Intelligent Servo System

ISS User's Manual

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1. Contact your Acuity distributor or call Acuity Technologies at (650) 369-6783 to obtain a return merchandise authorization (RMA) number within the applicable warranty period. Acuity will not accept any returned product without an RMA number.

2. Ship the product to Acuity, postage prepaid, together with your bill of sale or other proof of purchase. your name, address, description of the problem(s). Print the RMA number you have obtained on the outside of the package.

1. Overview

The Intelligent Servo System consists of servos and network servo controllers, position and motion control components for aerospace, robotic, and automation uses. The servos may be purchased as standalone units or for control by the NSC network servo controller. The Network Servo Controller (NSC) configures the servos, supplies power and CAN bus control for the servos, provides a single-point serial host computer interface for multiple servos, and facilitates coordinated motion between servos.

1.1 Servos

The IS servos have two case sizes and a range of torque/speed combinations. A network of up to 20 IS servos together with up to 12 third party PWM servos may be configured and controlled through the NSC. Servos may be operated in torque, speed or position control mode. Servos are delivered configured for position control with a reconfigurable position range of +/- 45 degrees.

1.1.1 Networked Servos

Networked servos are configured and controlled by sending commands to the NSC's RS-232 or RS-422 port. Each networked servo has 2 connectors. Either connector may be connected to the NSC or to another servo using ISS servo cables, which provide power and CAN bus communications. The last servo in a chain of servos must have a termination plug in its unused connector.

1.1.2 Standalone Voltage / RS232 servos

If the standalone version of a servo is ordered, one connector accepts RS-232 input for configuration and motion commands as well as an analog voltage input for torque, speed or position control and a HOME command input line. The second connector provides power to the servo. Standalone servos are configured with commands similar to those used to control the CAN network servos, but the commands go directly to the servo rather than to the NSC's RS-232 or RS-422 port. Standalone servos are controlled individually and cannot be networked or connected to an NSC.

1.2 Network Servo Controller

The NSC Network Servo Controller has four functions: Providing a single host interface for multiple servos, implementing CAN protocol to distribute motion and configuration commands from the host processor to individual servos and relay status back to the host, performing synchronized motion with multiple servos, and supplying power to servos. Configuration consists of functions such as selecting torque, speed or position mode, setting speed or position range limits, and optionally setting motor current limits. The NSC implementation of the CAN protocol allows the host system to communicate with a network of servos without the necessity of implementing CAN communication on the host or maintaining multiple serial ports on the host.

1.3 Use and Maintenance

The ISS Servos and NSC controllers form a rugged system designed for use on mobile platforms. However, they should be protected from severe shock and vibration, such as that which might be experienced on a vehicle without suspension or with high engine vibration. In these cases the components should be mounted with the supplied grommets.

The servos are sealed, with protection against rain, washdown, short term immersion to 1 meter in water and pressure differentials of +/- one atmosphere. It is not recommended that the servos be operated under water.

See the ISS datasheet for additional information.

2. Hardware Power Up

2.1 Servos with Network Servo Controller

A standard networked system consists of an NSC, one or more IS servos, a servo cable for each servo, an NSC power cable, and two or more termination plugs.

The NSC has four CAN connectors, and up to five servos can be connected to each in a daisy-chain configuration, for a total of 20 servos.

Performing the following steps in this order will minimize the chances of damage to servos in the event of an error such as connecting to your power supply incorrectly, or causing damage to plugs from high voltage arcing.

1. Connect the NSC power cable connector to the NSC. It is advisable to include a high power switch between the supply and the controller and to double check the supply connection polarity. The NSC and servo plugs are not designed to act as high voltage switches and should not be plugged/unplugged with power applied.

2. Connect the NSC power cable's flying leads to your system power supply.

3. Turn on power. The green LED will light when power is applied to the NSC. If the power light flashes, no servos are detected. This is normal when no servos are connected. If it blinks when servos are connected it may be due to improper network geometry or missing termination plugs.

The red LED is normally off. If the Red LED flashes, there is a servo error. The LED will flash the number of times indicating the address (1 to 20) of the servo with a fault, pause, and repeat. If more than one servo has a fault, the lower numbered servo will be indicated. Transient faults such as momentary position errors may not be indicated, but will appear in status messages from the NSC to the host.

4. Remove power from the NSC and connect the servos to the NSC through the four 8-pin ports on the NSC front panel with the servo cables supplied. Either connector on a servo may be used for connection to an NSC or another servo.

Typical Daisy Chain Configuration

5. Install the termination plugs.

- There are 2 pairs of servo connectors on the NSC front panel, one above and one below the LEDs. If one connector of a pair is used and the other unused, the unused connector have a termination plug installed. If neither connector of a pair is used, it is not necessary to terminate the pair. Termination plugs, however, may be used to seal the unused connectors.

- The last servo in each chain must have a termination plug in the unused connector.

6. Connect the serial cable from the NSC to your host computer. If the NSC is equipped with an RS-232 port a straight-through serial cable is needed, and may be ordered as an option. If the NSC is equipped with an RS-422 port the dual twisted-pair cable may be ordered as an option. Ensure that the cable is wired appropriately for the pinouts of your host connector.

7. Reapply power. The NSC green LED should come on and stay on. The red LED should remain off.

8. Initiate communication with the NSC through a terminal emulation program or the demonstration software supplied. See the NSC and servo command set for commands and queries.

2.2 Standalone RS-232 / Voltage Input Servos

1. Connect the power and voltage input signal or RS-232 host to the servo cables.

2. Plug the cables into the proper servo connectors.

3. Turn on system power. A new servo will center and hold that position in the absence of an input signal or command from the RS-232 port. Position will change over +/- 45 degrees as a +/- 10V differential signal is applied or position commands are issued over the serial port. The servo should echo serial commands received.

3. Component Descriptions

3.1 Servos

Case Aluminum, black anodized
Shafts Hardened steel
Diameter: ISS, 6 +0/-.03 mm. ISL, 10 +0/-.03 mm.
Gears Steel
Sealed output and connectors
Position Feedback: 5000 count optical quadrature optical encoder on output shafts
Index and Home channels

Connectors: LEMO 1K series
Connector characteristics

Humidity (max):	<=95% [at 60 deg C /140 F]
Vibration:	15 g [10 Hz - 2000 Hz]
Shock Resistance:	100 g [6 ms]
Salt Spray Corrosion:	>144 hr
Climatic Category:	50/175/21
Shielding (min):	95 dB (10 MHz)
Shielding (min):	80 dB (1 GHz)
IP Rating:	66

3.1.1 Fault Protection

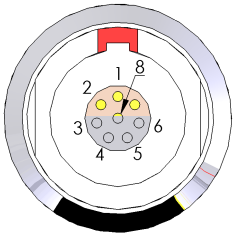
The IS Servos include built-in protection against possible fault conditions, including:

- Software error handling
- Status reporting for a large number of possible fault conditions
- Protection against conditions such as excessive temperature, under/over voltage, loss of commutation signal, short circuits between the motor power outputs and between each output and power input/return
- Recovery from loss of commutation signals and communication errors

3.2 Networked Servos

3.2.1 CAN Servo Connectors

The pinout and wire chart for both of the power plugs/cables on a networked servo are shown below. The connectors are capable of carrying 7 amps on each of the 3 power and 3 ground pins.



8 Pin ISS/NSC Receptacle
1: CanH
2: +V
3: +V
4: GND
5: GND
6: GND
7: CanL
8: +V

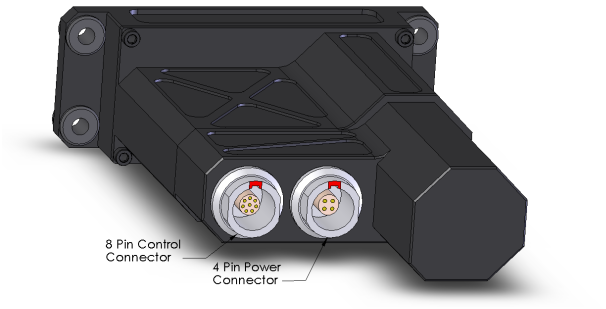
Servo CANbus/Power Connector Pinout

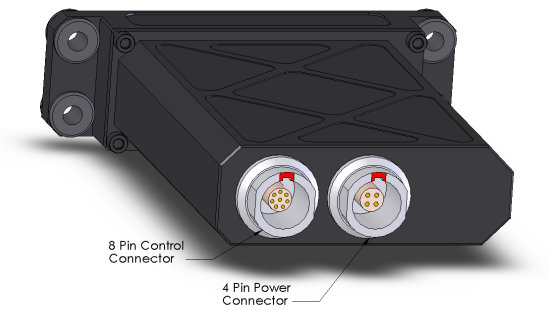
3.3 Standalone RS-232 / Voltage Input Servos

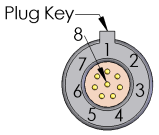
Servos ordered as standalone units can be controlled via RS-232 or a +/- 10V differential input signal. They are configured via RS-232 commands. See the Servo Commands section of the Command Set chapter.

3.3.1 Standalone Servo Connector Locations and Pinouts

ISL Servo	ISS Servo

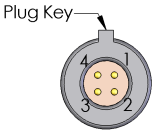






Pin	Wire	Function
1	Orange	AN+
2	Lt. Orange	AN-
3	Green	H+
4	Lt. Green	H-
5	Blue	Rx
6	Lt. Blue	Tx
7	Brown	RS Return
8	Lt. Brown	NC

Standalone Servo Control Connector



Pin	Wire	Function
1	White	+Vin
2	Brown	GND
3	Green	+Vin
4	Yellow	GND

Standalone Servo Power Connector

3.3.2 Standalone Servo Analog Voltage Input

Maximum operating differential voltage	±10V
Maximum absolute differential input voltage	± 16V
Differential input resistance	3.74 Kohms
Analog input command resolution	14 bits

Using the Analog Input

To use the analog input to control position, speed, or torque, the serial command UM must first be used to select the analog input as the control source and configure it as desired.

Driving the Analog Input with a Single-Ended Source

To use the differential analog input with a single-ended source, AN+ should be connected to the signal source and AN- to ground at the signal source location with a twisted pair.

3.3.3 Standalone Servo Home Input

Standalone servos may be moved to their hardware home location by applying 3.3 to 5 V to the H+ input. H- is the return for the home signal and should be grounded. If the servo is enabled it will move to its home position. The Home input has an internal 10K pulldown resistor.

3.4 Network Servo Controller

3.4.1 Servo Control

The NSC can control IS servos as well as smaller pulse width controlled servos driven by RC style pulses (1-2 ms, 50-400 Hz). Up to 20 IS servos and 12 PWM servos may be connected.

3.4.2 Servo Power

IS servo power must be supplied on the main NSC power connector. This power also supplies the NSC's internal electronics and host serial port. The voltage input range is dependent on the version ordered.

3.4.3 Controlling PWM Servos

Power for any third Acuity or third party PWM servos must be applied to some of the V+ pins of AUX1 and/or AUX2 or supplied to servos separately. If less than 12 PWM servos are being driven, the unused power/ground pins on AUX1 and/or AUX2 can be used as inputs. Maximum current is 3 Amps per pin. The twelve power pins on AUX and AUX2 are connected together internally but isolated from the rest of the NSC and may have 0 to 48V applied. AUX1 and AUX2 ground pins are connected to NSC ground.

3.4.4 Using PWM Input Signals

Signals from a servo controller such as an RC radio receiver can be used to control IS or PWM servos attached to the NSC. Eight input pins on the AUX2 connector accept 1-2 ms PWM signals at up to 500 Hz. When pulses are received, the same width pulse is transmitted to the mapped servo channel if the input has been mapped to a PWM address.

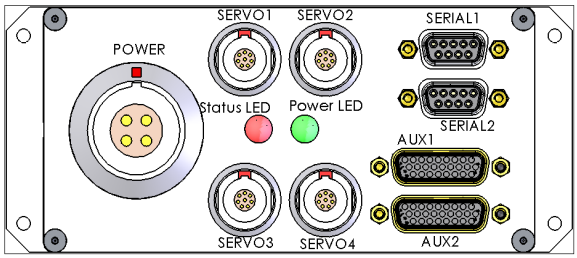
If the input has been mapped to an IS address, the command is interpreted as a torque, speed, or position signal for that IS servo. In torque mode, pulse widths of 1 to 2 ms is mapped to a current range of +/- the value specified in the last current limit command. PWM inputs outside the 1 to 2 ms range will be limited, or clipped, to 1 or 2 ms before generating the servo signal. Servos are shipped with the current limit set appropriately, so current limits should only be modified if reduction in peak torque is required.

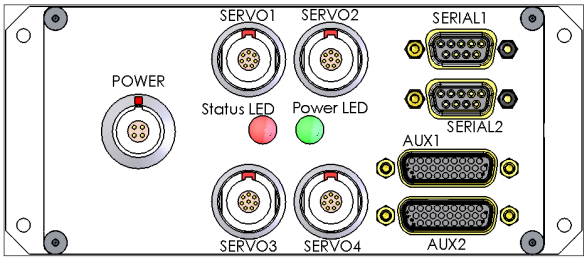
3.5 NSC Front Panel

The NSC connectors described below are mounted on the NSC front panel.

SERVO1	
SERVO2	
SERVO3	
SERVO4	
SERIAL1	RS-232 or RS-422 Host Interface
SERIAL2	Reserved: Do not connect.
AUX1	4 PWM outputs, 8 PWM inputs
AUX2	12 PWM outputs

POWER
Green Power LED
Red Status LED





NSC-60 **NSC-20**

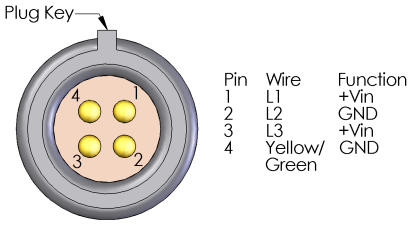
NSC Front Panel

3.5.1 NSC Power Connector

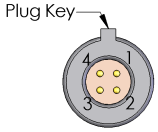
The large power connector on the NSC-60 is capable of 30 Amps on each of its 2 power and ground pins. The smaller power connector on the NSC-20 is capable of 10 Amps per pin.

3.5.2 Cable Plug

The pinout of the plug on the power cable supplied with the NSC, looking into the cable plug (not the mating NSC connector) is shown below.



Pin	Wire	Function
1	L1	+Vin
2	L2	GND
3	L3	+Vin
4	Yellow/ Green	GND

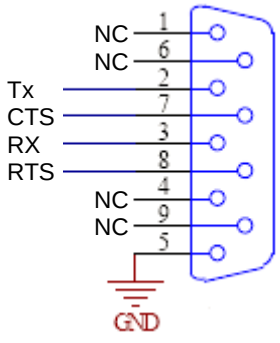


Pin	Wire	Function
1	White	+Vin
2	Brown	GND
3	Green	+Vin
4	Yellow	GND

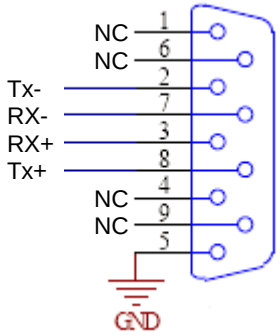
60 Amp NSC Plug **20 Amp NSC Plug**

3.6 Serial and Auxiliary Input Connectors

Pinouts are shown below for the SERIAL1, AUX1, and AUX2 connectors.



SERIAL1 – RS-232 model



SERIAL1 – RS-422 model

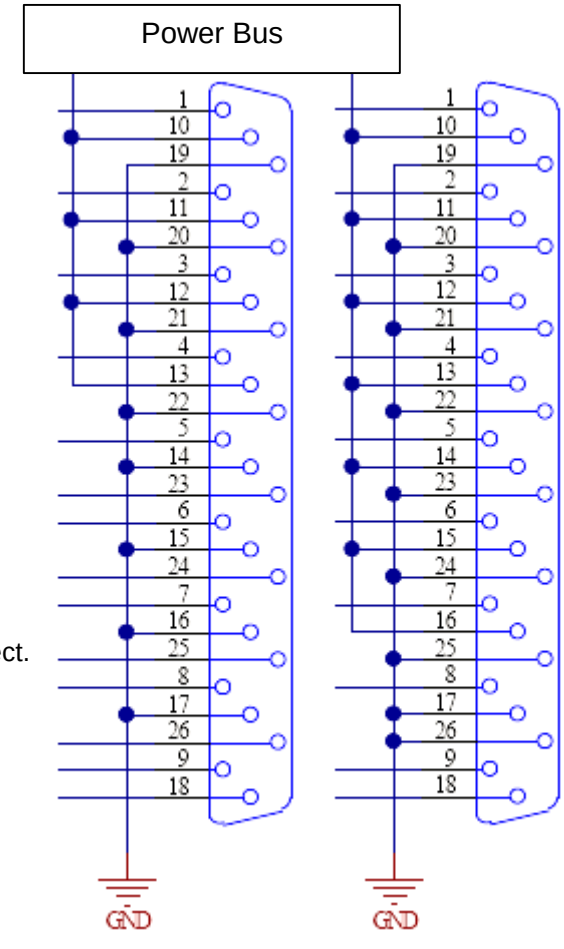
PWM Output Address Map

Connector	Pin	Servo Address
AUX1	1	21
AUX1	2	22
AUX1	3	23
AUX1	4	24
AUX2	1	25
AUX2	2	26
AUX2	3	27
AUX2	4	28
AUX2	5	29
AUX2	6	30
AUX2	7	31
AUX2	8	32

AUX1 Power Pins: 10-13
AUX1 Ground Pins: 14-17, 19-22

AUX2 Power Pins: 10-16
AUX2 Ground Pins: 17, 19-26

Reserved: AUX1 pins 9,18, AUX2 pins 9, 18. Do not connect.



AUX 1 AUX2

PWM Input Address Map

Connector	Pin	Input Address
AUX1	5	1
AUX1	23	2
AUX1	6	3
AUX1	24	4
AUX1	7	5
AUX1	25	6
AUX1	8	7
AUX1	26	8

3.6.1 NSC Front Panel LEDs

The green LED will light when power is applied to the NSC. If the power light flashes, no servos are detected. This is normal when no servos are connected. If it blinks when servos are connected it may be due to improper network geometry or missing termination plugs.

The red LED is normally off. If the Red LED flashes, there is a servo error. The LED will flash the number of times indicating the address (1 to 20) of the servo with a fault, pause, and repeat. If more than one servo has a fault, the lower numbered servo will be indicated. Transient faults such as momentary position errors may not be indicated, but will appear in status messages from the NSC to the host.

4. Command Set

4.1 NSC Commands

The NSC accepts commands for itself and the servos connected to it over the 232 or 422 serial port. The commands in this section are executed by the NSC and may generate a sequence of commands to a servo. Except for the **Move Servo** command, all commands are in ASCII. These consist of ASCII command codes and command parameters.

The commands in the section Servo Commands have the same syntax and can be used with standalone servos or in networked systems. In a networked system they are passed directly to the servos through the NSC. The servo to which commands apply is specified with the SS (Select Servo) command.

Servo responses are relayed through the NSC. Servo heartbeats are followed by a two character servo address identifier, from 01 to 32. Reponses to queries can be assumed to come from the currently selected servo.

ASCII NSC commands consist of a two letter code which in some cases is followed by an [index] specifier, an = sign, and a parameter value. Commands must be terminated by CR, LF, or semicolon.

AD[NN]	**Set new servo address**
AP[NN]	**Map PWM input to servo**
EN	**NSC Echo on/off**
NR	**Set/query NSC status reporting level**
NS	**Query Network status**
knabbbb…	**Move servo (binary command)**
SB=A	**Set NSC baud rate**
SS=AA	**Select servo**
TS	**Synchronize Time**
UK	**Universal kill motor command**
US	**Universal stop motion command**

4.1.1 NSC Command Descriptions

Set NSC Baud Rate

SB=A – Sets/reports the NSC host port baud rate. Valid values are

0 = 4800, 1 = 9600, 2 =19200, 3 = 38400, 4 = 57600, 5 = 115200.

When the NSC or a serial standalone servo powers up, it looks for a stream of Space (ASCII byte code 32) characters at 9600 baud. If a stream of spaces is detected, it will set its baud rate to 9600, which is also the default. If the first of a stream of 5 space characters is not detected within 250 ms, it will set its rate to the value for which it has been configured and begin accepting commands. This allows a user to establish contact with an NSC whose baud rate setting is unknown or does not match that of the host, by powering it up while transmitting space characters or holding down the space bar when using a terminal emulator set to 9600 baud. Note that an SV command must follow this command to make the change permanent.

Baud rate of the CANBus cannot be changed.

EN Echo on/off
Set/query the NSC character echo mode. A parameter value of 1 turns NSC serial port character echo on, 0 turns echo off. May be turned off if local echo at terminal emulator is on.

knabbbb{nabbbb…} – Move Servos (Binary Command)
Sends a torque, speed, or position command to one or more servos, depending on the servo mode (Servo SM command), and immediately executes the motion. This command is composed of binary values, so it cannot be issued from a keyboard. It is used for high speed control of a servo network from a host control program through the NSC. This command does not have a specific code. Rather, the first byte of the command is a binary value specifying the number of CAN servos being commanded. Valid values are 1-20. This command causes the NSC to issue a TC, JV, or PA command followed by a BG command to the specified servo(s) (not the servo presently selected with the SS command).

The second byte and (optionally) every 5th subsequent byte is a servo address. Valid values are 1-20. The four bytes following each address are a position or speed value for that servo, depending on the mode of the servo. A 4 byte value must follow each address, and the number of 5-byte address-parameter pairs must match the binary value of the first byte of the command. The parameter is a 32 bit two's complement value representing the number of encoder counts for absolute or relative position mode, the servo speed in encoder counts/second for speed mode, or the current in milliamperes for torque mode, per the present value of SM for each servo addressed.

Replies: Servo ack or status according to the status reporting value for each servo and the NSC.

AD[NN] – Set New Servo Address
Seeks a servo attached to the CAN network with address NN, and changes its address to AA. The default address for new servos is 127. As each new servo is added to a network, AD[127]=AA should be performed to set its address within the range 01-20 before adding another new servo. Servos will retain their addresses when moved from one network to another, so care must be taken to avoid conflicting addresses.
Reply: The new servo address if it was successfully assigned, 0 otherwise.

AP[NN] – Map PWM Input to Servo
Maps PWM input NN to servo AA. NN is in the range 1 to 8, and AA in the range 1 to 32. If the servo address is in the range 1 to 20, the 1 to 2 ms input is scaled to the configured position, torque, or speed limits for that servo. If AA is in the range 21 to 32, the corresponding output PWM width and repetition rate will track the input PWM signal with up to 1 ms delay.

NR - Set/query NSC status reporting level
Set the way NSC status messages are sent to the host. This is distinct from the status reporting level for a servo. In a network, each servo will report status to the NSC in accordance with its settings and the NSC will always relay these messages, as it does all servo activity. (See the servo command SR.) The NSC status configuration applies only to NSC status and error conditions.

Status reporting command parameters are formed from 3 digits. The first controls error reporting, the second controls command acknowledgment, and the third controls periodic heartbeat transmission.

1XX: Send no NSC error or status messages to host.
2XX: Report NSC hard errors.
3XX. Report NSC hard and soft errors. (default)

X1X: Send no command acknowledgements.
X2X: Send an error message if NSC command is invalid. (default)
X3X: Send an 'A' acknowledgement to each valid servo command and an error message if invalid.

XX1: Send no 'N' heartbeat. (default)
XX2: Send 'N' heartbeat once every second.
XX3: Send 'N' heartbeat once every 0.1 second.
XX4: Send 'N' heartbeat once every 0.01 second.
XX5: Send 'N' heartbeat once every 0.001 second.

Error Codes:
50: Normal operation. Sent only in response to an NS command.
Soft Errors:
51: Can Bus Soft Error, retried successfully
Hard Errors:
52: Can Bus Hard Error
53: Servo Communication Failure – an expected response or heartbeat was not received

Error code 53 is followed by a 2 character servo address, 01 to 32.

NS – Query Network Status
Returns one of error codes 50-53.

Heartbeat
'N' – This is a single character message from the NSC, not a command. If status reporting level 3 is set, this heartbeat acknowledgement is sent from the NSC to the host after each message. This provides assurance that the NSC is functioning properly and receiving servo commands with a minimum of communication overhead. The heartbeat consists of the letter N. This is acknowledgement that a motion command has been received by the NSC, not an indication that the servo has received the command or that motion has been completed. This is not the same as an individual servo 'S' heartbeat, which is relayed through the NSC from a servo.

Select Servo
SS – Select a servo for subsequent configuration and motion control commands. Addresses of networked servos must be two characters and must be in the range of 01 to 32. Upon power-up the default value of SS in the NSC software is 127.

Synchronize Time

TS – Set all servos time to the specified value, synchronized to within 100 microseconds. This can be used with the BT command for multi-axis synchronized motion.

UK – **Universal Kill Motor Command**
When the NSC receives a UK command, it sends MO=0 commands to all CAN servos. This command disables power to the motor, but the shaft may coast due to inertia.

US – **Universal Stop Motion Command**
When the NSC receives a US command, it sends a Stop Motion (ST) command to all CAN servos. The ST command stops immediately and puts it into the position control mode. For a detailed description of the SM commands, refer to the Servo Command Set documentation below.

4.2 Servo Commands

The IS servos use a 2 character motion control command set. The servo commands are the same whether communicating directly with a Standalone IS Servo or with a Network IS Servo through the NSC, except that servos must first have addresses assigned and a servo must be selected using the **AD** and **SS** commands (described above) when using the NSC. When communicating with a standalone servo NSC commands will have no effect.

Cautions

Note that several non-volatile servo parameters including current limits set with CL[N] are preset for the IS servos. Exceeding the factory default values of these parameters may result in damage to the servo.

Standalone Servos

The following commands are interpreted and executed by the servos. In a networked system, they are interpreted and relayed to the currently selected servo by the NSC. Any servo responses are relayed to the host through the NSC.

BT	Begin motion at specified time
CL[N]	Motor current limitations
EC	Current error
EH[N], EL[N]	Position and velocity error limits
ER	Last Error
ES	Servo Echo on/off
FD	Load factory default parameters from PROM
HL[N], LL[N]	Jerk, acceleration, speed and position limits
HO	Move the servo to the hardware home location or stop homing
HV	Homing velocity
ID	Set/Report CAN node address
IN	Set/Report motion command input source
JV	Jog at constant velocity
KA	Acceleration feedforward gain
KF	Velocity feedforward gain
KP, **KI, KD**	PID gains for servo control loops
LD	Load parameters from flash
MO	Motor enable/disable - necessary to change some configuration parameters.

MS	Motion status
PA	Move to absolute position
PE	Position error
PR	Move to relative position
PU	Power up behavior
PV	Report present velocity
PX	Report present position
RS	Soft reset
SR	Status reporting level
ST	Stop motion immediately and hold position
SV	Save parameters to non-volatile flash
TC	Torque (motor current) command
TM	System time
TR	Target radius
UB	Baud rate
VE	Velocity error

4.2.1 Servo Command Descriptions

When using the motion control commands JV, PA, and PR, each motion mode starts with its entire set of applicable parameters and limits HL[N] and LL[N]. Starting a point-to-point motion uses the present limit settings of acceleration smoothing (jerk), acceleration/deceleration, speed, and position. Therefore these parameters should be set to the desired values before initiating a motion.

Maximum magnitude of all parameters must be $< 2^{32}$-1 unless otherwise noted.

A few commands are available in binary format. Binary values of 2 bytes or more are in little endian.

abbbb – Move Servo (Binary Command)
Send a torque, speed, or position command. This command is composed of binary values, so it cannot be issued from a keyboard. It is used for high speed control of a servo network from a host control program through the NSC. The motor must be enabled (MO=1) for this command to have an effect. These moves take place at once: They are not affected by the BT command. This command does not have a specific code. Rather, the first byte of the command is a binary value specifying the type of motion commanded. Valid values are 1-4. A 4 byte parameter must follow. The parameter is a 32 bit two's complement value representing the number of encoder counts for absolute or relative position mode, the servo speed in encoder counts/second for speed mode, or the current in milliamps for torque mode.

First byte binary codes:

1: Absolute position
2: Relative position
3: Velocity
4: Torque (motor current)

Replies: Servo ack or status according to the servo status reporting control value.

BT – Set the time of execution of the next motion command
Starts the ***next*** PA, PR, JV, or TC command at the time specified, provided the specified time is after the time of receipt of the BT command and the motion command. If the command has not begun executing

by the time a second motion command is received the pending delayed command is removed. Sending BT=0 will remove any pending delayed execution. See also TM.

Note: The servo time in milliseconds is a 32 bit value and will wrap around when the time value reaches 2^{32}-1 milliseconds. Users should ensure that this does affect operation of the BT command.

CL[N] - Current limits
Set the instantaneous peak and continuous current limits. Note that if these values are changed it is possible to damage the motors in some servo models. If the continuous current limit is exceeded for more than 2.7 seconds, the current will be reduced to the continuous current limit. If a motion command attempts to drive the current above the peak current limit, the current will be limited to the peak current limit.

CL[0] sets/reports the maximum peak current, in amperes. Valid limits are 0 to 6.6 amperes.
CL[1] sets/reports the maximum continuous current, in amperes. Valid limits are 0 to 3.3 amperes.

EB – Query error code binary
Reports the current error status of the servo as an 'E' character followed by a 32 bit binary long word. Each error condition is reported with a corresponding bit in the long word set. See EC for error descriptions.

EC –Query error code ASCII
Reports the current error status of the servo as an ASCII string of 32 '1' or '0' characters. Each error condition is reported by one character.

Hard errors will shut down the drive. To re-enable the drive, ensure that the cause of the problem has been corrected before re-enabling it by sending the MO=1 command.

Error Codes

Normal operation	0000 0000 0000 0000 0000 0000 0000 0000

Hard Errors

Hard CAN bus communication failure	0100 0000 0000 0000 0000 0000 0000 0000
Power circuitry short	0010 0000 0000 0000 0000 0000 0000 0000
Temperature limit exceeded	0001 0000 0000 0000 0000 0000 0000 0000
Power supply failure	0000 1000 0000 0000 0000 0000 0000 0000
Under voltage	0000 0100 0000 0000 0000 0000 0000 0000
Over voltage	0000 0010 0000 0000 0000 0000 0000 0000
Power up reset occurred	0000 0001 0000 0000 0000 0000 0000 0000
Motor commutation failure	0000 0000 1000 0000 0000 0000 0000 0000
Unknown Amplifier Error	0000 0000 0100 0000 0000 0000 0000 0000
EEPROM Read Error	0000 0000 0010 0000 0000 0000 0000 0000

Short, Commutation, and Over-temperature errors, require disabling the motor (MO=0) or power cycling the servo to restore operation.

Soft Errors

Bad command code received	0000 0000 0000 0000 0000 0000 0000 0001
Bad parameter value received	0000 0000 0000 0000 0000 0000 0000 0010
Continuous or peak current limit triggered	0000 0000 0000 0000 0000 0000 0000 0100
EEPROM Write Error	0000 0000 0000 0000 0000 0000 0000 1000

Soft CAN error – transmission retried	0000 0000 0000 0000 0000 0000 0001 0000
Position following error	0000 0000 0000 0000 0000 0000 0010 0000
Speed following error	0000 0000 0000 0000 0000 0000 0100 0000
Position limit error – At or beyond limits on motion	0000 0000 0000 0000 0000 0000 1000 0000
Speed limit error – At or beyond limits on motion	0000 0000 0000 0000 0000 0001 0000 0000

EH, EL – Error High, Low Limits
Set/report the error level at which a soft position or speed error will be reported.

EL[1] = Lower speed error limit
EL[2] = Lower position error limit

EH[1] = Higher speed error limit
EH[2] = Higher position error limit

Lower limits must be < 0, Higher limits > 0.

ER – Latched Errors
Reports/clears errors detected in the current power cycle since the last time ER was cleared. In the case of transient errors such as a CAN bus soft error, this value will be retained after the error condition has corrected. ER=0 will clear the retained errors. See EC for list of error bits

ES – Echo on/off
A value of 1 turns NSC serial port character echo on (default), 0 turns echo off. An alternative to local echo at terminal emulator.

FD – Load factory default parameters from PROM
Reads the factory servo parameters from non-volatile memory and set the active parameters to the retrieved values. See also SV and LD.

HL[N], LL[N] – Jerk, acceleration, speed and position limits
Positive and negative values for motion limits. HL[N] sets/reports the positive limit for each, and LL[N] the negative limit.

N = 1 Jerk, in encoder counts/sec^3
N = 2 Acceleration, in encoder counts/sec^2
N = 3 Speed, in encoder counts/sec
N = 4 Position, in encoder counts

Jerk is defined as the rate of change of acceleration.
For all except position, lower limits must be < 0, Higher limits > 0.
For position, lower limits must be <= 0, Higher limits >= 0. Setting both to zero allows unlimited rotation.

Position limits and speed limits are enforced in all types of motion.
Acceleration and jerk limits are enforced only in PA and PR moves. The jerk limits are used to set the rate of acceleration in PA and PR moves.

The position and speed limits are enforced in three ways. First, a position or speed motion command with a parameter that exceeds the limits will be rejected as invalid. Second, path planning is performed such that if the planned trajectory will cause commanded speeds or positions outside the limits, the trajectory is altered. Third, actual speed and position are checked at 1 millisecond intervals and commanded motor

power is limited to generate only those motor currents that will accelerate away from the limit reached. For example, reaching a positive limit will clip (signed) commanded motor current to zero or less.

It is possible for an external force or inertia to carry the speed or position past the limits set: No power is applied to the motor for enforcing limits.

HO – Home
Reports whether the servo is homing, or moves the servo to the encoder home location (HO=1) and then sets the servo position to zero, or stops homing (HO=0). Servos may be configured to home on power up, or only on receipt of this command.

HV – Home velocity
Sets/reports the speed at which the servo will home. Range: > 0 and within the velocity limits in presently in effect.

ID – CAN node address
Sets/reports the CAN address of the servo, from 1 to 127

IN - Motion command input source
Sets/Reports motion command input source. The serial port remains active for configuration and other commands.

1: Serial port
2: Analog Input
3: PWM Input

JV – Jog at constant velocity
Reports last JV commanded, or ramps to the specified velocity, in encoder counts/second, and continues until the next motion command is received or a position limit is exceeded. Uses the jerk and acceleration limits to reach the commanded velocity. JV=0 will stop using these limits. To stop immediately and hold position, use the ST command. See also PV for actual velocity.

KA – Acceleration feedforward gain
Applies a motor current proportional to the instantaneous commanded speed in position control in addition to the KF and PID output current. This can be used to improve transient response in systems with large inertial loads. This parameter only has an effect in PA and PR commands, and their binary equivalents.

KF – Velocity feedforward gain
Applies a motor current proportional to the commanded speed (JV) or to the instantaneous speed in position control in addition to the KA and PID output current. This can be used to improve transient response in systems with a high degree of mechanical speed-proportional damping. This parameter only has an effect in JV, PA and PR commands, and their binary equivalents.

KP, KI, KD - Servo Proportional-Integral-Derivative gains
The IS servo controllers implement PID control with an optional feedforward term. The controllers and motors are tuned to perform well with most loads. For highly inertial loads it may be appropriate to reduce the proportional and integral terms to reduce overshoot or oscillation. These parameters can be read and adjusted through the KP, KI, KD, KA, and KF commands.

Warning: Changing these parameters can result in violent unstable motor motion. We recommend setting low limits for maximum positive and negative motor current before experimenting with these values. Keep in mind that the position, speed, acceleration, and current limits can affect servo dynamics for large movements. Test stability with small motions before trying large movements or high speeds.

LD - Load Parameters from Flash
Reads the stored servo parameters from non-volatile memory and set the active parameters to the retrieved values. See also SV and FD.

MO - Enables and disables (freewheels) motor power
MO=0 disables the motor. This is the idle state of the drive. The power stage is disabled and no current flows in the motor. MO=1 is the operative state of the servo drive, driving the motor and activating and executing the programmed motion. When first enabled, the servo holds its current position. MO=1 must be given before a motion command will move the servo. If MO is set to 1 and the motor is already on, nothing happens. MO is set to zero when a hard error occurs. See the EC error status query.

Note:
When PU=1 or PU=2 the servo drive will attempt to start (set MO=1) automatically after power on.

MS - Motion Status
Query the current status and target value. Responses are:

In JV command (JV=speed)
In PA command (PA=destination)
In PR command(PR=target)
In TC command(TC=torque)
Holding position (HL=position)
Homing (HO=1)
Motor off (MO=0).

MS is a query command only. Any parameter is ignored.

PA - Absolute Position
Reports last PA commanded, or commands motion to the specified target position. If a PA, PR, JV or TC command is being executed, is aborted and the motion takes place immediately. The drive moves to the desired target position as fast as possible, subject to the jerk, speed, and acceleration limits. See HH and HL commands. See also PR (Relative Position).

PE - Position Error
Reports the current position error when the motion status is (MS) is PA, PR, JV or HL. This is the error in the PID motion control loop, not the difference between the target location of a PA or PR command and the present location.

PR - Command Relative Position
Reports last PA commanded, or moves the distance specified from the current position. If a PA, PR, JV or TC command is being executed, is aborted and the motion takes place immediately from the current encoder position. If the servo is holding at a target location the relative move will be from the target location, not the current location which may differ from the target by a holding error. The drive moves to the desired target position as fast as possible, subject to the jerk, speed, and acceleration limits: See HH and HL commands. See also PA (Absolute Position).

PU– Power Up Behavior

Configures the servo's power up behavior. Valid parameters are

0: Do not activate the motor on power up. Servo will not engage until a motion or HO command is received. Zero position is the encoder position when the servo engages. This is the default.
1: Activate the motor, causing it to hold position, but do not move to home on power up.
2: Activate the motor and home the servo, setting the encoder value to 0 at the home location.

PV – Report Present Velocity
Reports the present velocity in encoder counts per second. This is an average of the velocity over the previous 10 milliseconds. This may be noisy and of low resolution at low speeds.

PX – Report Present Position
Reports the present position in encoder counts.

RS - Soft Reset
Restarts the servo as if from power up.

SR – Status Reporting Level
Set the way servo status messages are sent to the host. This is distinct from the status reporting level for the NSC. In a network, each servo will report status to the NSC in accordance with its settings and the NSC will always relay these messages, as it does all servo activity. (See the NSC command NR.)

Status reporting command parameters are formed from 3 digits. The first controls error reporting, the second controls command acknowledgment, and the third controls periodic heartbeat transmission.

1XX: Send no error messages to host.
2XX: Report hard servo errors only (default).
3XX. Report hard and soft servo errors.

X1X: Send no command acknowledgements.
X2X: Send an error message if servo command is invalid (default).
X3X: Send an 'S' acknowledgement to each valid servo command or an error message if invalid.

XX1: Send no 'K' heartbeat (default).
XX2: Send 'K' heartbeat once every second.
XX3: Send 'K' heartbeat once every 0.1 second.
XX4: Send 'K' heartbeat once every 0.01 second.
XX5: Send 'K' heartbeat once every 0.001 second.

Standalone Servo Heartbeat: Single 'K' character sent over serial port.
Network Servo Heartbeat: 5 bytes: 1 byte CAN ID followed by 'EE99'.

See the EC command for error code meanings.

ST - Stop motion immediately and hold position
Emergency stop and hold position. Decelerates as allowed by the peak current limit and hold position when stopped. To stop using the motion smoothness parameters, use the JV=0 command. To disable motor power immediately, use the MO=0 command.

SV - Save parameters to non-volatile flash
Saves the currently active servo parameters to non-volatile memory, overwriting the stored values. Does not affect the factory default values. See also LD and FD.

TC - Torque (motor current) command
Direct control of motor current. Valid command values are – CL[0] to CL[0].

TM - System Time
Set/report the servo time. If the time is not set, the servo's time is in milliseconds from power up. System time is not preserved across power cycles.

Note: The servo time in milliseconds is a 32 bit value and will wrap around when the time value reaches 2^{32}-1 milliseconds. Users should ensure that this does affect operation of the BT command.

TR - Target Radius
Set/report the distance from position target for deciding that a motion is complete when executing a PA or PR command. Range is 0 to 65535. The MS query will return "Holding position" once the servo has arrived within this radius of the target position and the speed has reached zero. The MS state will not change until the next motion command regardless of motion from external disturbances. The holding error can be read using PE.

UB – Baud Rate
Set/report the current baud rate in serial interface servos.
Values are

0: 4800 Baud
1: 9600 Baud
2: 19200 Baud
3: 38400 Baud
4: 57600 Baud
5: 115200 Baud

Baud rate of CANBus servos cannot be changed.

5. CD Directory Structure

The NSC and servos come with a CD with the following contents:

\doc	-This users guide and servo datasheet
\bin	- precompiled GUI-driven demo for Windows XP host
\src	- host demo program source code and MS C/C++ solution

6. Servo Interface Application

The Acuity Servo Interface for Windows XP is an interface for communication through a serial port with the NSC or with a standalone servo is found in the \bin directory of the distribution CD. This provides a simple interface for configuring servos and trying out motion commands.