STU - SERVO TERMINAL UNIT
DESCRIPTION AND OPERATIONS GUIDE

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SECTION 1.0 STU FUNCTIONAL DESCRIPTION

The Servo Terminal Unit or STU, receives high-speed serial data consisting of analog or digital channel information, and drives to up to two local TC-336 16 Channel Analog Output Modules, and up to eight local or remote TC-3161 16 Channel Digital Output/Driver or remote digital cards. By adding up to two TC-346 Analog Input Modules, full closed-loop servo control is possible for up to 32 analog channels. All servo parameters, including gains, low/hi limits, etc. are stored in battery-backed RAM memory, eliminating the need for discrete setup pots for each function.

Incorporating a PID (proportional/integral/derivative) closed loop algorithm, a far greater degree of control is possible compared with traditional servo cards used for animation. An auto-calibrate function allows the feedback endpoints to be automatically set, reducing the setup time if a pot is replaced or repositioned.

By using a "dumb" terminal connected to the front panel modular port, local setup and configuration of channel types, presets, etc. may be performed, in addition to diagnostics, channel-blinding and other functions.

All operations of the STU are controlled by a TC-3550 Processor/Receiver Card, which handles bi-directional communication with a CTU (Central Terminal Unit) or directly with a TC-560 Data Transmitter Card for smaller applications or programming.

NOTE: The slots within are STU are dependent on the card type. Please reference the installation section of this manual for slot dependencies.

External power supplies are required for the STU system. A typical configuration requires +5 VDC @ 1.5A, +/-15 VDC @ 1.2A, and +24 VDC @ 6A.

SECTION 2.0 INSTALLATION

The STU is designed as a card frame that will accept cards of different system functionality. All circuit cards use an industry standard 6.5" x 4.5" form factor, with either 22/44 or 28/56 dual edge connectors.

*As always, make sure that the power to the STU is **OFF** when inserting or removing cards in the STU card frame, or when working on I/O terminations.*

The slots within the STU card frame are not keyed and it is possible to insert a card into a wrong slot in which case there could be severe damage to some or all of the STU electronics.

When installing a STU follow the chart below for proper card placement. Slots are referenced left to right and 1 through 10 when facing the front of the STU card frame. When facing the front of a STU the solder side of all cards is on the right and the components are located on the left.

SLOT	ID	DESCRIPTION	NOTES	
N/A	TC-636	CPU Backplane		
1	TC-3550	CPU Card	Left-most Card	
2				
3	TC-346	16 Channel Analog Input Card	Feedback Inputs 1-16	
4	TC-336	16 Channel Analog Output Card	Servo Outputs 1-16	
5	TC-346	16 Channel Analog Input Card	Feedback Inputs 17-32	
6	TC-336	16 Channel Analog Output Card	Servo Outputs 17-32	
N/A	TC-613A	Digital Output Backplane	Handles 2 TC-3161	
			16 CHANNEL	**32 CHANNEL**
7	TC-3161	16 Channel Digital Output Card	Dig Out Ch 1 1-16	Dig Out Ch 1 1-16
8	TC-3161	16 Channel Digital Output Card	Dig Out Ch 2 1-16	Dig Out Ch 1 17-32
N/A	TC-613A	TC-3161 Digital Output Backplane		
9	TC-3161	16 Channel Digital Output Card	Dig Out Ch 3 1-16	Dig Out Ch 2 1-16
10	TC-3161	16 Channel Digital Output Card	Dig Out Ch 4 1-16	Dig Out Ch 2 17-32
			Repeats for additional digital output cards	
			Right-most Card	

IMPORTANT:

VERIFY ALL POWER CONNECTIONS AND VOLTAGES, ALL EXTERNAL CONNECTIONS, AND CIRCUIT CARD LOCATIONS PRIOR TO POWERING UP THE CARD FRAME.

ALWAYS VERIFY SAFETY CLEARANCE PRIOR TO POWERING UP HYDRAULICS.

SECTION 3.0 TERMINAL OPERATION

Rather than demanding the up to literally hundreds of setup pots, switches, or meters required for animation setup and calibration, the Triad STU/PID (Servo Terminal Unit) system is based on using a RS-232 serial terminal (hand held, full size, or emulator running on a PC) to access and setup all servo parameters, initial positions, and to perform Hand/Off/Auto (HOA) functions. Please refer to the reference section for information on the TechTerm terminal.

Configuration and other operating parameters are stored in battery-backed RAM memory when the processor is not powered up. The communications parameters for the terminal are as follows:

> 9600 baud, No parity, 8 data bits, 1 stop bit
> (2 stop bits may be required for upload/download procedures)

There is normally a "sign-on" message displayed whenever the processor is reset, otherwise the display is normally "quiet" until a specific request is entered from the terminal.

To get the STU's attention, press the ESC (escape) key on the terminal. The STU's should respond with a menu roughly as follows:

> STU: Cfig Diag Prcd R.un Srvo Xmem Version 95.04E

Options are normally selected by pressing the letter key corresponding to the desired operation, i.e. "C" for configure, "D" for diagnostics.

The system will continue to receive and process most analog and digital functions in the background while the terminal is in use. Some tasks are not possible while the menu functions are being used. Therefore, it is essential that the interface be placed into the "R"un mode (or reset) when all terminal operations are complete.

The **Escape** key is generally used to terminate any operation, and to return to the next higher selection or menu level. Pressing ESC from the (main) menu will also cause the system to restart similar to R.un. If ESC is pressed two (2) times within one second at the main STU: menu, the system will drop into the Triad/65 monitor and debugger, and all functions will cease. The only (known) exception is when it is necessary to 'exit' the terminal mode. In this case CTRL-A is used to exit terminal operation and return to the Diagnostic menu. To restart the system from the monitor, either do a hardware reset or enter the following from the terminal:

> C000G (that's zero, not "o"!)

Severe damage can be caused by changing **any** parameters stored in the RAM memory using debugger commands. This should only be attempted if directed by Triad!

Refer to the section "TechTerm" operation for more information regarding the hand held terminal used for diagnostics, maintenance, and focus operations.

SECTION 4.0 SETUP AND CONFIGURATION

C.fg, short for configure is used to setup many of the one-time parameters for the current card frame, as well as where it "lives" within the total system I/O space.

Once configured, further changes should be avoided to prevent conflicts with other frames in the system and to be sure that the channels are properly configured for the type of analog and digital outputs being used for the controlled device. The configuration profile may be displayed, printed or uploaded for future recovery in the event of a system failure or replacement.

The terminal will display a line similar to the following:

CONFIG: D.ip L.oc P.rt S.et U.pdn Xmem Z.ap Version 95.04E

D.ip A soft-switch used to emulate the 8 position hardware dip switch used on older Triad cards, and is used to set variables or options. Most of these are being phased into menu options. The value is entered in HEX and should be set to 10.

L.oc Used to select the analog and digital channels that will be decoded locally within the STU frame. These configuration parameters are defined within the total I/O space of the Show Control System, and must match the settings configured in the CTU and/or TC-560 Transmitter Interface within the Show Control Computer.

NAME:
Allows entry of a 16 character name for each frame.

FRAME:
The local card frame ID, from $F1 to $F8. This will be used in the future to setup bi-directional communications between the CTU and other DTUs (Data Terminal Units) and STUs in a system. Currently, use a value of $F1 (although anything will work).

FORMT:
Choose between CTU or STU data formats (C or S). You must make a decision.

ABANK1:
ABANK2:
A STU may only process 32 local analog servo channels. Analog banks are designated as A0 through AF:

A0: 1-32	A4: 129-160	A8: 257-288	AC: 385-416
A1: 33-64	A5: 161-192	A9: 289-320	AD: 417-448
A2: 65-96	A6: 193-224	AA: 321-352	AE: 449-480
A3: 97-128	A7: 225-256	AB: 353-384	AF: 481-512

AOFST1:
Shifts first logical channel of analogs, e.g. an offset of 16 would make physical channel 1, logical channel 17. Valid values range from 00 to 19.

DBANK1:
For digitals, there are two banks, D0 or D1 that select which group of 256 digitals will be used by local digital cards in the STU.

D0: 1-256 D1: 257-512

DiCHAN:
Selects the number of strobe pulses to generate for local digital I/O card subchannels, and should be set to 16 or 32 based on the cards and configuration being used.

DiSHFT:
It is possible to offset the logical card numbers without rewiring the data/strobe signals to the decoder/driver card using the DSHFT parameter. A DSHFT of 0 maps logical card 1 to physical card #1, 2 to 2, etc. By using a DSHFT of 1,physical card 1 will receive data from logical card 2, 2 from 3, etc. The maximum DSHFT is 7.

P.rt Will print (display) the software revision and configuration settings. A communications program (such as ProComm) may be used to capture this information for future reference. (We also suggest that the analog and digital presets be logged.)

S.et Used to set additional operating modes of the STU.

SET: P.ot S.wt M.ax Wake

P.ot Used to assign an external analog input or pot to one of the analog output channels. Four inputs are available (along with 10 V reference and ground) on the 6 pin modular connector on the first TC-346 Analog Input Module in the STU frame. If one or more pots are assigned, data for that channel follows the input, not show control.

S.wt Used to assign an external digital input to a digital output channel OR to a animation macro program stored in EPROM. Up to eight switch inputs are allowed. The signal is active low, TTL level, and is input on the TC-3550 Processor PB0-PB7 pins.

M.ax Servo quantity defines the number of analog channels (starting at channel #1) that are to be processed as servo moves. All remaining channels may be configured for normal analog outputs.

Wake Selects a channel used to monitor movement during the wake-up mode after a system reset.

The wake-up system has been expanded to actually monitor one non-critical or hazardous move to determine if hydraulic or pneumatic power is present. An attempt is made to move the cylinder (+/- the deviation level), while monitoring the feedback pot for that move. If no movement is detected, the software will hang, holding all other levels to 0 volts. A terminal connected to the **terminal** port will report a series of characters indicating the attempt to ramp the wake-up channel.

When movement is detected from the A/D input module, the ease-in ramping of all gain settings (p/i/ and d) will begin (described elsewhere), and the system will come "alive".

U.pdn Will request for the associated configuration information to be Uploaded or Downloaded through an external computer connected to the Terminal port.

Xmem Will enter the Extended Memory Manager.

Z.ap Resets ALL parameters, configurations, etc. to the defaults. Use this as a LAST RESORT!!

Do NOT Z.ap all parameters unless you are very sure of what you are about to do, as ALL information as to the "personality" of this processor will be IMMEDIATELY AND PERMANENTLY DESTROYED (unless backed up or printed!).

Application: The configuration should be performed only be qualified personnel, using the parameters defined during initial system design, installation, and calibration. All settings are normally stored in non-volatile memory, and should only require alteration if a processor card (TC-3550) or other components are changed. The configuration must match that of the CTU (Central Terminal Unit) and/or transmitter interface.

Once all parameters and defaults have been configured, the values should be Uploaded to the show control system, or P.rinted to a hard-copy device for backup.

SECTION 5.0 DIAGNOSTICS SYSTEM

DIAG MENU

D.iag is the Diagnostics menu, and is used to exercise analog and digital channels, test serial communications, etc.

**** IMPORTANT ****

When any digital or analog channel is selected in the D.iagnostics system, it is automatically "blinded" from receiving any data from a higher source, such as the CTU or Show Control Unit (SCU). Otherwise, data from the other device would "wipe out" any local settings. The channel WILL REMAIN BLINDED until explicitly reset by using the R.estore command (independent for analog or digital submenus).

DIAG: Ana Dig Stat Term Esc Version 95.04E

ANA: Chan Mode Name Pre* Rest Stat Trim

Chan (Channel) Selects an analog channel to exercise, and allows setting or ramping the current level. A channel that is actually changed is blinded from higher data sources, including the CTU and Show Control Computer until manually R.estored.

In a STU, only analogs configured as direct outputs (not as SERVOS) should be changed here. Servo channels may be exercised from the S.ervo menu options from the main menu.

Mode Toggles each analog channel between off and servo. *****

Name Allows naming of an analog channel.

Pre* (Preset) Not implemented under diagnostics. Currently available under the servo menu.

Rest (Restore) - Resets all analog values to the preset (as defined above) and un-blinds all local analog channels. Data from the Show Control Unit will be used for all analog outputs.

Stat Status display for the analog channel levels. The value for each analog channel is displayed, followed by a "b" if the channel is currently "blinded" (as a result of changing an analog value using diagnostics). This display is designed for a 24x80 terminal, and will overload the TechTerm handheld terminal.

Trim Used to set the fine trim for 8 bit analog output channels OTHER than servo channels. The number is from 0-255, but only the 4 MSB's have an effect.

DIG: Chan Name Pres Rest Stat Zap

These are the digital diagnostics options, used to set/clear any or all of the digital channels in the local (or downstream remote) card frame(s).

Chan (Channel) Allows selection of an output card and subchannel on the card and shows the current status (on/off). Pressing the ENTER key will toggle the status of the channel on->off->on, and blind the output from show control.

Name Allows naming the digital channel.

Pres (Preset) Makes the current digital settings the default preset for when the transmitter card is reset or restarted.

Rest (Reset) Restores all digital channels to an UNBLINDED condition, and sets the values to the default (preset) value, either on or off as defined using the P.reset option.

Stat (Status) Displays the current status of all of the digital channels being received by the card frame. A "b" is displayed next to channels that are "blinded" as a result of local operation. Note that this display will overload the focus/remote terminal, and will only be useful on a 24x80 display screen.

Z.ap Resets all digital channels to clear or off. Unless this is also made a P.reset (see above), the channels will revert to their preset values when the channels are R.eset or the system is restarted. A prompt of "Are You Sure?" is presented; respond with "Y" to confirm clearing of all channels.

Stat Displays the current status of all of the digital and analog channels configured for this card frame. Note that this display will overload the focus/remote terminal, and will only be useful on a 24x80 display screen. A "b" next to a channel indicates that it is in a local "blind" condition and will not respond to external data.

Term Allows communication between the terminal port and devices connected to one of the auxiliary comm ports on the CTU/STU card frame. No buffering of data is performed in this mode, so the maximum communications speed is limited to the SLOWEST of the device baud rates.

SECTION 6.0 SERVO MENU

Srvo Used to configure and setup servo channels

First, select a channel number by using the < > keys (unshifted "," and ".") on a standard keyboard, or type in the channel (1-32 max), followed by the {enter} key. It is only possible to address the number channels configured as servo channels within this STU frame.

Up to four lines of parameters are available for display or editing. To roll through the pages, use the ">" (unshifted "." key). The parameter screens have been formatted to display on a two line, 20 character LCD pocket terminal.

To enter or change a parameter, type the first letter of the parameter name, such as "L" for low span, etc.

In all cases, the parameter may be entered as a series of digits terminated with an {enter}, or ramped up or down in real-time using the < > (, and . on a standard keyboard). To speed up the ramping, use the SHIFT key on combination with the < and >.

CAUTION - THE CURRENT NUMBER WILL ROLL OVER OR UNDER the highest or lowest values, i.e. 1 past 255 = 0, and 1 before 0 = 255. This allows a rapid change between the limits when required for testing limits, but must be used with extreme caution.

There are three methods to set the desired position of the move during setup and calibration. The default is to use the incoming data from the Show Programming System.

By entering a "/", the current value may be entered or ramped from the keyboard of the setup terminal. The third method is to read the value from the pot located on the first analog input card in the frame. In either of the last two modes, the incoming data from the show control unit is automatically "blinded" to prevent interference from a "higher" controller.

The parameters and their meaning are described in the following section.

Page 1	Gain	Int	Drv
	xxx	xxx	xxx

Gain This is the proportional ERROR GAIN variable, and is used to set the amount of correction applied to the servo valve. 0 is the minimum (no correction); a value of 12 seems to be a good starting place for pneumatic servo valves (i.e. the Atchley).

Int (Integral) This is the INTEGRAL or long-term factor of the PID algorithm. This will help average out long term errors and make the movement more consistent under real-world conditions. I suggest that you use a VERY LOW value for this parameter until the effects are fully coordinated with other movements. Too much INT will cause oscillations, especially with pneumatic cylinders with high break-away problems! The INT continues to add the errors since the system was started, and wants the cylinder to ultimately match the desired position even if the error is slight.

Drv (Derivative) This is the DERIVATIVE factor of the PID algorithm. This affects how much to weight the CHANGE from the previous sample to the current channel, and is used to help stabilize short term corrections without needing excessive error gain (which causes overshooting and oscillations). This variable is unavailable on most traditional servo cards, and its proper application will require some experimentation for the type of movement, cylinder and line size, etc. It works by comparing the current error (in position) with the previous error, adjusting the next "prediction" based on the magnitude of the difference and the DRV parameter.

Page 2 Low Hi Rfbk Xfbk
xxx xxx xxxx xxxx

Low (Span) Soft limit for the low end of the move. A value of 0 will allow the move to reach the full end of travel established during the feedback calibration, 8 bit value 0-127.

Hi (Span) Soft limit for high end of move, 128-255.

Rfbk (Retracted Feedback) This is the reading taken from the feedback (pot) at the FULLY RETRACTED limit of the move. This is a 12 bit number, with a range of 00-4095. The number may be entered directly, ramped with the < > keys, or READ AUTOMATICALLY FROM THE FEEDBACK POT using the "R" key with the pot placed in the retracted position.

Xfbk (Extended Feedback) Same as above for the fully extended position of the feedback pot.

These two readings are taken so that the system can accurately position and center the move without having to exactly match the mechanical center of the pot shaft, and in cases where the pot has more travel than actually allowed by the cylinder.

Application: Always set the extreme limits of the movement into the Extended and Retracted Feedback parameters first. Verify that the readings are reasonably consistent from end to end, and if not, look for an intermittent or loose pot or coupling. THEN set the HIGH and LOW span limits to prevent hitting a physical limit, or to reduce break-away from the end point of a cylinder. If a new pot must be installed or repositioned, all that will be necessary is to reset the feedback endpoints, NOT the span. The centering is calculated by the servo computer automatically. Further, the endpoints may be determined using the A.uto setup function.

	Page 3	Beg	Ofs	Pol	Enb
		xxx	xxx	xxx	xxx

Beg (Begin) This is the initial position that the move will assume when the servo frame is initialized **IF IT IS NOT RECEIVING DATA FROM THE SHOW CONTROL UNIT**. We recommend 128 (center position) for most moves.

* Ofs (Offset) This is a center trim, nominally 128 for 0 offset. A plus or minus offset to the output position will be applied as this number is raised or lowered.

** This is currently handled in the programming software; the center point should always be half-way between the feedback endpoints. Thus, OFFSET may not be implemented.

Pol (Polarity) If the feedback pot and servo valve are out of phase, no servo action will occur. (The move will tend to stick to one end or the other, with a snap "hysteresis.") The wires to the ends of the feedback pot OR the valve should be reversed (but not both) OR the polarity may be changed in software.

** ONLY ENTER A NUMBER OF 0 or 255 here. In future releases this will be a "toggle" (normal/invert). VERY STRANGE SHIT will happen if some other number is used.

** NOTE: If the Auto Calibrate function is used, the polarity will be established and set along with the feedback endpoints.

***** Enb (Enable) Will explain shortly.

Application: The BEGIN point is an initial starting point based on the type of movement, and the physical plumbing of the valve/cylinder combination. When the system is (re)started, it defines a place to locate to. During the first 20-60 seconds after a RESET (or power-up), the ERR, INT, and DER gains are reduced to 0, and begin a slow ramp to the target level, easing in the error correction to each servo-valve. Unless show data is being received (from a 'higher' controller), the BEGIN point will be the home position for the actuator.

Offset (or bias) is a value that is added or subtracted to the target value to shift the center point of the system at the neutral position. Due to the automatic center-point calibration of the feedback pot, this parameter normally found on crude servo cards should be avoided if possible, to avoid clipping at either of the end points. Instead, it is preferable to perform any offset functions within the show programming system, such that if a new pot, cylinder or valve is installed, the known reference point may be retained. (NOT implemented, as explained above.)

In a correctly plumbed and wired system, the POLARITY should always be 0, or NORMAL. However, if something is wired or hosed wrong, this option allows a reversal of the sense, without having to switch hoses or cables. Use a value of 255 to flip the polarity.

Page 4 I xxx F xxxx O xxxx

This display of current values is accessed by pressing the "C" (current) key on the setup terminal while viewing any of the parameter pages.

I (In) The current span position the system thinks it wants to be positioned to. Eight bit value, 000-255.

F (Feedback) The current reading of the feedback pot, 12 bit value, from 0000-4095.

O (Output) The current 12 bit analog data value being sent to the (servo valve) analog output channel.

AUTO: (Auto Calibrate - not shown on menu) - Performs an automatic calibration of the current channel, setting the extended and retracted feedback levels, as well as the correct polarity for this movement. The voltage to the servo valve is slowing ramped in one direction, then the other, and readings taken at the endpoint. These numbers may be listed and verified on the "page 1" screen. If you see 0 or 4095, it is very likely that the pot is bottoming out, or connected incorrectly, and that the move will not work reliably due to a dead-zone or intermittent connection within the pot/wiring. If the values do not differ by a value of at least 1000, then there is probably insufficient stroke within the pot, or the pot is loose or intermittent.

When the AutoCal function is complete, the system will drop into the manual position mode, with an initial position of 128 (or center). The value may be raised or lowered using the < and > keys, or typed in directly. Press ESCAPE to exit the test mode and work with other parameters.

The auto-calibrate is useful for most movements, but may not be appropriate for extremely broad moves, either because the time required for the movement is longer than the sampling period, or due to possible damage or injury caused by the open-loop voltage extremes applied to the servo valve.

* NOT IMPLEMENTED AT THIS TIME

SECTION 7.0 STU ERROR MESSAGES

89.10.01 If an error is detected in the incoming data, a character will be displayed on a connected terminal. The errors are:

The frame is not recognized, properly framed, or consistent with the configuration of the receiver <OR> the transmitter. (If the transmitter is configured to talk to a CTU, a STU cannot parse the data!)

Axx The analog frame data was corrupt, or not the correct ID for this frame. Use the C.onfig F.ormat command in the transmitter if you are connected directly to a STU, DTU, or RTU to match the analog bank(s) to the installation/programming channels. The analog offsets work in banks of 32, such that:

A0 = 1-32
A1 = 33-64
A2 = 65-96
A3 = 97-128
A4 =
(etc.)

A **STU** may only process 32 channels, so set the ABANK1 variable to match the overall offset as programmed, and set ABANK2 = 0 to disable processing this data. A CTU, DTU, or RTU may receive two (2) banks of analogs (which may or may not be necessarily consecutive), for a total of 64.

D The digital frame data was corrupt, or not the correct group for this frame. There are two (2) digital groups, D1 for channels 1-256, and D2 for channels 257-512.

* There is also a "shift" variable, which allows the physical data output connectors to offset to other digital cards without having to reconfigure the hardware. Using a shift of 0 causes the digital cards in the frame to respond to the normal hardware mapping.

The RED status LED on the front edge of the TC-3550 indicates that data is NOT being received from the main system. When proper data assigned to this frame is recognized, the red LED will extinguish. The GREEN LED should normally be on, indicating proper operation of the computer. If it is OFF, the CPU has never "booted", (i.e. there is no power). If it FLASHES, it indicates an internal error, such as an invalid application ROM, bad RAM, or some other hardware failure.

SECTION 8.0 HARDWARE

Cards that are associated with a STU are as follows:

TC-3550 (CPU/Data Receiver Card) - Communicates/controls other cards within a STU card frame from data provided by an external control system, or from a local memory expansion show data card.

TC-3505 (2 MEG Memory Card) - Battery backed-up random access read/write memory (RAM) or non-volatile random access read-only memory (ROM). The TC-3505 is an optional card.

TC-336 (16 Channel Analog Output) - A maximum of two (2) TC-336 Analog Output Cards can be configured per STU for a total of 32 closed-loop analog moves.

TC-346 (16 channel Analog Input) - A maximum of two (2) TC-346 Analog Input Cards can be configured per STU.

TC-3161 (16 Channel Digital Output Card) - A maximum of four (4) TC-3161 High-Current Digital Output Cards per STU or 64 total channels.

TC-636 (Active Card Frame Backplane) - This is the backplane in which the TC-3550, TC-3505, and all analog input/output modules plug into. It provides the necessary power and data buss interconnection, along with header connectors for external control termination. Data buffering is provided for up to eight 32 channel digital output modules.

TC-613A (Passive Card Frame Backplane) - This is the backplane in which up to two TC-3161 Digital Output Cards plug into. It provides the header terminations for external control termination, using IDC or DB style connectors.

Power required is +5VDC @ 1.5 amps for all digital and control logic, +/-15 at 1.2 amps for analog I/O modules and +24 VDC at an appropriate current rating for number and type of digital channels being controlled.

NOTES