Serial Communication Specification

Linkable Instrument Network

The Linkable Instrument Network is a serial communication system consisting of a control computer with one RS-232C port and one or more satellite units. A satellite unit can be a pump drive, mixer controller, or any future product that conforms to the communications protocol defined in this description. This description describes all the information needed to communicate with a pump drive. Since much of this information applies to other products, the term "satellite unit" will be used as a generic term for all devices compatible with the Linkable Instrument Network. The term "pump drive" will be used when the information applies only to MASTERFLEX Computerized Drives.

Drives

All communications between the control computer and satellite units is based on a pseudo daisy-chain principle. The transmission line of the control computer will pass through the input and output buffers in each of the satellite units. Each satellite unit will have the ability to turn the buffers on and off to block communications from other units below it in the daisy-chain. The output of the control computer would pass through each of the pump drives without software assistance from the pump drive. All Pump Drives in the daisy-chain must be powered up to enable communications with all drives.

The receive line of the control computer will originate in the transmitter of the last satellite in the chain. It will also be double buffered through each satellite. Each of the pump drives will have the ability to turn off its input receive line and place its own transmitter on the receive line to the control computer.

A third line, the Request To Send (RTS) will be a similarly buffered line. Each satellite will have the ability to set this line to signal the computer its request to send.

The maximum number of satellites is limited to 25 by the Linkable Instrument Network software to minimize communication time. However, up to 89 satellites could be controlled by a single RS-232C port using custom software since satellite units can be assigned any number from 01 to 89.

USB

Some drives are equipped with a USB Mini Port. The drive supports USB 2.0 through the use of WINLIN software (sold separately). WINLIN can be operated on Windows® XP and Windows® VISTA operating systems. USB needs to be selected within WINLIN in order for the drive to be recognized by the host computer. See the accessories section of this manual for cable information.

NOTE: USB is not recommended for long term continuous use due to Windows® operating system issues. For long running applications use RS232 communications.

Serial Connections

The Digital PWM BLDC Drives communicate with each other and a PC via a standard DB-9 modem cable (Cat. #22050-54). Older satellite units have a dual 6-position modular phone jack labeled “IN” and “OUT”. Pin 1 on both jacks is located towards the top of the drive. The control computer will have a standard DB-25 plug as found on most RS-232C connections. The DB-9 “AT” type connector can also be used with the DB-9 to DB-25 adapter included with the 07550-64 Computer to Pump cable assembly.

DRIVE DB9 IN
Pin 2 - TXD Transmit signal to computer
Pin 3 - RXD Receive signal from computer
Pin 5 - GND Ground
Pin 8 - RTS Request to send to the computer

DRIVE DB9 OUT
Pin 2 - RXD Receive signal from next satellite
Pin 3 - TXD Transmit signal to next satellite
Pin 5 - GND Ground
Pin 8 - RTS From next satellite

DB-25 PLUG ON CONTROL COMPUTER
Pin 2 - Transmitted data to satellite
Pin 3 - Received data from satellite
Pin 5 - Clear to send—RTS from satellite
Pin 7 - Ground

DB-9 PLUG “AT” type ON CONTROL COMPUTER (DTE) AND SATELLITE
Pin 3 - Transmitted data to satellite
Pin 2 - Received data from satellite
Pin 8 - Clear to send—RTS from satellite
Pin 5 - Ground

DB-9 SOCKET ON SATELLITE (DCE)
Pin 3 - Receive signal from the computer
Pin 2 - Transmit signal to the computer
Pin 5 - Ground
Pin 8 - Request to send—(RTS) to the computer

The serial lines between units will be passed from unit-to-unit by a hardware buffer on the input, connecting it directly to the output driver through a hardware gate. This way any output only sees one input load. If power is turned off on any pump drive, all drives below it in the daisy-chain cannot communicate.

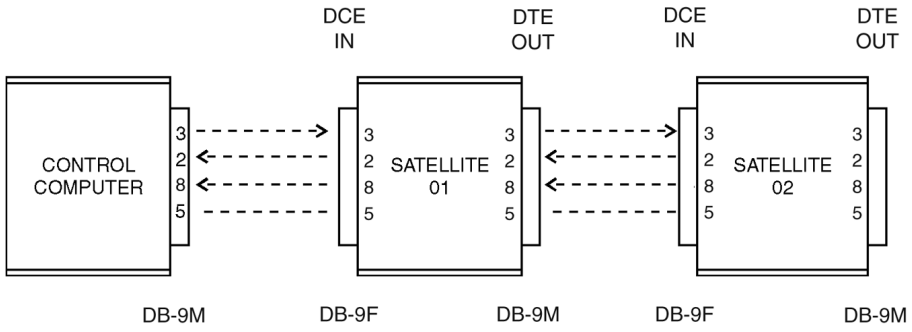

Figure 3-18. Serial Daisy-Chain Connections

Serial Data Format

The serial data format is full duplex (simultaneously transmit and receive), 1 start bit, 7 data bits, one odd parity bit, and one stop bit at 4800 bits per second. All data transmitted will consist of characters from the standard ASCII character set.

NOTE: Odd parity is defined such that the sum of the eight individual bits is an odd number (1, 3, 5 or 7).

Serial Protocol

All transmissions originate or are requested by the control computer (master). It may issue commands directly and it may request that the satellites report. When asked to report, the satellite would send the data requested. Should a satellite require communication with the computer, it has the ability to operate the request to send (RTS) line. Upon receiving the request, the computer would respond via the serial line (see *Serial Connections* section).

Start-Up Sequence

Normal start-up would consist of turning on all the satellite units first and then the control computer. Each satellite will enable its receive and transmit buffers and activate its RTS line. The control computer would then send the enquire <ENQ> command in response to the active RTS line. Upon receiving the <ENQ> command, all satellites with an active RTS line would disable its receive and transmit buffers to the satellites below it in the daisy-chain. Next the pump drives would respond with one of the following strings depending on its model number and version.

<STX>P?0<CR> = 600 rpm
<STX>P?2<CR> = 100 rpm

The control computer would only see the response from the first satellite in the chain since communications with the others is now blocked. The control computer would then send back <STX> Pnn<CR> with nn being a number starting with 01 for the first satellite and incrementing for each satellite up to 25 maximum. If the pump drive receives the data without errors it will perform the following steps:

1. Deactivate its RTS line and enable the receive buffers to the next satellite.
2. Send an <ACK> to the control computer.
3. Enable the transmit buffer from the next satellite within 100 milliseconds after the last byte has been sent.
4. Put a “P” and the satellite number received in the first 3 positions on the satellite display.

Start-Up Sequence (continued)

After the control computer receives the <ACK> it will see the RTS from the next satellite and again issue the <ENQ> command. The above process will be repeated until all satellites are numbered.

If a satellite does not receive valid data from the control computer or detects a transmission error, it will send a <NAK>. When the control computer receives the <NAK> it will resend the <STX>Pnn<CR> to the satellite. The Error Handling section describes the maximum retries the control computer will perform.

If a satellite is turned on after all the other satellites have been numbered, it will be numbered the same as described above with the next available number if no commands have been sent to the other satellites. If commands have been issued, the satellite is assigned a temporary number starting with 89 and decrementing for each subsequent satellite. This will cause the satellite to release its RTS so normal communication can proceed. The operator will be alerted to the condition that another satellite has come on-line and needs to be numbered. The operator will then be able to assign the new satellites a number so that they will appear correctly in the system. The control computer will use the following commands to renumber a satellite:

<STX>PooUnn<CR>

The “oo” is the old satellite number and “nn” the new number.

If a satellite is requesting to be numbered and the control computer has already issued 25 satellite numbers, the control computer will assign the satellite the number 89 as described in the preceeding paragraph and alert the operator to the situation.

If a satellite is powered down after it has been numbered, it will be treated as a new unit as described above when it is powered up again.

Remote/Local Operation

Once a satellite is in the remote mode, it can be returned to local mode using the control computer and the “L” command. If the control computer program is no longer running, the satellite can be powered off and then on to return it to local operation. If the “L” command is used, the satellite will retain its assigned number and respond to request commands from the control computer but ignore control commands.

Command Format

Most commands from the control computer are preceded with the start of text <STX> character (02 hex), a satellite identification letter (P for Pump, M for mixer) and a two digit satellite number (01 through 89). Numbers 00 and 90 through 99 are reserved for special cases. When the same command is to be executed by all pump drives, 99 is sent for the satellite number. Following the command character is the parameter field which varies in size from zero characters to 32 depending on the command. A carriage return <CR>, (0D hex) is used to indicate the end of a command string. (**NOTE:** the exceptions to this computer issued command format are <ENQ>, <ACK> and <NAK>.) See Figure 3-18.

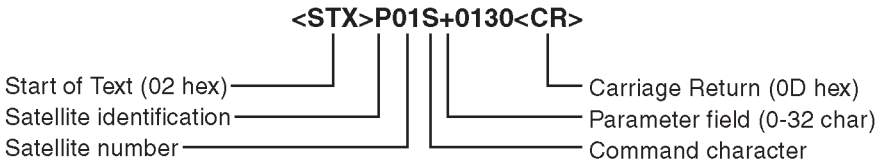

Figure 3-19. Command Format

More than one command can be put in a command string as shown following:

<STX>P09S+0500.0V08255.37G <CR>

The above multiple command string example would set the speed at pump satellite 09 to 500.0 rpm, clockwise direction, set 8255.37 revolutions and start the drive. The maximum number of characters allowed in one pump drive string is 38, including <STX>, Pnn and <CR>.

Command Features

1. INITIALIZING
   Before a pump drive can be controlled, it must first be numbered. If any command is issued before this is done, the satellite will not respond.
2. SETTING SPEED
   If a SPEED command is issued after the speed has already been set, the new speed will be used. If the pump drive is running and a different direction is sent to the pump, the pump will send back a <NAK>. A "H" command must first be issued before the direction can be reversed.
3. SETTING REVOLUTIONS
   When "Revolutions To Go" are set with the "V" command, they are added to the total revolutions to go counter. The maximum this counter can be is 99999.99. If a revolutions to go count is sent to the pump drive which would cause the counter to overflow past 99999.99, the pump drive will not add the value to its revolutions to go counter and will send the control computer a <NAK>. The revolutions to go counter can be set to zero by using the "Z" command, which will also cause the pump to stop if it is running when the "Z" command is received.

Control Computer Parameter Fields

The parameter field sent by the control computer is variable in length. The control computer will have the option of using leading zeroes, leading spaces, or no padding at all.

For example, if 200 revolutions was to be sent with the "V" command, the following list of parameters would all be accepted by the satellite as valid:

(s = space) 00200.00
ss200.00
sss200.00
sssss200
200.00
200.0
200

Satellite Data Fields

Any data that a satellite sends to the control computer will have a fixed number of characters which is determined by the command. For example, if the control computer requested the cumulative volume, it would always receive 10 characters representing the cumulative volume (0000000.00 to 9999999.99).

Pump Drive Status Request

When the control computer requests status from the pump drive ("I" command or <ENQ>), the satellite will respond with the following status information (see Figure 3-20):

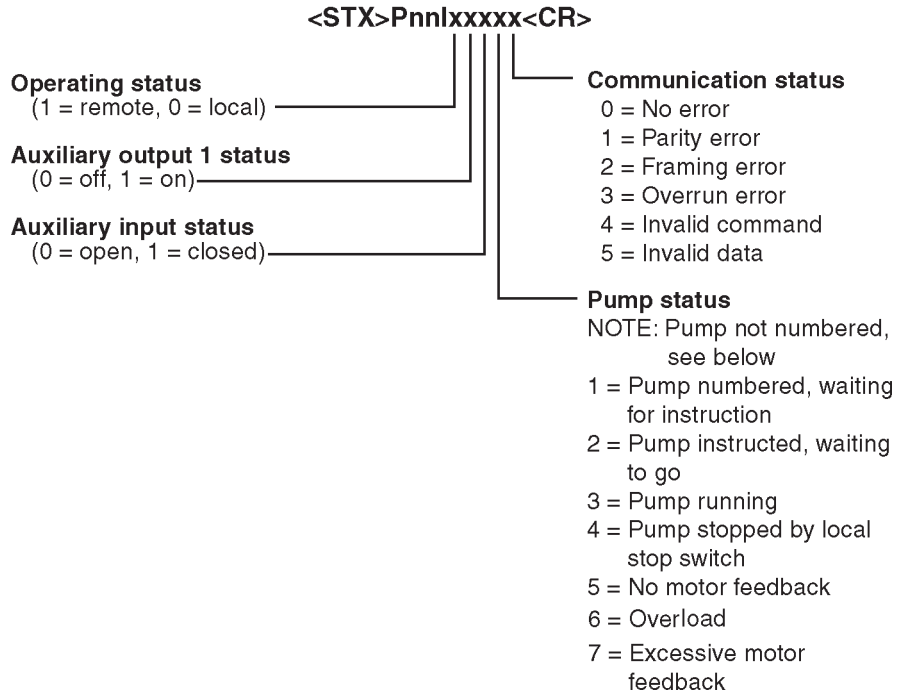

Figure 3-20. Parameter Fields

Pump Drive Status Request (continued)

NOTE: "Pump not numbered" is also a pump status, but it is not included in the pump status byte. This condition is handled separately using the P?x (see *Start Up Sequence* section).

When the satellite sends the status information, any status conditions that are latched by the satellite will be cleared by the control computer sending an <ACK>Pnn<CR>. If the satellite receives the "I" command again, it will respond with the same status information.

Satellite Response

When the pump satellite correctly receives a command, it will send back an <ACK> (06 hex) if it was not an all pumps command (P99). If data has to be sent back to the control copy in response to the command, it will be sent as shown in Table 3-2. If the satellite detected an error while receiving a command, it will respond with a <NAK>.

Error Handling

Depending on the error code received from the satellite, the control computer would have to take appropriate action to try to eliminate the error condition. Communication errors of type 1, 2 or 3 indicate a hardware type error: noisy communication lines, bad connection, glitches or circuit failure. Communication error codes 4 or 5 could be hardware errors as previously described or software errors caused by incorrect commands or data being sent by the control computer. For hardware type errors the control computer would try sending the same command to see if the problem was only momentary. If an error code is returned four times in a row or if there is no response at all, the control computer would abort trying to send the command and notify the operator of the type of error.

If a satellite does not respond at all, the control computer can assume one of the following:

1. If all other satellites connected after the satellite in question also don't respond, the communication link is broken at that point or the satellite is defective.

2. If all other satellites respond, the unresponding satellite is either turned off, removed from the loop, or defective.

Satellite Request to Send

When a satellite wants to communicate with the control computer, it will turn on its request to send (RTS) line and then wait for the (ENQ) enquire character (05 hex) from the control computer. The following list shows the possible conditions that would cause the pump drive to activate its RTS line.

1. Auxiliary input status change.
2. Motor error.
3. Stop key pressed at satellite while in the remote mode.
4. Programmed volume was reached.
5. Power up.

The following is the sequence of events for when RTS is activated by a pump drive:

1. Satellite enables RTS line.
2. When control computer detects RTS, it will transmit the (ENQ) enquire command (05 hex) after it completes any communications it may be in the process of preforming.
3. When the satellite that has its RTS line enabled receives the <ENQ> it will disable its RS-232C buffers to block the other satellites below it in the daisy-chain from communicating with the control computer. This would give the satellite closest to the control computer the highest priority if more than one satellite enabled its RTS line at the same time.
4. Next the pump drive will send the response from the “I” command as shown in *Pump Drive Status Request* field.
5. If the control computer received the satellite response without any errors (parity, overrun etc.) it will send an acknowledge <ACK>Pnn<CR> which will cause the satellite to release its RTS line and enable the RS-232C buffers allowing the satellites below it in the daisy-chain to communicate. If the control computer detected any error during the transmission it would send the enquire (ENQ) again which would cause the satellite to re-send its response. The control computer will retry a maximum of four times before aborting and reporting the error to the operator.
6. If more than one satellite has its RTS line enabled, the control computer would see only the response from the satellite closest to it. After the closest satellite sent its response and released the RTS line, the control computer would see the RTS of the other satellite and again issue the enquire command which would allow the next satellite with RTS active to respond.

Satellite Request to Send (continued)

7. If a satellite was responding to an enquire command and another satellite with higher priority also started to respond, cutting off the first responding satellite, the control computer would receive invalid data and get some type of error (parity or framing). This would cause the control computer to resend the enquire, but this time only the higher priority satellite would respond since the communications with the lower satellites is blocked.

Table 3-4. Pump Satellite Commands

Command Characters from Control Computer to Pump	Parameter Field
A Request auxiliary input status	none
B Control auxiliary outputs when G command executed	xy, x = aux1, y = aux2, 0 = off, 1 = on
C Request cumulative revolution counter	none
E Request revolutions to go	none
G Go Turn pump on and auxiliary output if preset	none = run for number of revolutions set by V command 0 = continuous run until Halt command
H Halt (turn pump off)	none
I Request status data	none
K Request front panel switch pressed since last K command	none
L Enable local operation	none
O Control auxiliary outputs immediately without affecting drive	xy, x = aux1, y = aux2, 0 = off, 1 = on
R Enable remote operation	none
S Set motor direction and rpm	+xxx.x, -xxx.x, +xxxx, -xxxx + = CW, – = CCW
S Request motor direction and rpm	none
U Change satellite number	nn = new satellite number
V Set number of revolutions to run	xxxxx.xx
Z Zero revolutions to go counter	none
Z Zero cumulative revolutions	0
<CAN> Terminates line of data up to and including STX (used primarily for keyboard input)	none
<ENQ> Enquire which satellite has activated its RTS line	none

Satellite Request to Send (continued)

Table 3-5. Sample Pump Commands and Responses

Control Computer Command String	Pump Drive Response
<STX>PnnA<CR>	<STX>Ax<CR> x: 0=open, 1=closed
<STX>PnnBxy<CR> xy: 0 = off, 1 = on x = aux1, y = aux2	<ACK> or none if P99
<STX>PnnC<CR>	<STX>Cxxxxxxx.xx<CR> max revolutions = 9,999,999.99
<STX>PnnE<CR>	<STX>Exxxxx.xx <CR> x : revolutions to go (99,999.99 max) (-xxxx.xx if drive overshoots)
<STX>PnnG<CR>	<ACK> or none if P99
<STX>PnnH<CR>	<ACK> or none if P99
<STX>PnnI<CR>	<STX>PnnIxxxxx<CR> (see Pump Drive Status Request section)
<STX>PnnK<CR>	<STX>Kx<CR> (see *Front Panel Switches* section)
<STX>PnnL<CR>	<ACK> or none if P99
<STX>PnnOxy<CR> xy: 0 = off, 1 = on x = aux1, y = aux2	<ACK> or none if P99
<STX>PnnR<CR>	<ACK> or none if P99
<STX>PnnS+0130<CR> or	<ACK> or none if P99
<STX>PnnS+0130.0<CR>	<ACK> or none if P99
<STX>PnnS<CR>	<STX>S+0432.9<CR>
<STX>PnnUnn<CR> nn = 01, 02, 03....87, 88, 89	<ACK>
<STX>PnnVxxxxx.xx<CR> V max = 99999.99	<ACK> or none if P99
<STX>PnnZ<CR>	<ACK> or none if P99
<STX>PnnZ0<CR>	<ACK> or none if P99
<CAN>	<ACK>
<ENQ>	<STX>P?x<CR> (on pump power up) <STX>PnnIxxxxx<CR> (see *Pump Drive Status Request* section)

Front Panel Switches

The control computer can read the satellite's front panel switches by issuing the "K" command. The satellite will respond with one character indicating the last switch pressed since the last "K" command was acknowledged. If more than one key was pressed, only the last one pressed is indicated. After the control computer receives the satellite's switch status, it must send an <ACK>Pnn<CR> to inform the satellite it can reset the switch status to no key pressed. Table 3-6 following shows the character returned by the "K" command and the corresponding switch for pump units.

Table 3-6. K command key codes for pump drives

0 = No key pressed	6 = Dir
1 = Stop/Start	7 = Size
2 = Prime	8 = Flow rate
3 = Mode	9 = Down arrow
4 = Dispense	A = Up arrow
5 = Cal	

ASCII Control Codes Used

Table 3-7. ASCII control codes used

DECIMAL	HEX	CHARACTER	
2	02	STX Start of Text	(CTRL - B)
6	06	ACK Acknowledge	(CTRL - F)
5	05	ENQ Enquire	(CTRL - E)
13	0D	CR Carriage Return	(CTRL - M) (CR)
21	15	NAK Negative Acknowledge	(CTRL - U)
24	18	CAN Cancel	(CTRL - X)