work - If the remote fails to work, it may need to be reset to the Sony TV and VCR codes. The codes are 002 for TV and 004 for VCR.
  Press and hold the code search button until the LED lights.
  Press the TV or VCR button, (the LED will blink).
  Then key in the three-digit code (002 for TV, 004 for VCR)

- Legs Not Working – If any of Crickets legs appear to not be moving correctly, try looking at the linkages and control wires. Something may have loosened. Many of the screws that retain the control linkages require a 3/32" Allen wrench. If a motor is not working at all, check the wiring and make sure the motor connectors are seated. Check that the joints on each leg is tight and the screw is not loose holding the leg to the body.

- Unexplained Erratic Operation – Sometimes fluorescent lights or camera flashes can falsely trigger the remote control. The decoder is programmed to ignore bad commands but it is possible for problems to occur. This should be very rare. Try running Cricket in another location to test for this problem. I've only had this occur under industrial fluorescent lights that run on 408 volts.

- Nothing Happens at All – If Cricket completely stops working, the battery may have gone dead or the Stamp controller may have a problem. If a multimeter is available, check the power at the connector on the controller board. Also try reloading the control program. If the Stamp software can't recognize the hardware there is a more serious problem.

- If the Stamp Programming software says "No Hardware Found" you've ether forgot to attach the cable, the battery is low or turned off, or a more serious problem has occurred.

Crickets are very reliable and usually if something goes wrong it has to do with the legs or the linkage. The legs and linkage are made from commonly available parts, which can be purchased at your local hobby store and home repair store. Replacement parts can also be purchased from me. The current parts list is not complete but in future releases of this manual, I will list all parts and sources so that users will be able to better maintain their Cricket robots. I can be contacted at the address and telephone number below. Documentation and program updates are available at http://home.earthlink.net/~henryarnold.

You can reach me through email at:

henryarnold@earthlink.net

Downloading a Stamp Program

The Parallax manual explains how to use the Stamp software but I thought I would give you my version of how to download a program, specifically the standard Cricket control software.

1. Turn on your computer and let it load Windows 95. Insert the floppy labeled “Cricket”. Using the mouse cursor select the "Start" button in the lower left corner of your screen. Select the "Run" icon and type a:\Stamp2.exe in the space provided and then select the "OK" button. This will run the Stamp Basic Programming Download tool.

2. You should have a blue screen That says "BASIC Stamp" in the upper right portion of the screen. Make sure Cricket is connected to the Com1 serial port but not turned on. Place Cricket upside down so he can’t walk away and then turn him on.

3. Press and hold the key "Alt" while you press the "I" key. This does an "Identify" of the Stamp hardware. You should get the message **"Found Hardware Version 1.0"**. If you get the message **"Error * Hardware not found"** then something is wrong. If you get the error message re-check that the cable is plugged into the computer and the robot and that the robot is turned on. Press the space bar to clear the screen message. Turn Cricket off momentarily.

4. If step three was successful, press and hold the key "Alt" while you press the "L" key. This operation allows you to load a program into the IBM PC. Using the cursor keys select CRICKET.BS2 and hit enter. You should see the program found in the Appendix.
   Turn Cricket on. Press and hold the key "Alt" while you press the "R" key. This downloads and runs the Basic program inside the robot.

5. Congratulations! You just ran your first Stamp Basic program.

Please refer to the Parallax manual in the Appendix for more details on programming and downloading programs.

Software Theory of Operation

The Basic program that controls Cricket performs many tasks including driving the motors, making sounds, blinking lights, and checking the feelers for obstacles. All of these tasks are performed in an endless loop “start” found at the beginning of the code section. All other go to subroutine (gosub) are executed from this endless loop. My description of the software will start on the first page of code and step through each section.

Here is a simple summary of what the Cricket program does:

Main Section
Make a bunch of noises
  Center the Legs
Start
  Turn the eyes on
  Walk one step forward with the right legs using "walkone:"
  Check if right or left feeler has been hit
  Walk one step forward with the left legs using "walkone:"
  Check if right or left feeler has been hit
  Goto start and do it again

If the right feeler is hit this section executes:

Right
  Make a noise
  Back up three steps using subroutine "backup:"
  Turn left three steps using the subroutine "walkone:"
  Go back to walking forward using the code at "start:"

If the left feeler is hit this section executes:

Left
  Make a noise
  Back up three steps using subroutine "backup:"
  Turn right four steps using the subroutine "walkone:"
  Go back to walking forward using the code at "start:"

Walkone
  Make a random chirp
  turn the LED on or off (opposite of what it was)
  move the center legs to the middle level position
  check the infrared port
  move the right leg motor
  move the left leg motor
  move the center leg motor
  check the infrared port
  Go back to walking forward using the code at "start:"

Backup
  take a left step back using subroutine “walkone”
  take a right step back using subroutine “walkone”
  repeat three times

The above description does not show the routines used when the Sony remote causes an interruption of autonomous operation.

Variables and Constants

The first part of the program defines quite a few constants. Constants are just fixed numbers with a name attached so that the program is more readable. For example, its a lot easier to understand "toggle LED" than "toggle 9", so the constant allows the programmer to replace numbers with names. Notice that the "center_motor" is connected to pin 1 of the STAMP and that "center_motor_pos" which is the position of the center motor is variable word which can have a value of 0 - 65535. There are many constants and variables needed to keep track of even a small robot like Cricket. Among the many constants are the min, max and mid constants which define the minimum, maximum, and mid point positions of the right, left, and center servos. Each of these constants represents the pulse width of each pulse sent to the hobby servos. Hobby servos require a stream of pulses that are between 1000us and 2000us wide. This pulse must be repeated at least every 20ms. The Basic Stamp uses the “pulsout” command to generate the pulse needed for the three motors. The “pulsout” commond uses increments of 2us so that a constant of 1000 reuslts in a pulse width of 2000us (2ms). Sending a pulse value of 500 (1000us) moves the motor to one extreme position, while sending a pulse value of 1000 (2000us) moves the motor to the opposite position. These constants can be adjusted if for example, Cricket walks crooked and needs one side to step further in order for him to walk a straight direction.

There are also constants for each of the 16 I/O pins of the Stamp module. You will notice names such as speaker which is output 6 of the Stamp. The eyes are output 5.

The rest of the constants determine operating parameters such as how many pulses are to be sent to a motor or how long to wait for an Infrared command before giving up.

Miscellaneous

Before Cricket starts to wander around he does a few miscellaneous things found just after the constant and variable section and before the “start” label. He first issues an initial burst of sounds implemented using Stamp “freqout” commands. Us the Stamp reference for an explanation of this command, which allows sounds to be made with a speaker. Cricket then does a little step routine to center all his legs. This is done so that turning Cricket on then off will allow him to be stored with his legs in a relaxed position. He waits 1 second (1000 ms) and then begins to walk at the “start” label.

The Main Loop, “Start”

The program begins at the "start:" label, the three motor positions are set and then the "walkone" subroutine is called to execute the motor positions. The first "gosub" causes the robot to step forward with the right legs the second "gosub" causes the robot to step forward with the left legs. The eyes are turned on toggled, the feelers are checked and we "goto start" and do it all again.

The first "for" loop in the "walkone" subroutine causes the center motor to go to the center position which is not leaning right or left. The second "for" loop takes either the right or left legs forward step depending on whether center_motor_pos, right_motor_pos, and left_motor_pos were set to the "min_pos" or "max_pos" values which are constants defined as 500 or 1000. The motor positions are set up as variables center_motor_pos, right_motor_pos, and left_motor_pos. Each variable is loaded with a position desired, usually the min and max constants. After the position is set, a "gosub" command is executed which sends the program to a subroutine which executes the motor position commands. This is found in the subroutine "walkone" which will send any motor position value that has been stored in the variables center_motor_pos, right_motor_pos, and left_motor_pos.

When "walkone" is finished it executes a "return" command which causes the program to execute from the next command after the "gosub" command.

During the “start” loop, the Stamp checks the feelers for a switch closure. If the feelers have detected an obstacle, program execution goes to either the “right” or “left” routines to deal with the obstacle. Notice these are not gosubs but just a simple jump. This is to avoid the possibility of too many nested subroutines. By doing a simple jump we have more freedom to deal with required actions after which execution just goes back to the “start” label.

The “right” and “left” Routines

Once Cricket hits an obstacle he needs to back up and then turn away from the object. He is programmed to backup three steps and turn three steps away from the obstacle. In order for the feelers to work, two commands must be issued:

```
"right_feeler   var   IN3"

"left_feeler    var   IN4"
```

These commands mean that the right feeler switch is an input on pin 3 of the Stamp and the left feeler switch is an input on pin 4 of the Stamp. The Stamp will use the names "IN3 and "IN5" to check whether the feelers are bumping into something.

Take a look at the first section after the "start:" label. There are two "if" statements that check to see if the feelers have hit anything. If they have then the robot will back up the three steps and turn right or left three steps. The code labeled "right" and left”, is similar to the start section of the code except for a sound at the beginning and the backup section. The code segments "start” , "right:" , and "left:" are just set ups for motor positions after which the subroutine "walkone:" is executed by the "gosub" command.

The “walkone” Routine

The “walkone” routine is an important part of the Cricket code. Almost all steps are taken using this code which does the job of sending the pulses to the three motors using the Stamp’s “pulsout” command. The number of pulses sent is determined by the constant “pulses”. Changing this constant determines how fast Cricket walks. The subroutine "walkone:" also has a random number controlled sound at the beginning which decides before each step whether to make a chirp sound. This causes the random chirps while Cricket walks around. "Random beep" generates any number between 0 and 65535 and if the number is less than 58000 the robot skips the sound. If the number is 58001 or greater, the robot chirps once. The hertbeat LED is also turned on or off during each step. The last thing that is check is the infrared port using the routine “check_ir”. If this routine determines that a infrared command has been issued, then other actions must be taken. One subtlety of this function is that it takes a small delay for the infrared to be checked. This delay actually affects the speed at which Cricket walks because it determines how quickly pulses are sent to the motors. If the delay is longer then the motors update slower.

The Routine “backup”

Looking at the "backup" section of the code, you'll notice it is very similar to the forward walking section of the code found in the "start" section. That's because to backup you do the reverse with

the legs that you would to walk forward. The robot leans to right side steps back with the left side, leans to the left side and steps back with the right side.

The Routines "back_it_up", "center_legs", "forward fast", "right_turn", and "left_turn"
These routines are all called as a result of a valid infrared command being received by check_ir. Each of these routines is similar in operation to the previous ones described except that a special walkone called just "walk" is used. The routine "walk" is similar to "walkone" except that the infrared port is ignored and the walk function is faster for the infrared override of autonomous operation. The infrared is ignored so that the current request can be executed without being interrupted by another command.

The Routine "check_ir"
Cricket's infrared hardware takes a 12 bit Sony Remote command and converts it into a n 8 bit ASCII value which can be read by the Stamp using a "serin" command. Once an 8 bit serial value is received, it is compared to valid values. If a match is found, various actions such as sounds or backing up are executed. The "serin" command used in "check_ir" is set to only wait for a specific amount of time (delay=8ms) and then to give up and return. One of the possible actions from the Sony Remote is stop or pause. Once Cricket has stopped, a valid command needs to be detected from the infrared port before autonomous operation can continue. The routine "stop_it" looks for a new valid infrared command before returning to "check_ir" which evaluates the command.

The Routine "stop_it"
When Cricket has been stopped using the infrared remote, execution waits in the routine "stop_it". This routine looks for a valid infrared command before continuing.

The "sound0 – 9" Routines
These routines are all similar and simply generates strings of different frequency and duration sounds. Most of the sounds are intended to sound like robotic insect sounds such as chirps. The Basic Stamp command "freqout" generates a tone of specified duration and frequency. After making the sound, each of these routines returns execution back to the "check_ir" routine.

The Basic code delivered with Cricket is simple and compact. It take up only about half of the Stamp II memory leaving plenty of room for new functionality.

Appendix A - Basic Stamp II Source Code for Cricket

Appendix B - PIC12C509 “C” Source Code for Sony Remote Decoder

Appendix C - Cricket Schematics

Appendix D - Parts List

Appendix E - PC Board Layouts

Appendix F - Data Sheets

Appendix G - Stamp II Users Manual

Online Manual available at http://www.parallaxinc.com