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Serial Communication for SA Amplifiers

In addition to user input via the front panel of the amplifier, it is possible to control many of the functions of the SA series of amplifiers using RS-232 serial communication. Communication is implemented as a multi-drop system, allowing up to 254 devices to be controlled via one serial port. The basic structure for communication consists of one byte of information combined with a parity bit and two stop bits. Note that the parity bit is *not* used for error checking; it is used to distinguish between addresses and other types of information.

Each SA amplifier has an identification number for serial communication (1-254) that can be set from the front panel. Care should be taken to ensure that no two amplifiers on the same serial port use the same number. Similarly, the baud rate is also set via the front panel. Note that a limited number of baud rates are available, and in some cases, significant timing error exists between the available rate and ones that are standard for RS-232 communication. Table 1 shows some of the common RS-232 baud rates, and the nearest available one on the SA. In most cases, timing error will not be problematic. The reliability of communication is largely dependent on the RS-232 hardware of the host computer. It may be necessary to choose a data rate that has low timing error in order to assure reliable serial communication. Note that the identification number and baud rate of the amplifier will be lost when the amplifier is turned off unless they are saved with the SAVE SETTINGS menu on the amplifier or the equivalent serial command.

Table 1
Baud Rates for SA Amplifier/Controllers

BAUD RATE (kBaud)		PERCENT
STANDARD	AVAILABLE	ERROR
9.6	9.62	0.2%
14.4	14.38	-0.1%
19.2	19.23	0.2%
28.8	28.98	0.6%
38.4	38.46	0.2%
57.6	57.14	-0.8%
76.8	76.92	0.2%
115.2	117.6	2.1%
230.4	222.22	-3.5%

Communication is always initiated by the host computer (typically a PC) rather than the amplifier. Communication begins with the host sending an address byte. An address is distinguished by a parity bit of 1, whereas all other transmissions (command or data bytes) have a party bit of 0. All controllers “listen” to all addresses. If a controller receives its address, it will return a status byte with a parity bit of 1 and execute all subsequent commands until it receives another address. The structure of the status byte is shown in Table 2. By reading the

114 SE Parkway Ct, STE 160
Franklin, TN 37064
Tel: 615/595-6665
Fax: 615/595-6610

status byte, important information about the amplifier can be determined. If a controller receives an address that is different from its own, no transmission is made and all subsequent commands will be ignored. Thus, it is not necessary to transmit the address each time a command is sent to the amplifier. The address is sent once by the host, and no additional address must be sent unless action is required from a different amplifier.

Table 2
Status Byte Codes for DSM SA Amplifier/Controllers

BIT	DESCRIPTION	FUNCTION NAME	VALUE
0	Internal Use		
1	Internal Use		
2	TTL Servo Enable Control	IsTTLServoEnabled	0=Disabled, 1=Enabled
3	Data Streaming Status	DataStreamStatus	0=Disabled, 1=Enabled
4	Position Mode – Ramp	PositionMode	0=Disabled, 1=Enabled
5	Servo Status	ServoStatus	0=Disabled, 1=Enabled
6	Position Mode – Voltage	PositionMode	0=Disabled, 1=Enabled
7	Temperature Status	TemperatureStatus	0=OK, 1=High Temp Shutdown

Some commands are simple one byte codes, while others have data associated with them. In the case of commands that send data to the amplifier, the command should be sent first, followed immediately by one or more bytes of data, again using a zero parity bit and two stop bits. Note that each command has a specific number of data bytes associated with it, and sending an incorrect number of bytes will result in extra data bytes being interpreted as commands or subsequent commands being interpreted as data, in the case of too few data bytes. Some commands will cause the amplifier to transmit one or more data bytes, also with zero parity and two stop bits. Since the amplifier always checks for an address byte, communication can be reset at any time by sending the amplifier address.

The current command set is summarized in the Table 3 below. Descriptions of the functions and how they are executed by a host computer follow the tables.

114 SE Parkway Ct, STE 160
Franklin, TN 37064
Tel: 615/595-6665
Fax: 615/595-6610

Table 3
Command Set for DSM SA Amplifier/Controllers

COMMAND DESCRIPTION	FUNCTION NAME	OP-CODE	DATA BYTES
Enable Servo	EnableServo	0x03	0
Disable Servo	DisableServo	0x04	0
Set Position Target	SetPositionTarget	0x05	3
Get Position Target	GetPositionTarget	0x06	0
Get Current Position	GetPosition	0x07	0
Set Proportional Gain	SetPGain	0x08	2
Set Integral Gain	SetIGain	0x09	2
Set Derivative Gain	SetDGain	0x0A	2
Save Settings	SaveSettings	0x0C	0
Move to Negative Rail	NegativeRail	0x0F	0
Move to Positive Rail	PositiveRail	0x10	0
Move to Zero Volts	ZeroVolts	0x11	0
Get Proportional Gain	GetPGain	0x14	0
Get Integral Gain	GetIGain	0x15	0
Get Derivative Gain	GetDGain	0x16	0
Start Triggered Move	StartTriggeredMove	0x17	0
Set Position Mode – Single Point	SinglePointMode	0x19	0
Set Position Mode – Voltage Input	VoltageMode	0x1A	0
Set Position Mode – Ramp	RampMode	0x1C	0
Set Ramp Rate	SetRampRate	0x1D	3
Get Ramp Rate	GetRampRate	0x1E	0
Enable Data Streaming	EnableStream	0x1F	0
Disable Data Streaming	DisableStream	0x20	0
Set In Range Band	SetInRange	0x22	2
Get In Range Band	GetInRange	0x23	0

114 SE Parkway Ct, STE 160
Franklin, TN 37064
Tel: 615/595-6665
Fax: 615/595-6610

Enable Servo 0x03h

Enable Closed Loop Servo Control

Parameters

None

Packet Structure

write	Op-Code 0x03h							
	7	6	5	4	3	2	1	0

Description

When the SA amplifier is turned on, its default condition is approximately 0 V applied to the PZT and servo control disabled. This command enables servo control, allowing the amplifier to vary the voltage applied to the piezo-actuator based on the feedback target and signal from the feedback device.

Return Values

None

See Also

Disable Servo

Disable Servo 0x04h

Disable Closed Loop Servo Control

Parameters

None

Packet Structure

write	Op-Code 0x04h							
	7	6	5	4	3	2	1	0

Description

This command halts servo control in the SA amplifier. Although the feedback values continue to be sampled, they are not used to change the voltage applied to the piezo-actuator. Note that the applied voltage is left at its present value, rather than being automatically returned to 0 V.

Return Values

None

See Also

Enable Servo, Move to Zero Volts

114 SE Parkway Ct, STE 160
Franklin, TN 37064
Tel: 615/595-6665
Fax: 615/595-6610

Set New Position Target 0x05h

Load a new position target for closed loop control

Parameters

3 Byte Position Target

Packet Structure

write	Op-Code 0x05h							
write	Low byte of Position Target							
write	Middle byte of Position Target							
write	High byte of Position Target							
	7	6	5	4	3	2	1	0

Description

This command instructs the amplifier to load a new value for the target position. It does not automatically enable servo control. The command should be immediately followed by three bytes that describe the target. The position target is transmitted in engineering units as a three byte number with the low byte transmitted first, followed successively by the middle and high bytes. Implementation is typically made with nanometers as the engineering unit. Thus, some or all of the high byte will be zero, depending on the stroke of the actuator.

Return Values

None

See Also

Get Current Position Target

Get Current Position Target 0x06h

Send the current position target for closed loop control

Parameters

None

Packet Structure

write	Op-Code 0x06h							
read	Low byte of Position Target							
read	Middle byte of Position Target							
read	High byte of Position Target							
	7	6	5	4	3	2	1	0

Description

This command directs the amplifier to transmit the position target it is using for servo control. It does not affect servo enable/disable status. The position target is transmitted in engineering units as a three byte number with the low byte transmitted first, followed successively by the middle and high bytes. Implementation is typically made with nanometers as the engineering unit. Thus, some or all of the high byte will be zero, depending on the stroke of the actuator.

Return Values

3 Byte Position Target

See Also

Set New Position Target

114 SE Parkway Ct, STE 160
Franklin, TN 37064
Tel: 615/595-6665
Fax: 615/595-6610

Get Current Position 0x07h

Send the current position of the actuator

Parameters

None

Packet Structure

write	Op-Code 0x07h							
read	Low byte of Position							
read	Middle byte of Position							
read	High byte of Position							
	7	6	5	4	3	2	1	0

Description

This command directs the amplifier to transmit the position of the actuator, based on the feedback device. This value is updated once per servo cycle (typically 1500 Hz) even when servo is disabled. The position is transmitted in engineering units as a three byte number with the low byte transmitted first, followed successively by the middle and high bytes. Implementation is typically made with nanometers as the engineering unit. Thus, some or all of the high byte will be zero, depending on the stroke of the actuator.

Return Values

3 Byte Position Target

See Also

Set New Position Target

Set New Proportional Gain 0x08h

Load a new proportional gain for closed loop control

Parameters

2 Byte Gain

Packet Structure

write	Op-Code 0x08h							
write	Low byte of Proportional Gain							
write	High byte of Proportional Gain							
	7	6	5	4	3	2	1	0

Description

This command instructs the amplifier to load a new value for proportional gain. It should be immediately followed by a low and high byte that describe the gain. Valid values are 0-50,000. The proportional gain is used in the digital PID routine that controls the position of the actuator. These values are displayed as divided by 1000 by the amplifier, i.e. from 0.000 to 50.000.

Return Values

None

See Also

Get Current Proportional Gain

114 SE Parkway Ct, STE 160
Franklin, TN 37064
Tel: 615/595-6665
Fax: 615/595-6610

Set New Integral Gain 0x09h

Load a new integral gain for closed loop control

Parameters

2 Byte Gain

Packet Structure

write	Op-Code 0x09h							
write	Low byte of Integral Gain							
write	High byte of Integral Gain							
	7	6	5	4	3	2	1	0

Description

This command instructs the amplifier to load a new value for integral gain. It should be immediately followed by a low and high byte that describe the gain. Valid values are 0-50,000. The integral gain is used in the digital PID routine that controls the position of the actuator. These values are displayed as divided by 1000 by the amplifier, i.e. from 0.000 to 50.000.

Return Values

None

See Also

Get Current Integral Gain

Set New Derivative Gain 0x0Ah

Load a new derivative gain for closed loop control

Parameters

2 Byte Gain

Packet Structure

write	Op-Code 0x0Ah							
write	Low byte of Derivative Gain							
write	High byte of Derivative Gain							
	7	6	5	4	3	2	1	0

Description

This command instructs the amplifier to load a new value for derivative gain. It should be immediately followed by a low and high byte that describe the gain. Valid values are 0-50,000. The derivative gain is used in the digital PID routine that controls the position of the actuator. These values are displayed as divided by 1000 by the amplifier, i.e. from 0.000 to 50.000.

Return Values

None

See Also

Get Current Derivative Gain

114 SE Parkway Ct, STE 160
Franklin, TN 37064
Tel: 615/595-6665
Fax: 615/595-6610

Save Settings 0x0Ch

Save Settings to EEPROM

Parameters

None

Packet Structure

write	Op-Code 0x0Ch							
	7	6	5	4	3	2	1	0

Description

Most variables on the amplifier are stored in RAM and are thus lost on shut down or restart. This command is used to store critical values in EEPROM, allowing them to be recalled and loaded into the appropriate RAM location on restart. Presently, PID and serial communication settings are the only values thus stored. Thus, use this command to save PID and serial settings for future use before turning off the amplifier. Note that EEPROM has a finite life, so this command should not be repeatedly called by a computer program. The SAVE SETTINGS function disables servo control of the amplifier.

Return Values

None

See Also

None

Move Amplifier to Negative Rail 0x0Fh

Set the output of the amplifier to its most negative voltage

Parameters

None

Packet Structure

write	Op-Code 0x0Fh							
	7	6	5	4	3	2	1	0

Description

This command instructs the amplifier to disable servo control, if enabled, and output the low limit of voltage, typically about –25 V. This feature is useful for setting and confirming the position of feedback devices, such as capacitive probes.

Return Values

None

See Also

Move Amplifier to Positive Rail, Move Amplifier to Zero Volts

114 SE Parkway Ct, STE 160
Franklin, TN 37064
Tel: 615/595-6665
Fax: 615/595-6610

Move Amplifier to Positive Rail 0x10h

Set the output of the amplifier to its most positive voltage

Parameters

None

Packet Structure

write	Op-Code 0x10h							
	7	6	5	4	3	2	1	0

Description

This command instructs the amplifier to disable servo control, if enabled, and output the high limit of voltage, typically either approximately 160 V or 210 V. This feature is useful for setting and confirming the position of feedback devices, such as capacitive probes.

Return Values

None

See Also

Move Amplifier to Negative Rail, Move Amplifier to Zero Volts

Move Amplifier to Zero Volts 0x11h

Set the output of the amplifier to zero volts

Parameters

None

Packet Structure

write	Op-Code 0x11h							
	7	6	5	4	3	2	1	0

Description

This command instructs the amplifier to disable servo control, if enabled, and output approximately 0 V. This is sometimes desirable for reasons related to safety.

Return Values

None

See Also

Move Amplifier to Positive Rail, Move Amplifier to Negative Rail

114 SE Parkway Ct, STE 160
Franklin, TN 37064
Tel: 615/595-6665
Fax: 615/595-6610

Get Current Proportional Gain 0x14h

Transmit the proportional gain for closed loop control

Parameters

None

Packet Structure

write	Op-Code 0x14h							
read	Low byte of Proportional Gain							
read	High byte of Proportional Gain							
	7	6	5	4	3	2	1	0

Description

This command instructs the amplifier to transmit the value being used for proportional gain. The low byte is transmitted first, followed by the high byte. Valid values are 0-50,000. The proportional gain is used in the digital PID routine that controls the position of the actuator. These values are displayed as divided by 1000 by the amplifier, i.e. from 0.000 to 50.000. This function can be used to confirm that a new gain setting was received correctly.

Return Values

2 Byte Gain

See Also

Set New Proportional Gain

Get Current Integral Gain 0x15h

Transmit the integral gain for closed loop control

Parameters

None

Packet Structure

write	Op-Code 0x15h							
read	Low byte of Integral Gain							
read	High byte of Integral Gain							
	7	6	5	4	3	2	1	0

Description

This command instructs the amplifier to transmit the value being used for integral gain. The low byte is transmitted first, followed by the high byte. Valid values are 0-50,000. The integral gain is used in the digital PID routine that controls the position of the actuator. These values are displayed as divided by 1000 by the amplifier, i.e. from 0.000 to 50.000. This function can be used to confirm that a new gain setting was received correctly.

Return Values

2 Byte Gain

See Also

Set New Integral Gain

114 SE Parkway Ct, STE 160
Franklin, TN 37064
Tel: 615/595-6665
Fax: 615/595-6610

Get Current Derivative Gain 0x16h

Transmit the derivative gain for closed loop control

Parameters

None

Packet Structure

write	Op-Code 0x16h							
read	Low byte of Derivative Gain							
read	High byte of Derivative Gain							
	7	6	5	4	3	2	1	0

Description

This command instructs the amplifier to transmit the value being used for derivative gain. The low byte is transmitted first, followed by the high byte. Valid values are 0-50,000. The derivative gain is used in the digital PID routine that controls the position of the actuator. These values are displayed as divided by 1000 by the amplifier, i.e. from 0.000 to 50.000. This function can be used to confirm that a new gain setting was received correctly.

Return Values

2 Byte Gain

See Also

Set New Derivative Gain

Start Triggered Move 0x17h

Begin moving to a previously loaded position

Parameters

None

Packet Structure

write	Op-Code 0x17h							
	7	6	5	4	3	2	1	0

Description

While in single point mode, the amplifier will move the actuator to the new position as soon as the new target is loaded. In ramp mode, the amplifier waits for a software trigger to begin the move. The start triggered move command is sent to begin a move in ramp mode.

Return Values

None

See Also

Set Position Mode – Ramp

114 SE Parkway Ct, STE 160
Franklin, TN 37064
Tel: 615/595-6665
Fax: 615/595-6610

Set Position Mode – Single Point 0x19h

Set the amplifier position control status to single point mode

Parameters

None

Packet Structure

write	Op-Code 0x19h							
	7	6	5	4	3	2	1	0

Description

Single point mode is the default operating condition for a servo amplifier. In this mode, the controller immediately moves the actuator to its new position when a new target is loaded. No contour is followed and no limits are placed on velocity or acceleration. The shape of the move profile is a function of the PID parameters and actuator dynamics.

Return Values

None

See Also

Set Position Mode – Voltage Input, Set Position Mode – Ramp

Set Position Mode – Voltage Input 0x1Ah

Set the amplifier position control status to voltage input mode

Parameters

None

Packet Structure

write	Op-Code 0x1Ah							
	7	6	5	4	3	2	1	0

Description

If the amplifier you purchased has been configured for this mode of operation, it is possible to use an analog signal to communicate target position to the amplifier. Although other options are available, the amplifier is typically configured for a +/-10 V input signal. This mode is useful for cases where a contoured move or position profile such as a sine wave is desired. The fidelity of the actuator motion compared to the input waveform is dependent on many factors, including PID settings, actuator dynamics, and feedback signal conditioning.

Return Values

None

See Also

Set Position Mode – Single Point, Set Position Mode – Ramp

114 SE Parkway Ct, STE 160
Franklin, TN 37064
Tel: 615/595-6665
Fax: 615/595-6610

Set Position Mode – Ramp 0x1Ch

Set the amplifier position control status to ramp mode

Parameters

None

Packet Structure

write	Op-Code 0x1Ch							
	7	6	5	4	3	2	1	0

Description

Ramp mode is an alternative mode of operation for the amplifier. In this mode, the controller does not immediately move the actuator to its new position when a new target is loaded. After a new target position is loaded, the controller waits for a serial trigger command and then begins the move profile. The actuator is not moved to the new position as rapidly as possible. Rather, the position target is incremented or decremented (depending on whether the new position target is higher or lower than the current one) each servo cycle by an amount described by the ramp rate. This process continues until the actuator reaches the new target position, at which time a TTL line is set to indicate that the move is. Thus, the resulting move profile targets constant velocity rather than the damped second order response found in single point mode.

Return Values

None

See Also

Set Position Mode – Single Point, Set Position Mode – Voltage Input, Start Triggered Move

Set New Ramp Rate 0x1Dh

Load a new ramp rate to be used in ramp mode

Parameters

3 Byte Ramp Rate

Packet Structure

write	Op-Code 0x1Dh							
write	Low byte of Ramp Rate							
write	Middle byte of Ramp Rate							
write	High byte of RampRate							
	7	6	5	4	3	2	1	0

Description

This command instructs the amplifier to load a new value for the ramp rate used in ramp mode. It should be immediately followed by a 3B ramp rate, transmitted from low to high byte. The ramp rate is transmitted in nanometers per servo cycle, with the high and middle bytes before the decimal, and the low byte after the decimal. Thus, acceptable ramp rates are between 0.0039 nm/cyc and 65,535.996 nm/cyc. When executed in an amplifier with a 1500 Hz servo rate, this results in a slew rate between 5.9 nm/s and 98 mm/s. At extremely high and low speeds, the move profile may become uneven and quantized. Note that the final move will be smaller than other moves in the profile, unless the ramp rate is adjusted so that it is evenly divisible into the difference between the old and new position targets.

Return Values

None

See Also

Get Current Ramp Rate

114 SE Parkway Ct, STE 160
Franklin, TN 37064
Tel: 615/595-6665
Fax: 615/595-6610

Get Current Ramp Rate 0x1Eh

Send the value of ramp rate currently used in ramp mode

Parameters

None

Packet Structure

write	Op-Code 0x1Eh							
read	Low byte of Ramp Rate							
read	Middle byte of Ramp Rate							
read	High byte of RampRate							
	7	6	5	4	3	2	1	0

Description

This command instructs the amplifier to transmit the value being used for ramp rate. It is useful for confirming that a new ramp rate was received correctly.

Return Values

3 Byte Ramp Rate

See Also

Set New Ramp Rate

Enable Data Streaming 0x1Fh

Instruct the amplifier to send a continuous stream of position data during a ramp move

Parameters

None

Packet Structure

write	Op-Code 0x1Fh							
	7	6	5	4	3	2	1	0

Description

This command instructs the amplifier to transmit the position reading every servo cycle during a ramp move. The transmission is configured as a normal 3B position, with the exception that a 1B index is transmitted before the position. The index is initialized to zero at the start of the ramp and “rolls over” after 255. Commands that request a transmission from the amplifier should not be used during data streaming, as the response will be mixed in with the stream of position data. Also note that because 4B of data are transmitted every servo cycle, relatively high baud rates must be used during streaming. To prevent errors due to inadequate data transfer rates, the amplifier will not transmit streaming position data if its baud rate is less than 115.2 kBaud.

Return Values

None

See Also

Disable Data Streaming, Send Current Position

114 SE Parkway Ct, STE 160
Franklin, TN 37064
Tel: 615/595-6665
Fax: 615/595-6610

Disable Data Streaming 0x20h

Instruct the amplifier not to send a continuous stream of position data during a ramp move

Parameters

None

Packet Structure

write	Op-Code 0x20h							
	7	6	5	4	3	2	1	0

Description

This command instructs the amplifier to disable streaming position data during a ramp move. It will also set the trigger line low if it is not already low, signaling the end of data transmission.

Return Values

None

See Also

Enable Data Streaming

Set New In Range Band 0x22h

Load a new in range band

Parameters

2 Byte Value

Packet Structure

write	Op-Code 0x22h							
write	Low byte of In Range Band							
write	High byte of In Range Band							
	7	6	5	4	3	2	1	0

Description

This command instructs the amplifier to load a new value for the in range band. It should be immediately followed by a low and high byte that describe this value. The in-range value is sent and received in nanometers, and valid values are 0-50,000. In range band is displayed by the amplifier in micrometers, and it used to determine when a ramp move has been completed. For example, if the in-range band is set to 80 nm, when the stage moves to within 80 nm of the final position target, the move is considered complete; at this time the trigger line will transition from high to low and transmission of position data via data streaming mode will halt.

Return Values

None

See Also

Get Current In Range Band

114 SE Parkway Ct, STE 160
Franklin, TN 37064
Tel: 615/595-6665
Fax: 615/595-6610

Get Current In Range Band 0x23h

Transmit the in range band

Parameters

None

Packet Structure

write	Op-Code 0x23h							
read	Low byte of In Range Band							
read	High byte of In Range Band							
	7	6	5	4	3	2	1	0

Description

This command instructs the amplifier to transmit the value being used for the in range band. The low byte is transmitted first, followed by the high byte. Valid values are 0-50,000. This function can be used to confirm that a new in-range band value was received correctly.

Return Values

2 Byte Value

See Also

Set New In Range Band