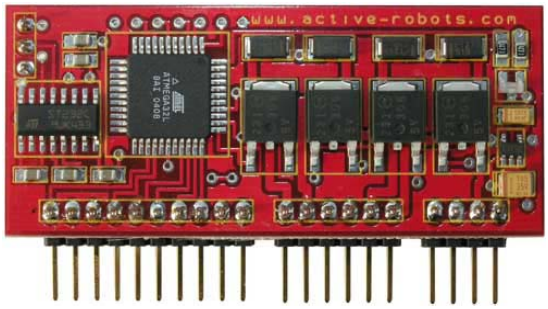
ACTIVE ROBOTS

EASY STEP™ 3000



Serial Communications Protocol

V1.02

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1 Introduction

1.1 Easy-Step ™ 3000 Module

The Easy-Step ™ 3000 (ES3000) has several control options (digital, analogue and serial data), this document mainly explains the serial data communications protocol. Digital and analogue[voltage modes 1,2,3] control is covered in the document 'ES3000 users guide'.

The ES3000 has an onboard microcontroller, RS232 Converter and motor interface circuitry. The unit is designed for controlling a single unipolar stepper motor. Any computer (PC, Mac, Palmtop etc) with an RS232 interface can be used to control or interrogate the ES3000, in this document we will refer to this computer as the - PC (Personal Computer).

The ES3000 remembers the mode it is in (PC, Remote & Voltage), even if the power is removed (with the exception of teach mode).

1.2 Standard / Pro Versions

The ES3000 is available in two forms '**standard**' and '**pro**', the standard version is compatible with all the commands covered in this document. The 'Pro' version allows up to 25 command sequences to be stored within the ES3000, these steps can then be replayed, these facilities are easily accessed from the program that is shipped with ES3000 "Easy Step ISP ™ " (ISP= Interactive System Programmer).

The Standard version can be 'un-locked' and converted to 'Pro' – visit www.active-robots.com/easy-step3000.shtml (you will need your ES3000 serial number).

1.3 Basic Communication structure

Data from the PC to the ES3000 is enclosed in 'curly' brackets, { } , technically referred to as "Braces" (ASCII codes {=123D/7Bh/0111 1011B, }=125D,7Dh, 0111 1101B)

Data from the ES3000 to the PC is enclosed is 'square' brackets, [ ] , technically referred to as "Brackets" (ASCII codes [=91D/5Bh/0101 1011B,]=93D/5D/0101 1101B).
(Where D=Decimal, h=Hexadicimal, B=Binary).

The PC initiates communication by issuing a command to the ES3000 module, the module may follow instructions (by moving the motor), or responding with information (e.g. current Status) etc.

Example comms code – showing the transmission of the 'demo mode' command – {CD}

BASCOM AVR
Print "{CD}" 'Toggle demo mode

Microsoft Visual Basic
MSComm1.Output = "{CD}" 'Toggle demo mode

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1.4 Serial Port Settings

The Easy Step ™ 3000 Module uses the following comms setup:

Baud Rate 19200
Parity N
Data Bits 8
Stop Bits 1
No Hardware Flow Control

Below is an example of setting up the comport on a PC using Microsoft Visual Basic;

```
MSComm1.CommPort = 1                    'Select Comport number one
MSComm1.Settings = "19200,N,8,1"        'Baud rate/Parity/Data Bits/StopBits
MSComm1.Handshaking = comNone           'Flow control
MSComm1.InputLen = 1                    'Read one byte at a time
```

In BASCOM AVR you can setup the comms via the Options Tab (Alt + o):
Options > Communications > then select the various available options.

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2 Command Protocol

2.1 Overview

The Easy- Step ™ 3000 command set is divided into **three** distinct command types.
1. "C" prefix, are all commands that **setup** the ES3000.
2. "I" prefix are all **immediate move** instructions
3. "P" prefix are associated with the **hardware inputs**.

All data sent is in plain ASCII text, for example ASCII for '1' = 49 or 31 in hex or 00110001 in binary. No spaces are needed between characters or termination characters (CHR$13 etc). Some commands use commas ',' to separate data. Received data from the ES3000 may have a semi-colon ';' i.e. [a;b]

2.2 Single command Sequence concept

Many commands can be sent as a single command sequence extended data packets. The protocol can send all the following instructions as a single command; No. of steps, Start speed, Max step rate, Ramp factor and Motor mode.

{IE1000,200,600,5,0} ←

IE = command (Go To Relative Position)
1000 = Number of steps
200 = Start Step Rate
600 = Max Step Rate
5 = Ramp Factor
0 = Motor Mode (Full 2 phase) ← }

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2.3 Real Time functionality

While the ES3000 is busy it will ignore all further serial communications (one further instruction is buffered and executed when the current task is finished).

2.3.1 BUSY PIN

To synchronise real time control the Busy pin can be monitored, when the Busy pin is **low** the ES3000 is **not** ready for further serial comms.

2.3.2 Remote/Slave mode (REPLAY Inputs)

Stored sequences can also be replayed (up to 25 [only in ES3000 Pro version]) by means of **hardware alone**. Inputs IP3 and IP4 are used to achieve this; IP3 replays 'all', and IP4 'walks through' the sequence memory, a sequence at a time (every time the pin is toggled 1-0-1).

2.3.3 SOFTWARE ONLY

To synchronise real time events in software only; request a command that requires the ES3000 to respond with information (for example the CF command) when the ES3000 responds you now know you can issue another command safely. So for example you could issue the following two commands; {IE1000} {CF}, when the {IE1000} command has finished ES3000 will then execute the {CF} command stored in its buffer, and will respond with the software version [xxx;y;zzz] , now we know that the ES3000 is free to execute another command.

You have to be aware of software comms time outs as the ES3000 may take many seconds to perform some of your commands.

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3 CX - Command Instructions

3.1 CA - Max Speed Setting

{CAxxx}

This command is used to set the maximum step rate of the motor (motor steps per second i.e. a 1.8° /step motor will rotate at 1 revolution per second at a step rate of 200).

Where: xxx = Maximum Step Rate

Minimum step = 1
Maximum step = 999

Although manufacturers issue guidelines as to the maximum step rate of a motor, the loading and supply voltage will greatly affect the speeds that can be achieved, for example a typical small motor will completely stall at a step rate of about 1000.

Example {CA3} sets a step rate of 3, {CA999} sets a rate of 999 steps/second

As a approximate guide to working out your maximum step rate (motor speed) then use the following example calculation;

A motor has the following characteristics: 1.8º /step (or 200 step per revolution), 3.3 Ohm phase resistance and a phase inductance of 3.4uH. Calculate the maximum step rate, assuming we have a need for 85% motor torque, Given: 2 Time constants = 85% torque?

Ans.
Two Time constant in ms = 2 * (3.4/3.3) = 2.06ms per step

Max step rate = 1S / 2.06ms = 485 steps per second

Of course individual motors may differ and “Forcing Resistors” can be used to increase the step rate, by increasing the effective voltage across the phase coils, forcing the coils to pass current more rapidly than they normally would.

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3.2 CB - Ramp Factor

{CBxxx}

The ramp factor is one of the variable factors within a formula that is used to calculate acceleration and deceleration, the higher the number the longer the acceleration/deceleration times will be. Start Step Rate and Step Speed setting are also factors that affect timings.

Where: xxx = Ramp Factor

Minimum = 0
Maximum = 200

NOTE on issuing a Ramp Factor command the ES3000 module will respond with some serial comms, *it is not enclosed in brackets and is not useable.*

3.2.1 Ramp Factor Chart

Start Speed	Step Speed	Ramp Factor	Acceleration Time (Secs)
100	*500*	*0*	*2s*
100	*500*	*1*	*2.8s*
100	*500*	*5*	*5.5s*
100	*500*	*10*	*9s*
200	**600**	**0**	0.5s
200	**600**	**10**	2.5s
200	**600**	**50**	10s
200	**600**	**100**	18s

It should be noted that a high ramp factor causes very slow acceleration, this can cause the number of steps to “run out” before full speed is reached and thus the motor will slow down again without reaching full speed.

Say for example you only wanted to move two hundred steps (1 rotation with 1.8º motor) but the ramp factor meant an acceleration/deceleration time of 20seconds then the motor would hardly increase above the start step rate.

The ‘Easy Step 3000 ISP ™’ program displays the deceleration time in a box next to the Ramp Factor entry box.

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3.3 CC - Step Mode

{CCx}

There are three possible step-mode settings

Where: x = 0 Full Step 2 Phase
x = 1 Full Step 1 Phase (Wave)
x = 2 Half Step

Minimum = 0
Maximum = 2

Full step 2-phase mode is the power-on default setting. In Full step 2-phase mode two coils are energised at the same time giving the highest available torque, with a 200 step/revolution motor this equates to 1.8º per step.

Full step 1-phase (Wave) mode gives the same size step (1.8º) as full step mode, but only one coil is energised at any time so saving on power. Note that not all motors will run efficiently in wave mode.

Half step mode, as its name suggests doubles the available number of steps per revolution improving positional accuracy by a factor of 2.

For the logic truth tables for these modes see the Easy Step ™ 3000 User Guide

3.4 CD - Demo mode

{CD}

This command is used to set/clear demo mode. In demo mode, at power up the ES3000 will perform a short routine to show the functionality of the on board LED and motor connection.

The LED will change from Green to Red to Orange and then repeat the sequence finally stopping on Green. The motor will then spin in full step mode 200 steps clockwise followed immediately by 200 steps anticlockwise returning the motor to its original position.

When the sequence is complete, the ES3000 is ready to accept commands.

NOTE *Demo mode will only work if the ES3000 PCB is in PC mode*, if the ES3000 is in Voltage or PIN/Remote modes then demo mode is disabled.

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3.5 CE - Store Sequence

{CEa,b,c,d,e,f,g,h,i}

Up to 25 sequential steps can be stored in the Easy Step ™ 3000 internal EEPROM memory. Each of these steps contains the information necessary to create a unique step profile for that motor run/position set.

The each line has the following format; it contains the number of lines in the sequence, and the following lines contain their line number, the start step rate, max step rate, acceleration factor, mode, dwell, command and where appropriate the number of steps to move.

Where:
a = Line Number (1 to 25)
b = Total No. Lines in Sequence (1 to 25)
c = Command Number (1 to 11)
d = Steps + or –
e = Start Step Rate or Pull in Rate (1 to 999)
f = Max Step Rate (1 to 999)
g = Ramp Factor (1 to 200)
h = Dwell Time (1 to 2000000)
i = Step Mode

Dwell Time - pauses the motor for the amount of time specified, after the movement command has finished. Time is entered is in tenths of a second, i.e. 20 = 2sec, 1=100ms

Command number - refers to the command you wish to send, these are:
1 – ID (Go To Absolute Position)
2 – IE (Go To Relative Position)
3 – PF …..
4 – PG
5 – PH
6 – PJ
7 – PK
8 – IM
9 – IN
10 – CQ
11 – CR

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3.5.1 CE Store Sequence example

Suppose we wish to send and store the following commands to the Easy Step ™;

{IE1000,200,600,5,20,0} ←
{IE2000,200,600,5,20,0}
{IE3043,200,600,5,20,0}

IE = command number 2 (Go To Relative Position)
1000 = Number of steps
200 = Start Step Rate
600 = Max Step Rate
5 = Ramp Factor
20 = Dwell Time (2 seconds)
0 = Motor Mode (Full 2 phase)

} ←

We would use the CE command this way;

{CE1,3,2,1000,200,600,5,20,0} ←
{CE2,3,2,2000,200,600,5,20,0}
{CE3,3,2,3043,200,600,5,20,0}

Note these extended command sequences include a dwell time, so that pauses can be made between commands on playback, thus the order of data is different from a normal extended command sequence (see 6.4 & 6.5).

If stored sequences are being replayed in hardware using the **IP4** input then the dwell time between sequences is determined by IP4 input; each time the input is toggled (1-0-1) the next sequence will be carried out.

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3.6 CF - Software Version, Pro Status & Ser. Number

{CF}

Issuing this command will return the Easy Step ™ 3000 module software version and shows if the Pro version feature has been activated.

This command will generate an instant response form ES3000.

Reply: [x.xx;y;zzz]

Where: x.xx = ES3000 Software Version
y = Mode, U = Pro Mode Enabled, L = standard
zzz = Serial Number

3.7 CG - Replay a stored sequence

{CGx}

Setting CG will cause the ES3000 to replay a stored sequence. This command will only work if Pro Mode has been enabled.

Where: x = 1 – Demo Mode, Play Demo Sequence on Power Up
x = 2 – Replay Stored Sequence Pro version only

3.8 CI - Start Step Rate (Pull in Rate)

{CIxxx}

Set this value to a speed that your motor can be started from rest without missing steps. This can only be found by experimentation as the Pull in Rate is affected by load, L/R operation and supply voltage. The manufacturer of your motor may give a Maximum Pull in Rate for an unloaded motor, this is a good guide, but can rarely be achieved in practice.

Where: xxx = Start Step Rate (Pull in Rate)

Minimum = 0
Maximum = 999

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3.9 CP - Motor Power Rest State

{CPx}

This command instructs the unit to switch power either **on** or **off** to the motor coils when it is at rest.

If the motor is to stand for any length of time, then it can be beneficial to stop with the motor power off. This will save power, reduce motor and drive circuit heating. However, ensure that positional integrity can be maintained with power off i.e. the detent holding torque of the motor is sufficient to prevent movement.

Where: x = 0 – Stop with Power Off (default)
x = 1 – Stop with Power On

3.10 CQ - Set Home Position

{CQ}

Issuing this command will set the current position register to zero, the mark register will not be affected, so the Mark register will still contain a previously set value that will contain the 'offset' from the original Home position NOT the new one.

3.11 CR - Set Mark Position

{CR}

Issuing this command will set the Mark position register to the current position register.

3.12 CS - Mode Selection

{CSxx}

The ES3000 has 4 operating modes that can be selected by the CS command. Only Modes 0,1,21,22,23 are preserved through a CPU Reset or Power Down. The ES3000 will default to factory speed settings in modes 21,22,23. If a CPU Reset occurs in Teach mode then PC mode is the default state.

Where xx :-
0 = PC (default from factory)
1 = Pulse or Remote/slave
21 = Voltage, 0-270°
22 = Voltage, 0-1000°
23 = Voltage Centre off
31 = Teach Mode – Send steps to PC
32 = Teach Mode – Turn Motor CCW
33 = Teach Mode – Turn Motor CW

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3.13 CU - Current Status

{CU}

The Current Status command will return immediately the start rate, max rate, ramp factor, mode and current position register. The values are comma separated and must be interpreted by your software.

Response:	[a,b,c,d,e,f,]
Where:	a = Actual Position
	b = Start Rate (Pull in Rate)
	c = Max Step Rate
	d = Ramp Factor
	e = Step Mode
	f = Motor Stopped Power State

3.14 CV - State of Input Pins

{CV}

When a request is made to show the state of the input pins, the five inputs on the Easy Step ™ 3000 module labelled IP1/2/3/4/5 will be scanned and their state stored. This will then be built into a string and sent to the PC. The response will be a 1 if the pin is high or 0 if low.

Response:	[a,b,c,d,e]
Where:	a to e represents IP1 to IP5

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4 IX - Command Instructions

4.1 ID - Go To Absolute Position

{IDxxx}

Issuing the ID command will cause the ES3000 to move the motor to the specified location relative to the home position. Positive numbers are clockwise, negative numbers anti clockwise (viewed from the front of the motor).

Where xxx = number of steps

4.2 IE - Go To Relative Position

{IExxx}

The IE command will cause the ES3000 to move the motor to a position that is relative to the current position. Positive numbers are clockwise, negative numbers anti clockwise (viewed from the front of the motor).

Where xxx = number of steps

4.3 IM - Go To Mark Position

{IM}

This will take the motor to the previously set mark position, if no mark position has been set then issuing this command will have the same effect as sending the motor to the Home position.

4.4 IN - Go To Home Position

{IN}

This will return the motor to the previously set home position or where the motor was when ES3000 was powered up.

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5 PX - Command Instructions

5.1 PF - Go To Absolute Position with inputs 1 & 2 as stops

{PFxxx}

This command uses inputs 1 & 2 as additional stops. Pulling either of the lines low will cause the motor to stop. However, the stop will not be immediate, the current ramp settings will be used to protect positional integrity, and therefore the motor may turn for some time after the stop signal has been received. To minimise movement keep the ramp times as low as possible.

Immediately prior to executing the command both lines are checked, if either are low at that point no movement will take place.

Where xxx = number of steps

5.2 PG - Go To Relative Position with inputs 1 & 2 as stops

{PGxxx}

This command uses inputs 1 & 2 as additional stops. Pulling either of the lines low will cause the motor to stop. However, the stop will not be immediate, the current ramp settings will be used to protect positional integrity, and therefore the motor may turn for some time after the stop signal has been received. To minimise movement keep the ramp times as low as possible.

Immediately prior to executing the command both lines are checked, if either are low at that point no movement will take place.

Where xxx = number of steps

5.3 PH - Go Clockwise Until Input 2

{PH}

The motor will turn clockwise until input 2 is taken low. However, the stop will not be immediate, the current ramp settings will be used to protect positional integrity, and therefore the motor may turn for some time after the stop signal has been received. To minimise movement keep the ramp times as low as possible.

Immediately prior to executing the command the line is checked, if it is low at that point no movement will take place.

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5.4 PJ - Go Counter Clockwise Until Input 1 then Zero Position

{PJ}

Use this command to set the Home position. When input 1 goes low the motor will stop, then mark the home position i.e. set the current position counter to zero.

However, the stop will not be immediate, the current ramp settings will be used to protect positional integrity, and therefore the motor may turn for some time after the stop signal has been received. To minimise movement keep the ramp times as low as possible.

Immediately prior to executing the command the line is checked, if it is low at that point no movement will take place.

5.5 PK - Go Clockwise Until Input 2 Then Mark Position

{PK}

Use this command to set the Mark position. When input 2 goes low the motor will stop, then set the Mark position i.e. store the current position register in the Mark register. However, the stop will not be immediate, the current ramp settings will be used to protect positional integrity, and therefore the motor may turn for some time after the stop signal has been received. To minimise movement keep the ramp times as low as possible. Immediately prior to executing the command the line is checked, if it is low at that point no movement will take place.

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6 Instruction Summary

6.1 Command Instructions

CA - Maximum Step Rate
CB - Ramp Factor
CC - Step Mode 0=Full 2 phase, 1=Full 1phase (Wave), 2=Half
CD - Demo Mode
CE - Store Sequence
CF - Display Software Version
CG - Replay Stored Sequence
CI - Start Step Rate
CP - Motor Power Rest Sate
CQ - Set Home Position
CR - Set Mark Position
CS - Mode Selection
CU - Show Current Status
CV - Show State of Input Pins

6.2 Immediate Move Commands

ID - Go to Absolute Position
IE - Go to Relative Position
IM - Go to Mark Position
IN - Go to Home Position

6.3 Immediate Move With Input Pin References

PF - Go to Absolute Position with inputs 1 & 2 as stops
PG - Go to Relative Position with inputs 1 & 2 as stops
PH - Go clockwise until input 2
PJ - Go anticlockwise until input 1 and zero position
PK - Go clockwise until input 2 & Mark Position

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6.4 Command capable of 'command sequences'

CE - Store Sequence
CQ - Set Home Position
CR - Set Mark Position

ID - Go to Absolute Position
IE - Go to Relative Position
IM - Go to Mark Position
IN - Go to Home Position

PF - Go to Absolute Position with inputs 1 & 2 as stops
PG - Go to Relative Position with inputs 1 & 2 as stops
PH - Go clockwise until input 2
PJ - Go anticlockwise until input 1 and zero position
PK - Go clockwise until input 2 & Mark Position

6.5 Command sequence or extended commands

All commands **listed in 6.4** can be sent with the full command sequence which takes the form of:

{IE1000,200,600,5,0} ←

IE = command (i.e CE,CQ,CR,ID… etc)
1000 = Number of steps
200 = Start Step Rate
600 = Max Step Rate
5 = Ramp Factor
0 = Motor Mode (Full 2 phase)

} ←

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