![TECAN logo]

Operating Manual

Cavro® XMP 6000 Multichannel Syringe Pump

June 2006

737847-A

Operating Manual

Cavro® XMP 6000 Multichannel Syringe Pump

TECAN.

Document Status Sheet

Title:	Cavro® XMP 6000 Multichannel Syringe Pump Operating Manual		
ID:	737847-A, en		
Version	**Revision**	**Issue**	**Major changes**
1	A		First release

This page has been intentionally left blank.

TECAN.

C   ASCII Chart of Codes for U.S. Characters

D   Multichannel Pump Chemical Resistance Chart

E   XMP 6000 Physical Specifications

F   CAN Communication Commands

G   Command Quick Reference

List of Figures

1 Getting Started

Congratulations on your purchase of the Cavro® XMP 6000 Multichannel Syringe Pump from Tecan Systems.

The XMP 6000 is a fully programmable, open frame, precision liquid handling pump module, designed for applications in the 10 µL to 5 mL range. It is controlled by an external computer or microprocessor and automates pipetting, diluting, and dispensing functions.

This chapter includes these topics:
- Regulatory Considerations
- XMP 6000 Features at-a-Glance
- Unpacking the XMP 6000
- Functional Description of the XMP 6000
- Safety
- Tips for Setting Up the XMP 6000

1.1 Regulatory Considerations

The XMP 6000 is a general laboratory module. Since it not a medical device, it is not subject to FDA regulatory approval. The XMP 6000 uses only recognized components and bears the UL Recognized Component Mark:

The use of UL Recognized components in a product or system allows UL to focus the evaluation of the complete system on its intended end-use, and thus speeds up the evaluation of that product or system. For more information regarding UL certification of Tecan Systems' syringe pumps, please visit the Underwriters Laboratories Inc. website at http://www.ul.com/info/standard.htm. Tecan Systems' customer file number for the recognized component is E164638.

1.1.1 CE

As a module designed for incorporation into larger systems that require independent testing and certification, the XMP 6000 does not carry its own CE mark.

1.1.2 Radio Interference

The XMP 6000 can radiate radio frequency energy, which may cause interference to radio and television communications. Follow standard good engineering practices relating to radio frequency interference when integrating the XMP 6000 into electronic laboratory systems.

1.2 XMP 6000 Features at-a-Glance

The XMP 6000 is a syringe pump that is designed for OEM precision liquid handling applications. It has the following standard features and functions:

- Available in 2, 4, 6, and 8 channel configurations
- Syringe sizes ranging from 100 μL to 5 mL
- Accuracy $<$ 1.0% at full stroke with 1 mL syringe using DI water at 25°C
- Precision $\leq$ 0.05% at full stroke with 1 mL syringe using DI water at 25°C
- Standard dispense/aspirate resolution of 6,000 increments
- Microstep dispense/aspirate resolution of 48,000 increments
- 3-way and 3-way with bypass solenoid valves
- Borosilicate glass, PEEK, and Kalrez$^{®}$ fluid contact
- RS-232, RS-485 and CAN interface
- Programmable plunger speeds from 1.2 sec/stroke to 160 min/stroke, with ramps and on-the-fly speed changes
- Teflon coated lead screw drive with a quadrature encoder for lost-step detection
- Pump diagnostics, self-test, and error reporting
- Auxiliary inputs and outputs
- Operates using a single 24V DC power supply

1.3 Unpacking the XMP 6000

To unpack the module, follow these steps:

1 Remove the pump module(s) and accessories from the shipping cartons.

2 Check the contents against the packing slip to make sure that all the components are present.

1.3.1 ESD Considerations

The XMP 6000 is an electronic device that is sensitive to electrostatic discharge (ESD). Static discharge from clothing or other fixtures can damage these

components. To prevent premature failure of pump components, use good ESD practices when handling the XMP 6000. These include, but are not limited to:

- Using wrist or ankle straps
- ESD mats or worktables
- ESD wax on the floor

Prepare an ESD-free work area before the chassis is grounded.

1.4 Functional Description of the XMP 6000

The XMP 6000 uses a stepper-motor driven syringe and solenoid valve design to aspirate and dispense measured quantities of liquid. Both the syringe and the valves are replaceable. Functional descriptions and illustrations of each major XMP 6000 component are provided in the following sections.

Figure 1-1   *XMP 6000 Multichannel Syringe Pump*
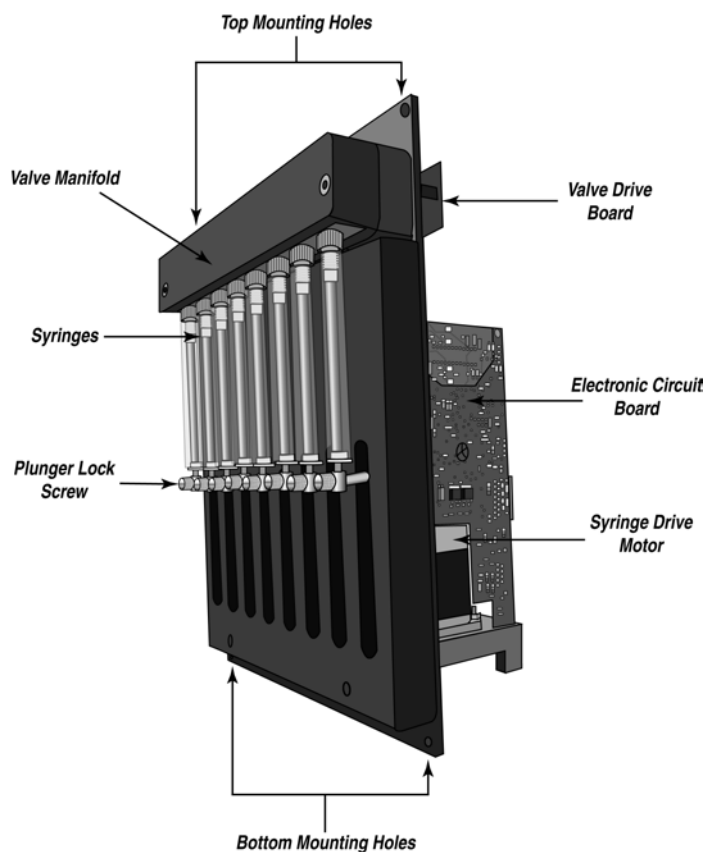
1.4.1 Syringe and Syringe Drive

The syringe plunger is moved within the syringe barrel by a lead screw drive that incorporates a 1.8° stepper motor and quadrature encoder to detect lost steps.

The syringe drive has a 60 mm travel length and resolution of 6,000 increments (48,000 increments in fine-positioning and microstep mode).

The base of the syringe plunger is held to the drive by a drive pin and secured with a knurled screw. The top of the syringe barrel attaches to the pump valve by a 1/4-28" fitting.

Figure 1-2, "Syringe Components" shows the components of a typical syringe.

Figure 1-2   *Syringe Components*
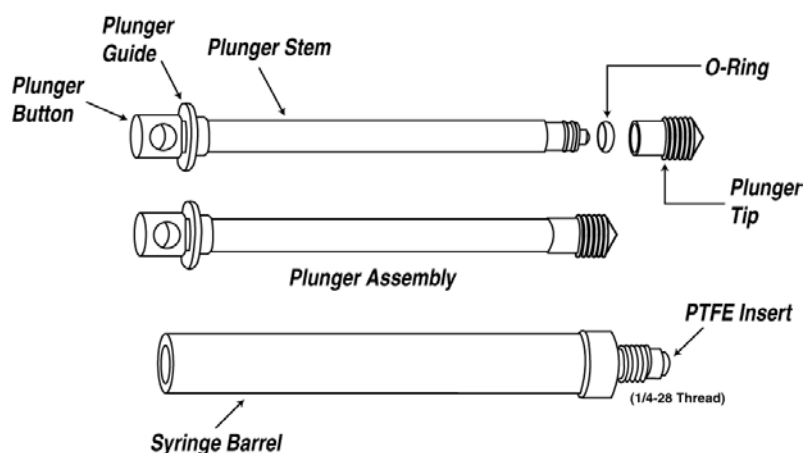
Syringes are available in these sizes: 100 μL, 250 μL, 500 μL, 1.0 mL, 2.5 mL, and 5.0 mL. For ordering information, see Appendix A, "Ordering Information".

Note: *To obtain optimal performance and maximum life from any syringe, please follow the syringe cleaning and maintenance procedure included with each Cavro Syringe. Technical Note #1 (PN 730317) contains practical tips for the use and maintenance of Cavro Syringes.*

1.4.2 Valve and Valve Drive

The standard configuration XMP 6000 is available with 3-way solenoid valves and 3-way with bypass solenoid valves.

The valve is constructed with a PEEK body and Kalrez diaphragm. The bypass position connects the input and output ports and is often used for flushing fluid lines.

Figure 1-3 shows the components of a 3-way valve.

Figure 1-3   *3-Way Solenoid Valve Components*
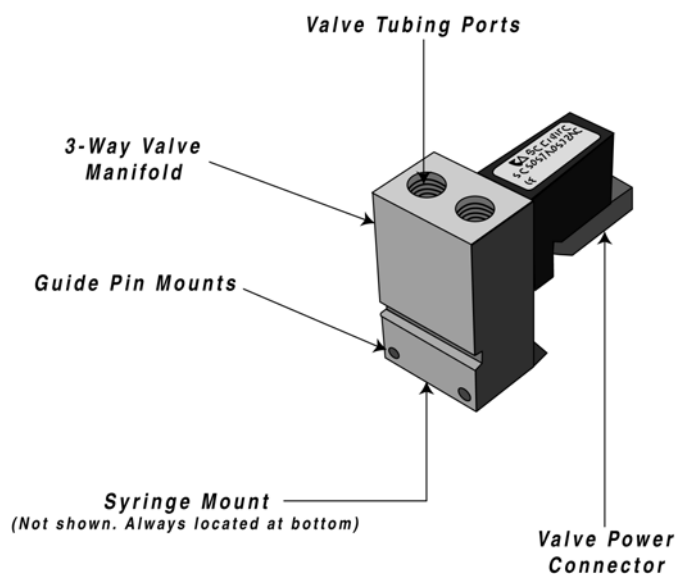
1.4.3   Printed Circuit Assembly

The XMP 6000 is equipped with two printed circuit boards. The main printed circuit assembly (PCA) holds the microprocessor and circuitry to control the syringe and valve drive. This PCA provides connectors for electrical inputs and outputs as well as a communication address switch. The second PCA is located behind the main PCA and provides power to the valves. For information on modes of operation, see Chapter 3, "Software Communication".

Figure 1-4 shows the accessible components on the main printed circuit assembly.

Figure 1-4   *XMP 6000 Printed Circuit Assembly External Connectors*
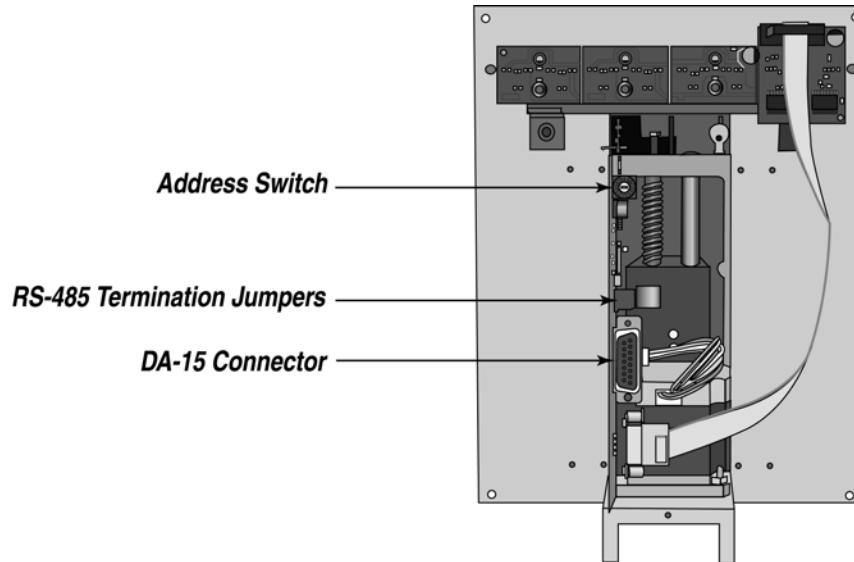
The XMP 6000 PCA has a DA-15 connector to handle power and communications. For more information on the printed circuit assembly inputs/ outputs and the address switch, see Chapter 2, "Hardware Setup".

1.4.4 Communication Interfaces

Depending on the pump configuration, the XMP 6000 can communicate singly or in a multi-pump configuration through an RS-232, RS-485, or CAN (Controller Area Network) interface. For RS-232 and RS-485, baud rates of 9600 and 38400 are supported. For CAN, baud rates of 100K,125K, 250K, 500K, and 1M are supported.

For details on the communications interfaces, see Chapter 2, "Hardware Setup".

1.4.5 Multi-Module Configurations

Up to fifteen (15) Cavro modules can be connected in a *multi-module configuration* (also called "daisy-chaining"). In this configuration each module is addressed separately from a single terminal via its unique address, which is set using the address switch on the back panel of the module. For more information on setting addresses, see Chapter 2.

Communication within a multi-pump configuration can be done either using an RS-485 bus or a CAN bus. If an RS-485 communications bus is used, the first pump in the chain may receive either RS-232 or RS-485 communications. If a CAN communications bus is used, neither RS-232 nor RS-485 is required.

1.5 Safety

The Cavro® XMP 6000 Multichannel Syringe Pump is designed for pipetting and dispensing operations in the 10 μL to 5 mL range. Any other use is considered improper and may result in damage to the pump and/or unreliable test results.

The XMP 6000 is designed to meet recognized technical regulations and is built with state-of-the-art components. Nevertheless, risks to users, property and the environment can arise when the module is used carelessly or improperly. Appropriate warnings in this Operating Manual serve to make the user aware of possible hazards.

1.5.1 Notices and Symbols

Warning Notices Used in this Manual

The triangle warning symbol indicates the possibility of personal injury if the instructions are not followed.

Specific symbols indicate the hazard to which a user is exposed. A few examples follow.

Toxic Substance

Chemical or biological hazards can be associated with the substances used or the samples processed with the XMP 6000. Always be aware of possible hazards associated with these substances.

Explosion and Fire Hazard

Never process explosive or highly flammable liquids with the XMP 6000.

Pinch Point, Mechanical Hazards

Automatically moving parts may cause injuries (crushing, piercing)

Attention

The general "Read This" symbol indicates the possibility of equipment damage, malfunction or incorrect process results, if instructions are not followed.

1.6 Tips for Setting Up the XMP 6000

For complete information on setting up the XMP 6000, see Chapter 2, "Hardware Setup" and "Chapter 3, "Software Communication".

Note: Before performing any work with the XMP 6000, first read this Operating Manual carefully.

To ensure proper operation, follow these tips:

- Always set up and mount the pump in an upright position. Failure to do so can cause problems priming the system.
- Always run liquid through the syringe and valve when they are moving. Failure to do so can damage the sealing surfaces.
- Before running any organic solvents through the pump, see Appendix D, "Multichannel Pump Chemical Resistance Chart" for more information on chemical compatibility.
- Always power down the instrument when connecting or disconnecting pumps.

Caution! Keep fingers out of the syringe slot while the pump is running. Failure to do so can cause injury.

◯TECAN.

2   Hardware Setup

This chapter includes these sections describing the various parts of hardware setup:

- ◆ Power and Electrical Considerations
- ◆ Cabling
- ◆ Communication Interfaces
- ◆ Settings and Options
- ◆ Installing Components
- ◆ Mounting

2.1   Power and Electrical Considerations

The XMP 6000 requires a 24V DC power supply with a current rating of at least 2A for a 3-way valve or 2.5A for a 3-way bypass valve configuration, provided through a DA-15 connector. Tecan Systems recommends using one power cable for every two pumps to provide noise immunity, i.e., power should not be daisy-chained to more than two pumps.

2.1.1   Choosing a Power Supply

The 24V DC supply for a single XMP 6000 should meet the following basic requirements:

- ◆ Output voltage: 24V nominal ±2%
- ◆ Well-regulated power supplies are recommended, as operating pumps below 24V will affect performance.
- ◆ Current rating of at least 2.0A for 3-way and 2.5A for 3-way bypass configurations
- ◆ Output voltage ripple: 100mV rms maximum at full load
- ◆ Conformance to required safety and EMI/RFI specifications

Current should be limited to 35A or less.

2.1.2   Integrating a Power Supply

When a power supply is used to operate more than one XMP 6000 or other device, it must provide the total peak current for all devices. The power supply and filter capacitance together must satisfy the total peak input current for all devices.

Table 2-1 *XMP 6000 Peak Power Requirements by Configuration*

No. Channels	3-way Configuration	3-way Bypass Configuration
8	1.85A	2.25A
6	1.77A	2.03A
4	1.68A	1.85A
2	1.59A	1.68A

If the pumps are not operating simultaneously then a reduced power supply rating may apply. The minimum power supply rating must be confirmed by measurement.

External equipment that is inadequately sourced for current can cause overvoltage transients and sags, and can create unnecessary ripple current in the XMP 6000. This can result in decreased component life. Additionally, it is possible for a regulated power supply to become unstable with certain loads and oscillate if adequate filter capacitance is not present. Some forms of oscillation can cause failures in the XMP 6000. These issues can be avoided by using a properly designed commercial power supply.

Consideration should also be given to the wiring of the XMP 6000 and any additional devices. Wiring should be of sufficient gauge for the current, and as short as possible. Unless otherwise required by safety requirements, the power supply lines to the XMP 6000 should be 20AWG. Multiple XMP 6000s can be daisy-chained, provided that the wire size and the power supply are adequate for the total current. For more information on multi-pump cabling, see Section 2.2, Cabling.

To control power to the XMP 6000, switch power to the power supply. Do not use a relay or switch contacts between the 24V supply and the XMP 6000 (i.e., do not switch DC input to the pump).

Note: When an XMP 6000 *is idle, it can draw less than 50 mA. Be sure to check the minimum load requirement of the power supply.*

2.2 Cabling

A single connector supplies both power and communications to each XMP 6000. A unique address identifies each pump module. For more information, see "Address Switch Settings" later in this chapter. See also Chapter 3, "Software Communication".

Power requirements are described in Section 2.1, Power and Electrical Considerations.

Table 2-2 *DA-15 Connector Pin Assignments*

Pin	Function	Remarks
1	24V DC	
2	RS-232 TxD line	Output data
3	RS-232 RxD line	Input data
4	Reserved	
5	CAN high signal line	
6	CAN low signal line	
7	Auxiliary input #1	TTL level
8	Auxiliary input #2	TTL level
9	Ground	Power and logic
10	Ground	Power and logic
11	RS-485 A line	Data +
12	RS-485 B line	Data -
13	Auxiliary output #1	TTL level
14	Auxiliary output #2	TTL level
15	Auxiliary output #3	TTL level

Figure 2-1 shows the pin positions of the DA-15 connector on the printed circuit assembly. This is a male connector that requires a female connector on the mating cable.

Figure 2-1   *DA-15 Connector Pins*
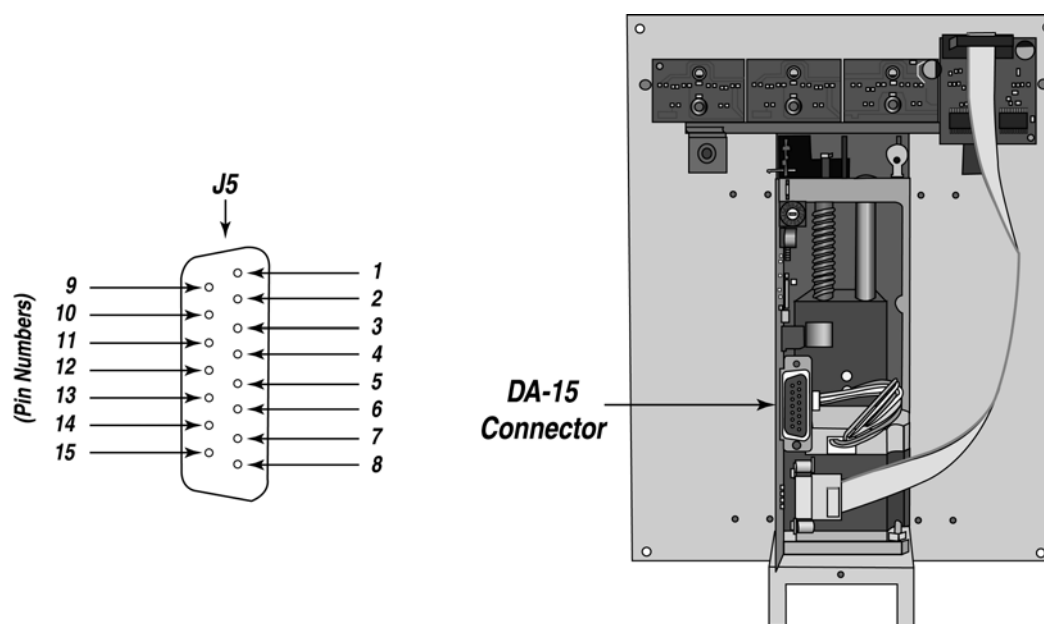
2.3   Communication Interfaces

The computer or controller communicates with the XMP 6000 through an RS-232 interface, RS-485 interface, or CAN (Controller Area Network) interface.The XMP 6000 automatically detects the communication interface.

Examples of cabling connections are shown in Figure 2-2, Figure 2-3, and Figure 2-4 on the following pages.

2.3.1   RS-232/RS-485 Interface

The RS-232 interface automatically converts the protocol to RS-485 for the benefit of any other devices which may be connected to the XMP 6000's RS-485 communication bus (this constitutes the so-called "multi-module" configuration).

Note: The RS-232 interface does not support hardware handshaking and requires only three lines: RXD, TXD, and Signal Ground.

When using a multi-module arrangement, up to 15 pumps can be addressed by the controller on the same communications bus. Take special care to ensure that the RS-485 A and B lines are not reversed. Refer to the cabling illustrations on the following pages. These illustrations show the multi-module cabling for RS-232,

RS-485, and CAN connections, respectively. Also shown is the external termination scheme for the RS-485 chain.

2.3.2 CAN Interface

The CAN interface is a two-wire serial system. The bus is driven differentially in a manner similar to RS-485. The major difference is in the protocol. The CAN protocol is designed to allow any device on the bus to send a message at any time. This is unlike other two-wire interfaces in which the slave devices can only transmit in response to a query. Using the CAN interface, the pump can send a message to inform the master that it has completed its task. Anti-collision detection (which reconciles problems that occur when two devices talk at once) is carried out by the CAN controller hardware.

Caution! *Always power off pumps before connecting to or disconnecting from the bus.*

RS-232 Cabling

Figure 2-2   *RS-232 Multi-Pump Cabling*
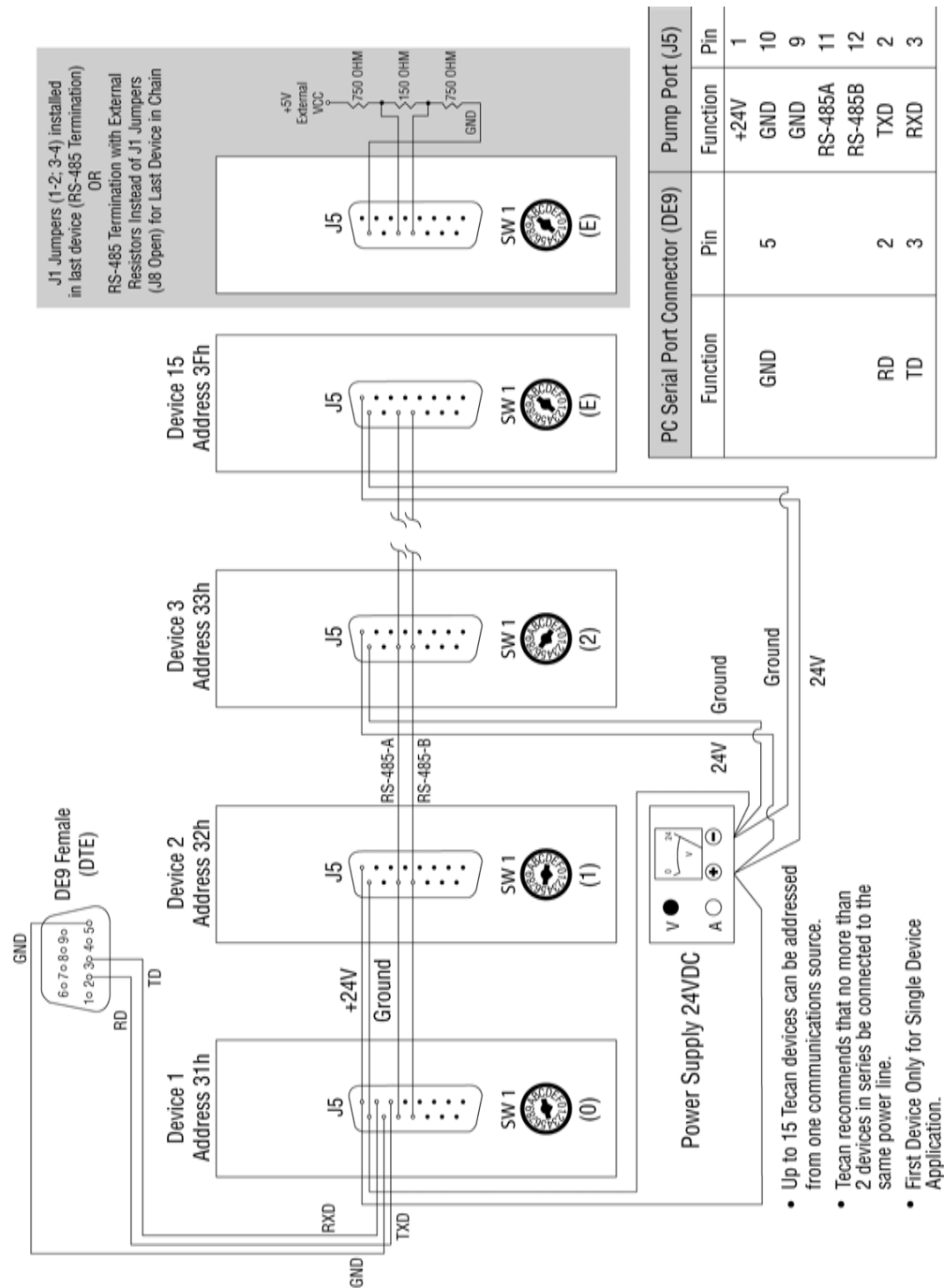
RS-485 Cabling

Figure 2-3   *RS-485 Multi-Pump Cabling*
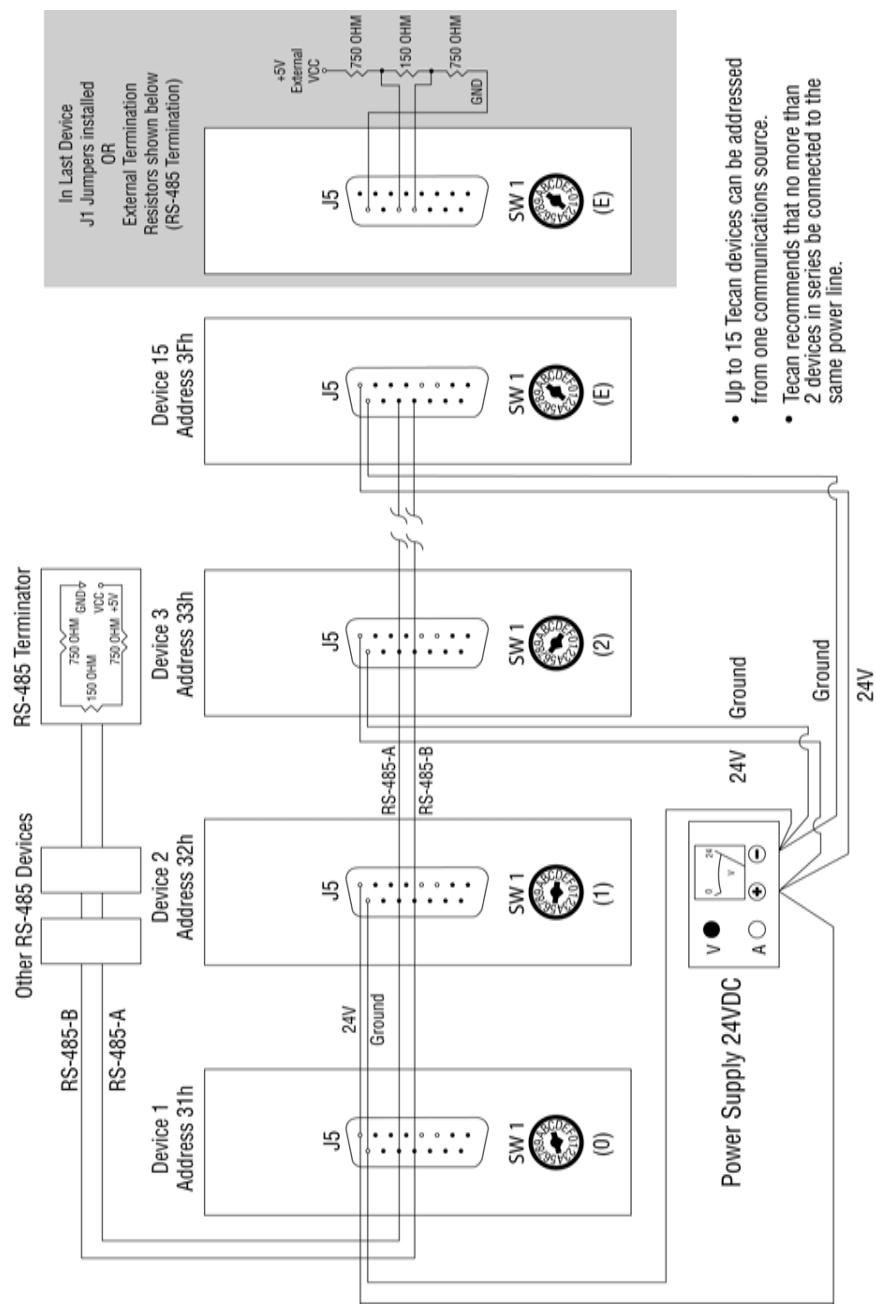
CAN Cabling

Figure 2-4   *CAN Multi-Pump Cabling*
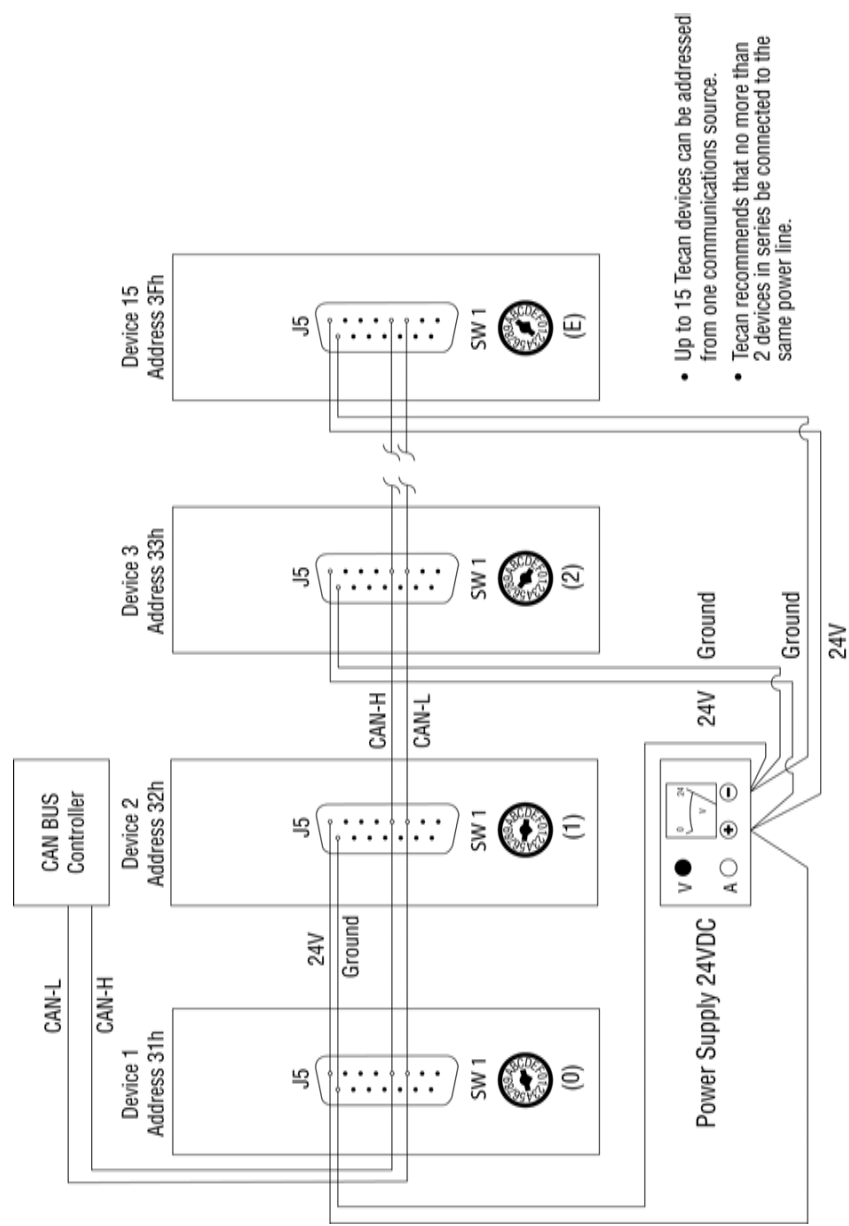
2.4 Settings and Options

2.4.1 Configuration Commands

The XMP 6000 firmware allows the user to configure the pump for different modes of operation. The U commands (see Chapter 3, "Software Communication") are used to write the configuration information to the non-volatile memory and control the following options:

◆ **Valve type:** Standard 3-way and 3-way bypass.
◆ **Baud rate:** RS-232/RS-485 communication is possible at 9600 baud (default) and 38400 baud. CAN communication is possible at 100K baud (default), 125K baud, 250K baud, 500K baud, and 1M baud rates.
◆ **Non-Volatile Memory Auto Mode:** Allows the pump to run command strings out of the non-volatile memory.

2.4.2 Address Switch Settings

The address switch (see Figure 2-5, "Address Switch") is located near the top of the XMP 6000 electronic circuit board. It is used to give each XMP 6000 in a multi-module configuration a unique or specific address, allowing the user to direct commands to specific pumps. The address switch has sixteen positions (numbered 0 through F). Fifteen positions (addresses 0 through E) are valid pump addresses.

Figure 2-5   *Address Switch*
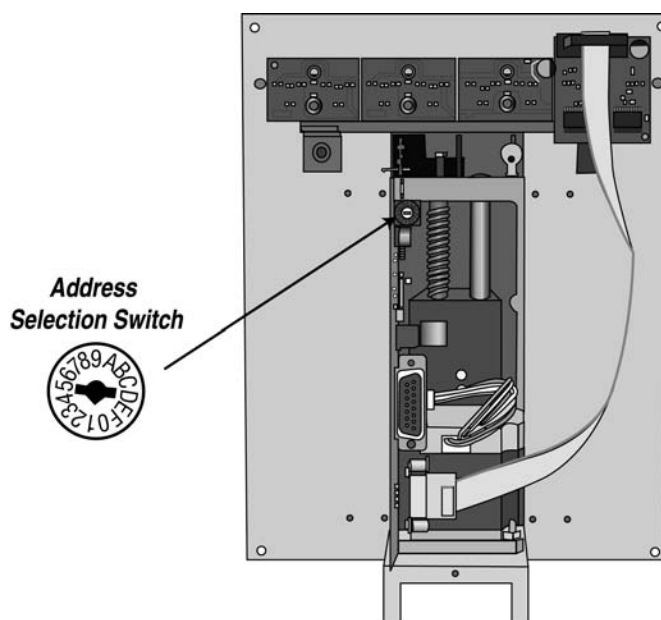
To set the address switch:

To set the address switch, use a jeweler's screwdriver or small flat head screwdriver and turn the switch in either direction to the desired position.

Note: *Power cycle (power down, then power up) the pump after setting the address switch.*

For information on the addressing schemes for different pump configurations, see Chapter 3, "Software Communication".

2.4.3   Self-Test

The "F" address switch position is used to activate the XMP 6000 self-test. Self-test causes the XMP 6000 to initialize, then cycle repeatedly through a series of plunger movements. The self-test cycles through speed codes 0 to 14. If an error condition occurs, the pump stops moving.

To run the self-test, set the address switch to position "F." Then supply power to the pump.

Caution! *Always run liquid through the syringe and valve. Failure to do so can damage the valves and syringe seals.*

2.4.4   J5 Inputs/Outputs

The XMP 6000 provides two auxiliary inputs and three auxiliary outputs that can be accessed through the DA-15 connector, J5. They provide TTL level signals. The outputs are controlled by the [J] command.

The auxiliary inputs are located on J5, pins 7 and 8. They can be read back using report commands ?13 and ?14. Additionally, the inputs can be used to externally trigger a command sequence using the [H] command. The commands are described in Chapter 3, "Software Communication".

The auxiliary outputs are located on J5, pins 13, 14, and 15.

2.5   Installing Components

2.5.1   Installing the XMP 6000 Solenoid Valve

To install the XMP 6000 **valve, follow these steps:**

1   Remove as much fluid as possible from the system by cycling the pump and using air as the system fluid.

2   Move the syringe plunger to the bottom of travel and power down the unit.

3   Remove the syringe and tubing from the valve that will be replaced.

4   Remove the valve manifold plate by loosening the socket head screws on either side of it.

5   With one hand, grasp the top and bottom of the valve and gently pull the assembly forward and remove it from the instrument.

6   With one hand, grasp the top and bottom of the *new* valve and plug it into the pump by lining up the valve with the valve mounting pins and gently pushing it into place.

7   Install the valve manifold cover and tighten the screws. Do not overtighten.

8   Install the syringe and tubing on the valve.

9   Power up the unit and initialize.

2.5.2   Installing a Syringe

To install a syringe, follow these steps:

1   Remove the plunger lock screw.

2   Install the syringe by following these steps:

   a. Slide the plunger button through the drive pin.

   b. Pull the syringe barrel up and screw the syringe into the valve.

   c. Fasten plunger lock screw.

Note: Make sure the plunger lock screw is securely tightened and the plunger button is free to move on the plunger drive pin.

2.6   Mounting

The XMP 6000 contains four mounting holes on the front plate of the frame.

Note: Always mount the pump in an upright position. Failure to do so can cause problems in priming the system.

To facilitate mounting, see Figure 2-6, "XMP 6000 Outline Drawing" for critical dimensions and location of the mounting holes.

Figure 2-6   *XMP 6000 Outline Drawing*
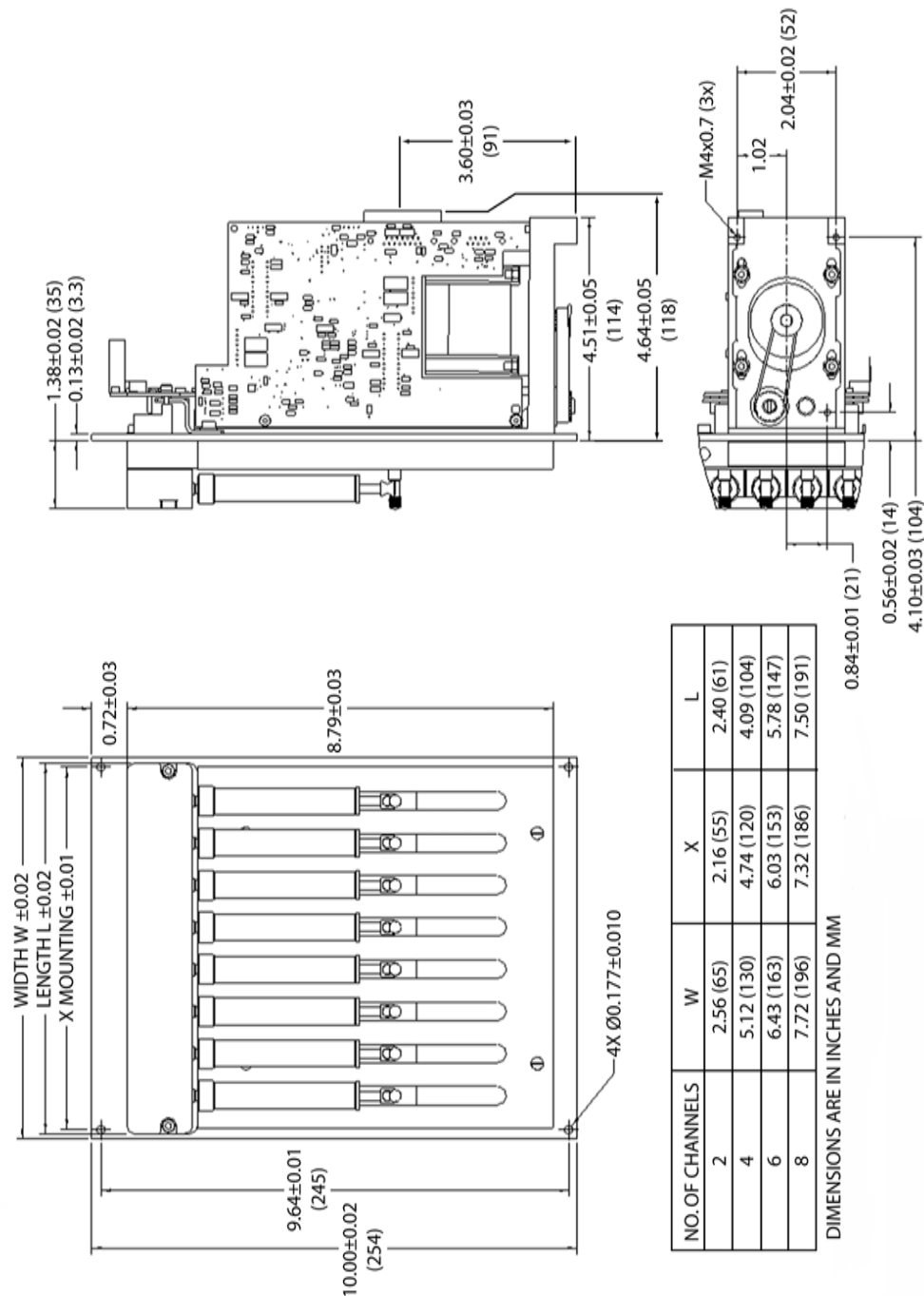
3 Software Communication

This chapter describes how to communicate with the XMP 6000: through an RS-232, RS-485, or CAN (Controller Area Network) interface.

This chapter includes these topics:
- XMP 6000 Addressing Scheme
- Communication Protocols
- Using the XMP 6000 Command Set
- Initialization
- Operating Commands
- Error Codes and Pump Status

3.1 XMP 6000 Addressing Scheme

As part of the communication protocol, an address for each pump must be specified. The user has the option of addressing a single pump, two pumps (dual device), four pumps (quad device), or all 15 pumps (all devices), depending on the address byte used. Each physical address in the address switch corresponds to a hexadecimal value, as shown in Table 3-1, Hexadecimal Addressing Scheme.

Table 3-1 *Hexadecimal Addressing Scheme*

Address (hex)		
RS-232/RS-485	**CAN**	**Device**
30	0	Master Address (master controller, personal computer, etc.)
31..3F	1..F	Addresses single device
41..4F	N/A	Addresses two devices at a time (dual device)
51..5D	N/A	Addresses four devices at a time (quad device)
5F	N/A	Addresses all devices on the bus

For example, an XMP 6000 with address switch set to 0 is addressed as device "31h" in the RS-232 or RS-485 communication protocol, hardware address 1 is addressed as device "32h," and so on.

Table 3-2, Address Switch Settings in Hex (ASCII), shows the different address switch settings for each of these configurations.

Table 3-2 *Address Switch Settings in Hex (ASCII)*

Switch Setting	Single Device		Dual Device		Quad Device		All Devices	
	Hex Address	**ASCII Address**	**Hex Address**	**ASCII Address**	**Hex Address**	**ASCII Address**	**Address**	**Value to Send**
0	31	1	41	A	51	Q	5F	–
1	32	2						
2	33	3	43	C				
3	34	4						
4	35	5	45	E	55	U		
5	36	6						
6	37	7	47	G				
7	38	8						
8	39	9	49	I	59	Y		
9	3A	:						
A	3B	;	4B	K				
B	3C	<						
C	3D	=	4D	M	5D	]		
D	3E	>						
E	3F	?	4F	O				
F	Self Test							

The user can communicate with all pumps in the chain by using address "5Fh," for example to initialize all pumps at once. Then each pump can be controlled independently by using addresses "31h" to "3Fh."

Note: *Multiple address commands cannot be used to determine device status or to request reports. Each device must be queried separately to gather status or generate a report.*

TECAN.

3.2   Communication Protocols

Three communication protocols are available:

* OEM communications protocol
* Data Terminal (DT) protocol
* CAN protocol

The XMP 6000 firmware automatically detects the communication protocol. However, this feature can be disabled and the communications protocol set manually.

Note: For more information on how to disable communication protocol autodetect, see Configuration Commands [U] (Table 3-5) later in this chapter.

The DT protocol can be run via an ASCII data terminal because no sequence numbers or checksums are used. For instructions on using a Microsoft Windows Terminal Emulator, see "Using DT Protocol with Microsoft Windows" in this chapter.

Note: Tecan Systems recommends using the OEM protocol for RS-232 and RS-485 interfaces. It provides increased error checking through the use of checksums and sequence numbers.

Once the XMP 6000 *detects either the OEM or DT protocol, it will ignore the other protocol until the next power cycle.*

3.2.1   OEM Communication Protocol

OEM communication is a robust protocol that includes automatic recovery from transmission errors. Table 3-3, OEM Protocol describes each setting within the OEM communication protocol.

Table 3-3   OEM Protocol

Parameter	Setting
Character Format	
Baud rate	9600 or 38400
Data bits	8
Parity	None
Stop bit	1
Command Block **(see "OEM Protocol Command Block Characters" for details)**	
1	STX (^B or 02h)

2	Pump address
3	Sequence number
3+n	Data block (length n)
4+n	ETX (^C or 03h)
5+n	Checksum
Answer Block **(see "OEM Protocol Answer Block Characters" for details)**	
1	STX (^B or 02h)
2	Master address (0 or 30h)
3	Status code
3+n	Data block (length n)
4+n	ETX (^C or 03h)
5+n	Checksum

OEM Protocol Command Block Characters

The command block characters in the OEM communication protocol are described below.

Note: All characters outside the command block are ignored.

When developing a parsing algorithm, the programmer should key on the STX as the beginning of the answer block and the checksum (character after the ETX) as the end of the answer block.

STX (^B or 02h)

The STX character indicates the beginning of a command

Pump Address

The pump address is a hexadecimal number specific for each pump.

Sequence Number/Repeat Flag

The sequence number is a single byte that conveys both a sequence number (legal values: 0 to 7) and a bit-flag indicating that the command block is being repeated due to a communications breakdown. The sequence number is used as an identity stamp for each command block. Since it is only necessary that every message carry a different sequence number from the previous message (except when repeated), the sequence number may be toggled between two different values (e.g., "1" and "2") as each command block is constructed. During normal communication exchanges, the sequence number

is ignored. If, however, the repeat flag is set, the pump compares the sequence number with that of the previously received command block to determine if the command should be executed or merely acknowledged without executing.

Note: If the operator chooses not to use this option, the sequence number can be set to a fixed value of 1 (31h).

The following two scenarios clarify this error detection mechanism.

Scenario 1.

1   The computer sends a command block stamped with sequence #1 to the pump.
2   The pump receives the command, sends an acknowledgement to the PC, and executes it.
3   Transmission of the acknowledgement message is imperfect; the PC does not receive it.
4   The PC waits 100 ms for the acknowledgement, then retransmits the command block with the sequence number left at 1 and the repeat bit set to indicate a retransmission.
5   The pump receives the transmission, identified as such by the repeat bit.
6   The pump checks the sequence number against that of the previously received command block. Noting a match, the pump sends an acknowledgement to the PC, but it does not execute the command (since it has already been executed).
7   The PC receives the acknowledgement and continues with normal communications.
8   The next command block is stamped with sequence #2 to indicate a new command.

Scenario 2.

1   The computer sends a command block stamped with sequence #1 to the pump.
2   The pump never receives the command due to a communication error and thus does not send an acknowledgement to the PC.
3   The PC waits 100 ms for the acknowledgement, then retransmits the command block with the sequence number left at 1 and the repeat bit set to indicate a retransmission.
4   The pump receives the retransmission, identified as such by the repeat bit.
5   The pump checks the sequence number against that of the previously received command block. Noting a mismatch, the pump recognizes this as a new command block and sends an acknowledgement to the PC. It then executes the command.
6   The PC receives the acknowledgement and continues with normal communications.

7 The next command block is stamped with sequence #2 to indicate a new command.

The sequence number/repeat byte is constructed as follows:

Bit #	7	6	5	4	3	2	1	0
Value	0	0	1	1	REP	SQ2	SQ1	SQ0

REP

0 for non-repeated / 1 for repeated

SQ0 – SQ2

Sequence value, as follows:

Sequence Value	SQ2	SQ1	SQ0
1	0	0	1
2	0	1	0
3	0	1	1
4	1	0	0
5	1	0	1
6	1	1	0
7	1	1	1

Note: Bits 4 through 7 are always fixed to the values shown.

Data Block (length n)

The data block consists of the data or commands sent to the pump or host (this is an ASCII string). When the pump is responding to a move or [Q] command, the data block length is 0 (i.e., no data string exists).

ETX

The ETX character indicates the end of a command string.

Checksum

The checksum is the last byte of the message string. All bytes (excluding line synchronization and checksums) are XORed to form an 8-bit checksum. This is appended as the last character of the block. The receiver compares the transmitted value to the computed value. If the two values match, an error free transmission is assumed; otherwise, a transmission error is assumed.

OEM Protocol Answer Block Characters

The answer block characters in the OEM communication protocol are described below.

Only the unique answer block entries are listed in this section. For common commands and answer block commands (characters), see the previous section, "OEM Protocol Command Block Characters."

Master Address

The master address is the address of the host system. This should always be 30h (ASCII value "0").

Status and Error Codes

The status and error codes define pump status and signal error conditions. For a description of status and error codes, see "Error Codes and Pump Status" in this chapter.

3.2.2 Data Terminal (DT) Protocol

The DT protocol can be used easily from any terminal or terminal emulator capable of generating ASCII characters at 9600 baud, 8 bits, and no parity.

Table 3-4   *DT Protocol*

Parameter	Setting
Character Format	
Baud rate	9600 or 38400
Data bits	8
Parity	None
Stop bit	1
Command Block (see "DT Protocol Command Block Characters" for details)	
1	Start command (ASCII "/" or 2Fh)
2	Pump address
2+n	Data block (length n)
3+n	Carriage Return ([CR] or 0Dh)
Answer Block (see "DT Protocol Answer Block Characters" for details)	
1	Start answer (ASCII "/" or 2Fh)

Parameter	Setting
Character Format	
2	Master address (ASCII "0" or 30h)
3	Status character
3+n	Data block (if applicable)
4+n	ETX (03h)
5+n	Carriage return (0Dh)
6+n	Line feed (0Ah)

DT Protocol Command Block Characters

The command block characters in the DT communication protocol are described below.

Start Block

The start character indicates the beginning of a message block.

Pump Address

The pump address is an ASCII character specific to each pump.

Data Block (length n)

The data block consists of the ASCII data or commands sent to the pump or host.

End Block

The end character indicates the end of a message block.

DT Protocol Answer Block Characters

The answer block characters comprising the DT communication protocol are described below.

Only unique answer block entries are listed in this section. For information on command and answer block commands (characters), see the previous section, "OEM Protocol Command Block Characters."

Master Address

The master address is the address of the host system. This should always be 30h (ASCII "0").

Status Character

The status and error codes define pump status and signal error conditions. See the description of the [Q] command in "Error Codes and Pump Status."

Data Block

This is the response from all Report commands with the exception of the [Q] command.

Carriage Return (0Dh)/Line Feed (0Ah)

This character terminates the reply block.

3.2.3 Using DT Protocol with Microsoft Windows

The XMP 6000 can be controlled in DT protocol mode directly from the Microsoft Windows terminal accessory.

To communicate with the XMP 6000 using Windows 3.x, follow these steps:

1 Connect the XMP 6000 to a communications port of the PC (for example, COM1).
2 From the Microsoft Program Manager window, select **Terminal** from the Accessories group window.
3 Select the **Settings** menu, and choose **Communications**.
4 Select a baud rate of 9600, 8 data bits, 1 stop bit, no parity, communications port connector, and no flow control.
5 Click **OK**.
6 Set the pump address switch to 0.
7 Power on the pump.
8 Type /1ZR<CR> to initialize the pump.
9 To run the pump, see the commands listed in "Using the XMP 6000 Command Set" in this chapter.

To communicate with the XMP 6000 using Windows 95/98/NT/2000/XP, follow these steps:

1 Run **Hyperterminal** from the **Start** menu.
2 Enter a name for the connection and select an icon, then click **OK**. The Phone Number dialog box appears.
3 Select the following in the fields provided:

    Connect using: Direct to <communication port> (usually COM1 or COM2, depending on how the hardware is set up)

    Click **OK**. The COM Properties dialog box appears.
4 Select the following in the fields provided:

        –   Bits per second: 9600

        –   Data bits: 8

        –   Parity: None

        –   Stop bits: 1

        –   Flow control: None

5   Click **OK**.

6   Select the **File** menu, and choose **Properties**. The Properties dialog box appears.

7   Select the **Settings** tab, and enter or select these options:

        –   Function, arrow, and Control keys act as:

             •   Select "Terminal keys"

        –   Emulation:

             •   Select "Autodetect"

             •   Enter "500" in Backscroll buffer lines

        –   Click the **ASCII Setup** button. The ASCII Setup dialog box appears.

8   Enter or select these options:

        –   Select "Send line ends with line feed"

        –   Select "Echo typed characters locally"

        –   Enter a Line delay of "0"

        –   Enter a Character delay of "0"

        –   Select "Wrap lines that exceed terminal width"

9   Click **OK** to close the ASCII Setup dialog box, then click **OK** to close the Properties dialog box.

10   Set the pump address to 0 or the appropriate address.

11   The communication protocol is detected automatically.

12   Power on the pump and initialize it by typing /1ZR and pressing **Enter**.

     To run the pump, see the commands listed in "Using the XMP 6000 Command Set" in this chapter.

3.2.4   CAN Interface Communications

CAN (Controller Area Network) is a two-wire, serial communication bus. It eliminates polling sequences that verify task completion. Using CAN, the pumps asynchronously report to the master or host when they have finished the current task.

Note: *All Tecan XMP 6000 pumps use CAN controller chips compatible with Phillips Semiconductor CAN bus specification, version 2.0.*

When using the CAN interface, termination resistors (120 ohm) are necessary at both ends of the bus. The pump does not provide CAN termination resistors.

CAN Messages

CAN messages consist of *frames.* Each frame has an 11-bit Message Identifier (MID) and a 4-bit length identifier. The bits:

◆ Indicate to which device on the bus the message is directed

◆ Identify the message type

◆ Show the direction of the message (to or from the master device)

◆ Represent the length of the data block. Data blocks can be from zero to eight bytes in length. Any message that requires more than eight bytes must be sent in a series of multi-frame messages. The receiving unit then assembles the separate frames into one long string.

CAN Message Construction

Each message frame begins with the Message ID (MID). The data block (up to 8 bytes in length) follows the MID and length information. The MID makes up three nibbles that are transmitted first in a message frame. The bits are grouped as shown in Figure 3-1, "CAN Message Structure".

Figure 3-1   *CAN Message Structure*
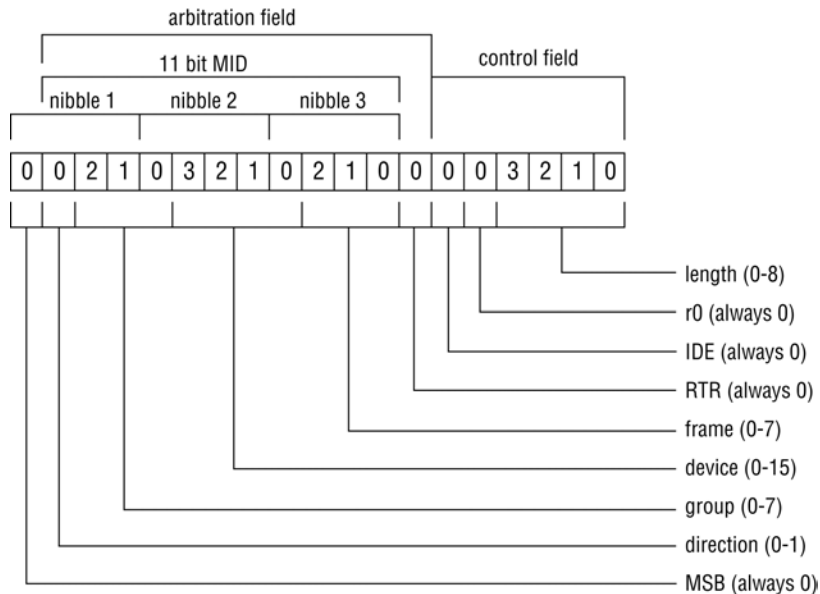
Direction

This is the direction bit. It lets the devices on the bus know whether the current message is to or from the master. "0" means that the message is from master to slave; "1" means the message is from the slave to the master.

Note: Peer-to-peer messaging is not supported.

Group

This is the group number (0 - 7). Each type device on the CAN bus has a group assignment. The XMP 6000 is assigned to group 2. The group number "1" is reserved for the boot request procedure.

Device

This is the address of the module in the particular group. Each group can have up to 16 devices. The address value is 0 - 15.

Frame

This lets the device know what type of message is coming. See "CAN Frame Types" in this chapter.

RTR

This bit is not used in Tecan Systems' CAN implementation and should always be set to 0.

IDE

This will always be set to 0 for standard format frames.

r0

Reserved bit, set to 0.

Length

This is the length of the data block in the message. Data blocks can be from zero to eight bytes in length.

CAN Frame Types

The frame types allow each device to know what type of command is coming in and enables faster processing of commands. Pumps respond to the frame types described below.

"On-the-Fly" Commands (V and T), Type 0

Normal commands use a frame type 1 (i.e., "Action Commands"). Since commands sent over the CAN bus with a particular frame type must complete before a subsequent command using the same frame type can be issued, a different ID must be used when issuing an "on-the-fly" command. For this reason, "on-the-fly" commands must be issued over the CAN bus with a frame type of 0 (zero).

When issuing "on-the-fly" commands, the frame type 0 commands will not generate completion messages and thus no pairing code is needed (these commands are simply acknowledged immediately).

Action Frames, Type 1

This frame type is used for action commands, such as Initialization commands, Movement commands, Valve commands, or to set pump operating parameters. All "task-type" commands are sent in this type message frame. When multi-frame messages are used to send an action command, this frame is the end message sent to the pump.

Common Commands, Type 2

This frame type is used for commands that are common to every device on the bus. The frame type is set to 2 and the command is a single ASCII character in the data block. The single ASCII character is described below.

Command	Description
0	Reset mode. This resets the pump and begins the boot request procedure.
1	Start loaded command. Just like sending an [R] command after a string has been loaded.
2	Clear loaded command. This clears out the command buffer.
3	Repeat last command. This command does the same thing as the [X] command.
4	Stop action immediately. This acts like a [T] command.

Multi-Frame Start Message, Type 3

This frame type lets the pump know that the next message will be longer than the 8-byte maximum for each frame. Subsequent frames will follow to complete the message.

Multi-Frame Data, Type 4

This frame type is used to identify a frame in the middle of a multi-frame message. The last frame of a multi-frame message for action commands must be type 1. The last frame of a multi-frame message response from the pump for report commands will be type 6.

Note: There is no type 5 frame.

Report/Answer Commands, Type 6

This frame type is used to get information back from the pump. It is similar in operation to the query commands (i.e., [?]) used in the OEM and DT protocols. The report command is one byte long and consists of one or more ASCII characters in the data block. Report commands in ASCII format are:

Command	Description
0	Report calculated plunger position in increments (standard/fine positioning)
1	Report start speed in increments per second
2	Report top speed in increments per second
3	Report cutoff speed in increments per second
6	Report current valve position
10	Report buffer status
13	Report status of input #1
14	Report status of input #2
15	Report the number of pump initializations
16	Report the number of plunger switches
17	Report the number of valve switches
18	Report the number of valve switches since last report
20	Report checksum
23	Report firmware version
24	Report zero gap increments
29	Report current status

When the pump responds to a query, the first two bytes of the data block are the status bytes. The first byte contains an error code (same error codes used with the RS-232 and RS-485 protocols) added to Ox20h. The second byte contains the value Ox60h and is not used. The remaining six bytes are for the response in ASCII. If the pump is only reporting current status, the message is only two bytes long. If the reply consists of more than six bytes, multi-frame messages are used.

CAN Data Block

The data block tells the pump what to do. Pump commands are sent in ASCII just like in RS-232 or RS-485. For command strings that are more than eight bytes in length, multi-frame messages are used. This permits long program strings to be sent as with the other communications interfaces (remember that the XMP 6000 buffer size is 255 characters).

Handling of Pump Boot Requests

When the pump is first powered up or receives a system reset command (frame type 2, command 0), the pump notifies the host of this condition by sending a boot

request message at 100 millisecond intervals until it receives a proper response. The group number is 1 for the boot request message. The frame type is 2 when the pump sends messages to the host, and the frame type must be 0 when the host replies to the boot request.

Example 1. The pump is set to address 0

Pump sends:

Dir	Group	Device	Frame	RTR	Length
1	001	0000	010	0	0000

Host acknowledges:

Dir	Group	Device	Frame	RTR	Length	Node ID	Slave ID
0	001	0000	000	0	0010	0010 0000	0010 0000

Host acknowledges the boot request with:

Dir = 0	Host to slave	**Note**:	
Group = 1	Boot request response group	Boot MID is the same for all nodes	
Device = 0	Always 0 in boot response		
Frame = 0	Boot request response frame		
RTR = 0	Always 0		
Length = 2	Two data bytes in return message		

Node ID	Group ID (2) + Pump Address (0)	" "	00h	Must respond with Group & Address
Slave ID	Same as Node ID (hex 20)	" "	00h	

Example 2. The pump is set to address 6

Pump sends:

Dir	Group	Device	Frame	RTR	Length
1	001	0110	010	0	0000

Host acknowledges:

Dir	Group	Device	Frame	RTR	Length	Node ID	Slave ID
0	001	0000	000	0	0010	0010 0110	0010 0110

Host acknowledges the boot request with:

Dir = 0	Host to slave	**Note**:	
Group = 1	Boot request response group	Boot MID is the same for all nodes	
Device = 0	Always 0 in boot response		
Frame = 0	Boot request response frame		
RTR = 0	Always 0		
Length = 2	Two data bytes in return message		

Node ID	Group ID (2) + Pump Address (6)	"&"	Hex	26
Slave ID	Same as Node ID (hex 26)		Hex	26

The pump will save the Node ID to use for message filter Group ID.

Note: The slave ID does not have to be the same as the node ID. The pump can be assigned any number between 0 and 0x7F (127) for the slave ID.

CAN Host and Pump Exchanges

When a slave pump receives a command, finishes a command, encounters an error condition, or responds to a query, it sends an answer frame to the host using the same frame type as the command it belongs to. The answer frame format is device dependent. Generally, it will have the following format:

<MID><DLC><Answer>

<MID>

11-bit message identifier. The direction bit is 1. The group number and the frame type are the same as received. Device ID is the slave message ID assigned by the host.

<DLC>

4-bit data length code

<Answer>

Data bytes block. The first byte of the data block is always the status byte, which is an error code (same error codes used with the RS232 and RS485 protocols) added to Ox20h. The second byte is always Ox60h. The remaining bytes contain the response in ASCII format. If the reply consists of more than six bytes, the multi-frame messages are used.

Note: Only one command of a given frame type can be in progress at any one time; e.g., after issuing a command to a slave pump with frame type = 1, the master must wait for the answer with frame type = 1 before issuing the next command with frame type = 1. If the user insists on sending the command, a command overload status results.

Several commands with different frame types can be in progress at the same time; e.g., an action command and a query command.

Following are typical exchanges between the host and slave for action commands, multi-frame commands, common commands, and query commands.

Action Command

The host commands [ZR] to a pump, and the pump is set to address 0.

Host sends:

0	XXXXXXX	001	0	0010	ZR
Dir	Slave ID	Frame Type	RTR	DLC	Data bytes

Pump acknowledges:

1	XXXXXXX	001	0	0000	
Dir	Slave ID	Frame Type	RTR	DLC	

After executing the command, pump reports status:

1	XXXXXXX	001	0	0010	<20h><60h>
Dir	Slave ID	Frame Type	RTR	DLC	Data bytes

Note: The mixed formats ASCII and hexadecimal are used in the data bytes block. The hexadecimal number is bracketed (< >). The rest of the fields are displayed in binary format.

Multi-Frame Command

The host commands [Z2S5gIA3000OgHD300G10G5R] to a pump, and the pump is set to address 0.

Host sends:

0	XXXXXXX	011	0	1000	Z2S5gIA3
Dir	Slave ID	Frame type	RTR	DLC	Data bytes
0	XXXXXXX	100	0	1000	000OgHD3
Dir	Slave ID	Frame type	RTR	DLC	Data bytes
0	XXXXXXX	001	0	1000	00G10G5R
Dir	Slave ID	Frame type	RTR	DLC	Data bytes

Pump acknowledges:

1	XXXXXXX	001	0	0000	
Dir	Slave ID	Frame type	RTR	DLC	

After executing the command, pump reports status:

1	XXXXXXX	001	0	0010	<20h><60h>
Dir	Slave ID	Frame type	RTR	DLC	Data bytes

Note: For multi-frame commands, the pump only acknowledges the last frame.

Common Command

After the host has sent command [A1000A0] to the pump, it sends command 1 of frame type 2 to a pump and makes the pump move. The pump is set to address 0.

Host sends:

0	010	0000	010	0	0001	1
Dir	Group	Device	Frame type	RTR	DLC	Data bytes

Pump acknowledges:

1	XXXXXXX		002	0	0000	
Dir	Slave ID		Frame type	RTR	DLC	

After executing the command, pump reports status:

1	XXXXXXX		002	0	0010	<20h><60h>
Dir	Slave ID		Frame type	RTR	DLC	Data bytes

Query Command

The host commands 29 of frame type 6 to a pump, and the pump is set to address 1.

Host sends:

0	XXXXXXX	110	0	0010	29
Dir	Slave ID	Frame Type	RTR	DLC	Data bytes

Pump reports:

1	XXXXXXX	110	0	0010	<20h><60h>
Dir	Slave ID	Frame Type	RTR	DLC	

Note: For query commands, no acknowledge frame is needed.

Report Command

The host sends command report 23 of frame type 6 to a pump, and the pump is set to address 1.

Host sends:

0	XXXXXXX	110	0	0010	23
Dir	Slave ID	Frame Type	RTR	DLC	Data bytes

Pump reports:

1	XXXXXXX	011	0	1000	<20h><60h><727920>
Dir	Slave ID	Frame Type	RTR	DLC	
1	XXXXXXX	110	0	0110	<20h>Rev<20h>A
Dir	Slave ID	Frame Type	RTR	DLC	Data bytes

Note: For a multi-frame reply, the start frame is type 3, the middle frame is type 4, and the last frame is type 6.

Note: For this example, the part number and revision level may change.

3.3   Using the XMP 6000 Command Set

The XMP 6000 features a robust command set which allows a wide range of parameters to be defined by the user. Many of the commands have default values; however, the default values may not provide the optimal settings for your application. Take a moment to familiarize yourself with each command in order to obtain the best performance for your application.

For a quick summary of all commands, see Appendix G, "Command Quick Reference".

When problems are detected, the XMP 6000 sends an error code. The error codes are described in "Error Codes" at the end of this chapter.

Note: *Some commands are invalid in the CAN interface. For a list of these commands, see Appendix F, "CAN Communication Commands".*

3.3.1   Command Execution Guidelines

To use the commands properly, keep the following in mind:
- All commands, except Report commands and most Control commands, must be followed by an [R] (Execute) command.
- Single or multiple command strings can be sent to the pump.

  For example:
  – A single command such as [A6000R] moves the plunger to position 6000.
  – A *multi-command string* such as [IA6000OA0R] switches the valve to the input position, moves the plunger to position 6000, switches the valve to the output position, and finally returns the plunger to position 0.
- The pump's command buffer holds a maximum of 255 characters. If a command is sent without the [R] (Execution) command, it is placed into the buffer without being executed. If a second command is sent before the first command is executed, the second command overwrites the first command (i.e., the first command string is erased).
- Once a command is executed, new commands are not accepted until the sequence is completed. Exceptions to this rule include interruptible (see "T Terminate Command" in this chapter) and Report commands.
- When a command is sent, the pump answers immediately. If an invalid command has been sent in a command string, the pump reports an error immediately. If there was an invalid parameter in the command, the pump will execute up to the invalid parameter, then stop. In the case of a [Q] (Query) command, the error is read back to the host computer.
- Always run liquid through the syringe and valve when issuing a Move command. Failure to do so may damage the valve and syringe seal.
- Keep fingers out of the syringe slot while the pump is running. Failure to do so can result in injury.

Command Syntax and Notes

The syntax for each command in the command set is:

<n>	Numerical value within a given range
0..6000	Range of numerical values allowed
(n)	Default value

Note:

- *Multiple values of <n> in a single command must be separated by commas*
- *Square brackets, [ ], are used to distinguish commands and should not be sent as part of the command strings.*
- *Commands are case-sensitive.*
- *Response time from the transmission of the checksum byte to transmission of the start character is less than 5 msec.*

3.3.2   Pump Configuration Commands

XMP 6000 pumps are preconfigured at the factory to the default settings. The firmware, however, allows the user to configure the pump to meet his or her specific requirements. Configuration options available to the user include resolution, backlash, valve type, and baud rate.

N <n>   Set Microstep Mode Off/On

The [N] command enables or disables microstepping (fine positioning). The syntax for this command is:

[N<n>]

where <n> = 0 or 1 (0 is the default)

Value of <n>	Description
0	**Normal mode:** All positions set and reported in half-steps; all speed settings in half-steps/sec and all slopes in half-steps/sec^2.
1	**Fine positioning mode:** All positions set and reported in micro-steps; all speed settings in half-steps/sec and all slopes in half-steps/sec^2. Maximum cutoff frequency limited to 750 half-steps/sec; maximum on-the-fly set velocity limited to 750 half-steps/sec.
2	**Micro-step mode:** All positions set and reported in micro-steps; all speed settings in micro-steps/sec and all slopes in micro-steps/sec^2.

K<n>   Backlash Increments

The [K] command sets the number of backlash increments. The syntax for this command is:

[K<n>]

where <n> = 0..62 in full step mode (48 is the default),
and <n> = 0..496 in fine positioning mode (384 is the default).

When the syringe drive motor reverses direction, the carriage will not move until the backlash due to mechanical play within the system is compensated. To provide this compensation, during aspiration, the plunger moves down additional increments, then backs up the set number of backlash increments. This ensures that the plunger is in the correct position to begin a dispense move. Note that a small volume of fluid flows out the "input" side of the valve during this operation.

>   Set User Data Command

The [>] command loads a byte of user data into non-volatile memory:

[> <n1>, <n2>], where: <n1> is 0..15 (location in non-volatile memory) and <n2> is 0..255 (data to load into non-volatile memory).

U<n>   Write Pump Configuration to Non-Volatile Memory

The [U] command is used to write configuration information to the non-volatile memory. The pumps are configured during the manufacturing process but can be reconfigured at any time with the following [U] commands:

Table 3-5 *Write Pump Configuration Command Values*

Value<n>	Description
16	XMP - 2 channel
17	XMP - 2 channel bypass
18	XMP - 4 channel
19	XMP - 4 channel bypass
20	XMP - 6 channel
21	XMP - 6 channel bypass
22	XMP - 8 channel
23	XMP - 8 channel bypass
30	Set Non-Volatile Memory Auto Mode
31	Clear Non-Volatile Memory Auto Mode
35	Auto-detect serial communication protocol (default)
36	OEM serial communication protocol

Table 3-5 *Write Pump Configuration Command Values*

Value<n>	Description
37	DT serial communication protocol
41	Set RS-232/RS-485 Baud rate to 9600
47	Set RS-232/RS-485 Baud rate to 38400
51	Set CAN Bus Baud rate to 100K
52	Set CAN Bus Baud rate to 250K
53	Set CAN Bus Baud rate to 500K
54	Set CAN Bus Baud rate to 1M
57	Set CAN Bus Baud rate to 125K

Note: [U] commands take effect upon the pump's next power up or when a [!] command is issued.

! Set Configuration Command

The [!] command sets the device to a new configuration after the [U] command has been issued. The device must be reinitialized after the set command has been received.

3.4 Initialization

3.4.1 Initialization Forces

Initialization moves the plunger to the top of travel, then backs off a user-specified number of increments (see k command) and sets this as position 0. Also, the input and output positions of the valve are assigned depending on the initialization command. All other command parameters are reset to default values.

The top of travel is recognized when upward movement of the plunger causes an overload condition.

The force at which the plunger presses against the top of travel can be controlled via a parameter after the Initialization command by the set initialization force command.

Caution! *To retain the integrity of the seal on smaller syringes, use a lower initialization force than that for larger syringes. The default initialization speed is 500 Hz.*

---

x <n>   Set Initialization Force Command

The [x] command sets the initialization force with which the plunger presses against the top of travel. The syntax for this command is:

[x<n>]

where:

<n> = the percentage of full force of the pump
<n> = 25..100

Note: During initialization the pump will move at full force except when pressing against the top of travel.

k <n>   Syringe Dead Volume Command

The [k] command sets the number of increments that the plunger drive is offset from the top of travel. The syntax for this command is:

[k<n>]

where:

<n> = the offset in increments from top of travel
<n> = 0..255 (122 is the default)
<n> = 0..2040 in fine positioning and microstep modes (976 is the default)

Under default initializations, the plunger moves upward until it contacts the top of the syringe, causing a forced stall initialization. The plunger then moves downward and upward, leaving a small gap between the syringe seal and the top of the plunger. This small gap was designed so that the Teflon seal does not hit the top of the plunger each time the syringe moves to the "home" position. This maximizes the life of the syringe seal.

The [k] command must be followed by the Initialization command [Z], [Y], or [W]. Each time the unit is powered down, the "k" value will return to the default condition.

For example, to offset 10 increments away from the top of travel, send the following commands:

– k10R
– ZR

3.4.2   Initialization Commands

Z <n>   Initialize Plunger and Valve Drive (Input)

The [Z] command sets the valves to the input position and initializes the plunger drive.

Z Parameter	Value	Description
<n>	0	Initializes plunger at the force set by the x command, and at default initialization speed (500 pulses/sec.)
	10-40	Initializes plunger at the force set by the x command, and at speed code <n>. See command <S> for a list of speed codes.

Y <n>   Initialize Plunger and Valve Drive (Output)

The [Y] command sets the valves to the output position and initializes the plunger drive.

Y Parameter	Value	Description
<n>	0	Initializes plunger at the force set by the x command, and at default initialization speed (500 pulses/sec.)
	10-40	Initializes plunger at the force set by the x command, and at speed code <n>. See command <S> for a list of speed codes.

z   Simulated Plunger Initialization

The [z] command simulates an initialization of the plunger drive, however, no mechanical initialization occurs. The current position of the plunger is set as the zero (home) position.

This command can be used after a plunger overload error, to regain control of the pump. After recovering from the overload condition using the [z] command, the pump must be reinitialized using the Z<n> or Y<n> commands to set the true home position.

Caution! *Incorrect use of this command can damage the device. Make sure the fluid lines are clear of obstructions before initializing the pump.*

3.5   Operating Commands

3.5.1   Valve Commands

Valve commands allow the user to switch the valves to the input and output ports.

I   *Switch Valve to Input Position*

The [I] command switches the valves to the input port. When viewing the unit from the front, the input port is on the left.

O   Switch Valve to Output Position

The [O] command switches the valves to the output port. When viewing the unit from the front, the output port is on the right.

B <n>   Binary Valve Addressing Command

The [B] command allows the user to switch each valve independently. The first valve (on the left) is represented by the first parameter. There must be a 0 or 1 for each valve.

B Parameter	Value	Description
<n>	0, 1	0 = input position 1 = output position

For example:

A typical command for an 8-channel device would be B01010101R (first valve input, second valve output, third valve input, etc.)

B   Switch Valve to Bypass (Bypass Configuration only)

For bypass configurations, this command will set all valves to the bypass position.

Caution! *When the valve is in the Bypass position, the syringe plunger will not move. Sending a Plunger Movement command causes an error 11 (plunger move not allowed).*

E <n>   Exponential ASCII Valve Addressing Command

This command allows the user to send a numerical ASCII value from $0..2^n-1$ to energize single or multiple valves in a pump, where *n* is equal to the number of channels in the pump. For example, to energize all valves on a 4-channel pump, send the command E15. To energize only the valve on the left, send command E8.

$$n = \sum_{i=1}^{n} (y \times 2^{(i-1)})$$

where

y = 0 for de-energized valve in channel *i*

y = 1 for energized valve in channel *i*

n = number of channels in the pump

i = specific pump channel

Note: The channel to the left is the highest numbered channel. For example, on an 8-channel pump, the channel count (i) from left to right is 8, 7, 6, 5, 4, 3, 2, 1.

3.5.2   Plunger Movement Commands

A <n>   Absolute Position

The [A] command moves the plunger to the absolute position <n>, where
<n> = 0..6000 in standard mode and 0..48000 in fine positioning and
microstep mode.

Command	<n> Parameter Value	Description
A	0-6000	Absolute position in half increments (N=0)
	0-48000	Absolute position in microsteps (N=1)
	0-48000	Absolute position in microsteps (N=2)

For example:

– [A300] moves the syringe plunger to position 300.
– [A6000] moves the syringe plunger to position 6000.

a <n>   Absolute Position (Not Busy)

This is the same as the [A] command, except that the status bit within the
reply string indicates that the pump is not busy.

P <n>   Relative Pickup

The [P] command moves the plunger down the number of increments
commanded. The new absolute position is the previous position plus <n>,
where
<n> = 0..6000 in standard mode and
<n> = 0..48000 in fine positioning and microstep mode.

Command	<n> Parameter Value	Description
P	0-6000	Relative position in half increments (N=0)
	0-48000	Relative position in microsteps (N=1)
	0-48000	Relative position in microsteps (N=2)

For example:

The syringe plunger is at position 0. [P300] moves the plunger down 300
increments. [P600] moves the plunger down an additional 600 increments to
an absolute position of 900.

The [P] command will return error 3 (invalid operand) if the final plunger
position is greater than 6600.

p <n>   Relative Pickup (Not Busy)

This is the same as the [P] command, except that the status bit of the reply string indicates that the pump is not busy..

D <n>   Relative Dispense

The [D] command moves the plunger upward the number of increments commanded. The new absolute position is the previous position minus <n>, where
<n> = 0..6000 in standard mode and
<n> = 0..48000 in fine positioning and microstep mode.

Command	<n> Parameter Value	Description
D	0-6000	Relative position in half increments (N=0)
	0-48000	Relative position in microsteps (N=1)
	0-48000	Relative position in microsteps (N=2)

For example:

The syringe plunger is at position 3000. [D300] will move the plunger up 300 increments to an absolute position of 2700.

The [D] command will return error 3 (invalid operand) if the final plunger position would be less than 0.

d <n>   Relative Dispense (Not Busy)

This is the same as the [D] command, except that the status bit of the reply string indicates that the pump is not busy..

3.5.3   Set Commands (Speed and Acceleration)

Set commands are used to control the speed of the plunger. Plunger movement is divided into three phases:

- **Ramping Up.** Plunger movement begins with the start speed and accelerates with the programmed slope to the constant or top speed.
- **Constant or Top Speed.** The plunger moves at the constant or top speed. Plunger speed can be programmed in Hz (half-increments/second) or in preprogrammed Set Speeds. The actual time the plunger travels is dependent on the ramping up and down. If the plunger move is short, it may never reach top speed.
- **Ramping Down.** The plunger will decelerate based on the programmed slope. To enhance fluid breakoff, the Cutoff command ([c]) can be used to define the end speed of the plunger just before it stops.

TECAN.

Note: The Cutoff command is only active in a dispense move. During aspiration the move will end at the start speed [v].

For each plunger move, the firmware calculates how many increments the plunger must travel during each phase in order to move the total number of increments commanded. If the plunger is moving at a rate less than 900 Hz, the pump automatically microsteps to reduce the pulsation.

The top speed can be changed on the fly (while the plunger is moving) using the [v] command, providing the top speed is less than or equal to the start speed. Ramps are not included in on-the-fly speed changes; therefore, large speed changes (100 Hz to 1000 Hz) are not recommended.

Note: Unless the top speed is less than or equal to the start or cutoff speed, always program the pump in order of the move: start speed [v], top speed [V], cutoff speed [c].

Changing Speed on the Fly

Speed changes can be made while the syringe plunger is moving. This is called "changing speed on the fly."

Speeds can be decreased or increased between 5 and 750 Hz (i.e., in the fine positioning region).

To change speed on the fly:

1 Issue speed commands with identical start and top speeds (e.g., [v100V100]), followed by a Plunger Move command. Ramping is not allowed in on-the-fly changes.

2 Issue a new top speed in the range 5 to 750 (e.g. [V600]) while the plunger is moving, to change the speed on the fly.

Note: When the move completes, speed values revert to original values (i.e., value sent on-the-fly is temporary).

Note: When changing speed on the fly in CAN, use frame type 0.

L <n>   Set Slope

During the beginning and end of a move, the plunger speed ramps up and down respectively. The ramp is programmed using the Slope command. It is calculated as <n> x 2500 pulses/sec^2. The syntax for this command is:

[L<n>]

where <n> = 1..20 (7 is the default)

In normal or fine positioning modes (N0, N1) pulses are in half steps. In micro-step mode (N2) pulses are in micro-steps.
The corresponding slopes in pulses/sec^2 are listed below.

Slope Code	Pulses/sec^2 (KHz)
1	2500
2	5000
3	7500
4	10000
5	12500
6	15000
7	17500
8	20000
9	22500
10	25000
11	27500
12	30000
13	32500
14	35000
15	37500
16	40000
17	42500
18	45000
19	47500
20	50000

v <n>   Set Start Speed

The [v] command sets the speed at which the plunger begins its movement, in pulses/sec. The plunger will then ramp up (slope) to the top speed. The start speed should always be less than the top speed.

Command	<n> Parameter Value	Default Value	Description
v	50-1000	901	Set start speed in pulses/sec.

V <n>   Set Top Speed

The [V] command sets the top speed in pulses/second. This command may be sent while a command string is already executing. (See section on Changing Speed on the Fly, earlier in this chapter.)

Command	<n> Parameter Value	Default Value	Description
V	5-6000	901	Set top speed in pulses/sec.

Note: Syringes 2.5 mL and larger may require slower speeds. Users must determine the appropriate speeds for their applications.

S <n>   Set Speed

The [S] command sets a predefined top plunger speed, in pulses/sec. As <n> increases, the plunger speed decreases.

Command	<n> Parameter Value	Default Value	Description
S	0-40	16	Set plunger drive speed in pulses/sec.

These speed settings do not cover the full range of speeds the plunger can travel. They are commonly used speeds provided for the convenience of the user. All times are approximate and will vary with different ramp speeds and cutoffs. For information on determining timing for specific applications, see Appendix B, "Plunger Information".

The [S] command sets top speed without changing start speed, slope, and cutoff speed, except under the following conditions:
- If the start speed is higher than the (new) top speed, start speed is changed to equal the top speed.
- If the cutoff speed is higher than the (new) top speed, cutoff speed is changed to equal the top speed.

Speed codes, the Hz (pulses/second) equivalent, and seconds per stroke are listed below. Seconds/stroke values are based on default ramping.

Speed Code	Value (pulses/sec.)	Seconds/stroke (N=0, N=1)	Seconds/stroke (N=2)
0	6000	1.25	8.25
1	5600	1.30	8.80
2	5000	1.39	9.79
3	4400	1.52	11.1
4	3800	1.71	12.8
5	3200	1.97	15.1
6	2600	2.37	18.5
7	2200	2.77	21.9
8	2000	3.03	24.0
9	1800	3.36	26.7
10	1600	3.77	30.0
11	1400	4.30	34.3
12	1200	5.00	40.0
13	1000	6.00	48.0
14	800	7.50	60.0
15	600	10.00	80.0
16	400	15.00	120
17	200	30.00	240
18	190	31.58	253
19	180	33.33	267
20	170	35.29	282
21	160	37.50	300
22	150	40.00	320
23	140	42.86	343
24	130	46.15	369
25	120	50.00	400
26	110	54.55	436
27	100	60.00	480

Speed Code	Value (pulses/sec.)	Seconds/stroke (N=0, N=1)	Seconds/stroke (N=2)
28	90	66.67	533
29	80	75.00	600
30	70	85.71	686
31	60	100.00	800
32	50	120.00	960
33	40	150.00	1200
34	30	200.00	1600
35	20	300.00	2400
36	18	333.33	2667
37	16	375.00	3000
38	14	428.57	3429
39	12	500.00	4000
40	10	600.00	4800

Note: *To achieve maximum stroke time of 20 minutes for N=0, N=1 or 160 minutes for N=2, a set speed [S] cannot be used. The pump must be programmed using the [V5] command.*

c <n>   Cutoff Speed in Pulses/Second

The [c] command sets the speed at which the plunger ends its movement, in pulses/sec. The plunger will ramp down (slope) from the peak speed. The [c] command overwrites the [C] command.

Command	<n> Parameter Value	Default Value	Description
c	50-2700	901	Set cutoff speed in half-steps/sec. (N=0, N=1)
	50-900	500	Set cutoff speed in micro-steps/sec. (N=2)

Note: *[c] is only valid in a dispense move. During aspiration, [c] = [v].*

3.5.4 Interaction of Set Commands

The Start Speed [v], Top Speed [V], and Cutoff Speed [c] commands interact according to the following rules:

$$[v] \leq [c] \leq [V]$$

1 Start Speed should always be less than or equal to Top Speed. Changing the Start Speed will change the Cutoff Speed if Cutoff Speed is less than the Start Speed set. If the Start Speed [v] is greater than the Top Speed, the Start Speed will be set equal to the Top Speed.

2 Top Speed should always be greater than or equal to the Start Speed and Cutoff Speed. Changing the Top Speed will modify the Cutoff Speed and Start Speed if they were improper, but will not modify the stored Start Speed. For instance, values of 750, 100 and 1200 will cause the pump to run simply at the top speed of 100.

3 Cutoff Speed [c] should always be less than or equal to Top Speed [V] and greater than or equal to Start Speed [v]. Changing the Cutoff Speed will not modify the Start Speed or Top Speed. However, if Cutoff Speed is greater than Top Speed it will be ignored and the Cutoff Speed will be set equal to the Top Speed. And if the Cutoff Speed is set less than Start Speed, it will be ignored and the Cutoff Speed will be set equal to the Start Speed.

3.5.5 Control Commands

R   Execute Command or Program String

The [R] command tells the pump to execute a new or previously loaded but unexecuted command string. This command will also cause the resumption of a halted ("H") or terminated ("T") command string.

Commands containing [R] at the end of the string will execute immediately. If the command or program string is sent without the [R], it is placed in the command buffer.

Sending the [R] alone will execute the last unexecuted command in the buffer. Sending another [R] will not repeat the program string (i.e., the string has been executed).

Note: The [R] command (frame type 1) is valid in CAN communication. An equivalent command is ASCII 1 for frame type 2.

X   Execute the Last Command or Program String

The [X] command repeats the last executed command or program string.

Note: The [X] command (frame type 1) is valid in CAN communication. An equivalent command is ASCII 3 for frame type 2.

G <n> Repeat Command Sequence

This command repeats a command or program string the specified number of times. If a GR or a G0R is sent, the sequence is repeated until a Terminate command [T] is issued. The G command can be used to nest up to 10 loops and can be repeated up to 48,000 times.

The syntax for this command is:

[G<n>]

where <n> = 0..48000

For example, [A3000A0G10R] moves the syringe plunger to position 3000 then back to position 0. This sequence is repeated 10 times.

g Mark the Start of a Repeat Sequence

The [g] command is used in conjunction with the [G] command. The [g] command marks the beginning of a repeat sequence (loop) that occurs within a program string (i.e., the entire string is not repeated). Both the [g] and [G] commands can be used to nest up to 10 loops.

Table 3-6, Example Program String, shows the various segments of the command string [A0gP50gP100D100G10G5R].

Table 3-6 *Example Program String*

Command Segment	Description
A0	Move plunger to position 0.
g	Outer loop start.
P50	Move plunger down 50 increments.
g	Inner loop start.
P100	Move plunger down 100 increments.
D100	Move plunger up 100 increments.
G10	Inner loop, repeat 10 times.
G5	Outer loop, repeat five times.
R	Execute command string.

M <n> Delay Command Execution

The [M] command delays execution of a command in milliseconds to the closest multiple of five. This command is typically used to allow time for liquid in the syringe and tubing to stop oscillating, thereby enhancing precision. The syntax for this command is:

[M<n>]

where <n> = 0..30,000 milliseconds (5 is the default)

H <n>   Halt Command Execution

The [H] command is used within a program string to halt execution of the string. To resume execution, an [R] command or TTL signal must be sent.

The syntax for this command is:

[H<n>]

where <n> = 0..2

Two TTL inputs are available, input 1 (J5 pin 7) and input 2 (J5 pin 8). They control execution as follows:

<n> = 0	Waits for [R] or either input 1 or 2 to go low
<n> = 1	Waits for [R] or input 1 to go low
<n> = 2	Waits for [R] or input 2 to go low

Note: If the value of <n> is not specified, <n> defaults to 0.

The status of the TTL input lines can also be read using [?13]and [?14]. These commands are described in "Report Commands" later in this chapter.

T   Terminate Command

The [T] command terminates plunger moves in progress ([A], [a], [P], [p], [D], and [d]), control loops, and delays [M].

The [T] command will terminate both single commands and program strings. If a program string is terminated before completion, the [R] (Execution) command will resume the program string. If the command was terminated due to a problem or error, the pump must be reinitialized.

Caution! When a plunger move is terminated, lost increments may result. Reinitialization is recommended following termination.

Note: The [T] command (frame type 0) is valid in CAN communication. An equivalent command is ASCII 4 for frame type 2.

J <n>   Auxiliary Outputs

The [J] command sets the TTL output lines.

The syntax for this command is:

[J<n>]

where <n> = 0..7 (0 is the default)

The XMP 6000 provides three TTL outputs on J5 (pins 13, 14, and 15) that correspond to outputs 1, 2, and 3. They are controlled as shown in the following table:

Command	Output 3 (Pin 15)	Output 2 (Pin 14)	Output 1 (Pin 13)
J0	0	0	0
J1	0	0	1
J2	0	1	0
J3	0	1	1
J4	1	0	0
J5	1	0	1
J6	1	1	0
J7	1	1	1

0 = low; for example, Gnd
1 = high; for example, +5V DC

3.5.6 Non-Volatile Memory (EEPROM) Commands

The non-volatile memory in the XMP 6000 can store a program string thus providing the user with the option of computer-free operation. The pump can be configured to run stored programs using the U<30> command. See "Pump Configuration Commands" earlier in this chapter.

s <n>   Load Program String into Non-Volatile Memory

The [s] command is placed at the beginning of a program string to load the string into the non-volatile memory. The syntax for this command is:

[s<n>]

where <n> = 0..14

Up to 15 program strings (numbered 0 through 14) can be loaded into the non-volatile memory. Each string can use up to 128 characters. For example, [IA3000OA0R] requires 10 bytes.

Example Program String: [s8ZS1gIA3000OA0GR]

Command Segment	Description
s8	Loads string into program 8 of non-volatile memory (Address switch position 8)
Z	Initializes pump
S1	Sets plunger speed
g	Marks start of loop

Command Segment	Description
I	Switches valve to input position
A3000	Moves plunger to position 3000
O	Switches valve to output position
A0	Moves plunger to position 0
G	Endlessly repeats loop
R	Executes command string

e <n>   Execute Non-Volatile Memory Program String

Non-volatile memory command strings are executed by sending an [e] command. The executing program string can be terminated using the [T] command.

> [e<n>]

where <n> = 0..14 (the string number)

Note: An Initialization command should always be included in the non-volatile memory command string if the pump will be used in standalone mode.

U30   Set Run from Non-Volatile Memory Auto Mode

The [U30] command sets the "Run from Non-Volatile Memory Auto Mode" flag in the non-volatile memory and begins operating the pump in stand alone mode. The pump will run one of 15 command strings <n> as selected by the address switch,

where <n> = 0..E

U31   Clear Run From Non-Volatile Memory

The [U31] command clears the "Run from Non-Volatile Memory Auto Mode" flag in the EEPROM and begins operating in the default mode.

Note: U commands take effect upon the pump's next power up.

Linking Program Strings in the Non-Volatile Memory

Non-volatile memory program strings can be linked by ending one program string with an [e] command that refers to a second program string.

Example Program Strings:

> [s1ZgIA3000OA0G5e2R]
> [s2gIA3000OgHD300G10GR]

The first string loads an initialization and prime sequence into program 1 of the non-volatile memory (address switch position 1). It then links to string 2 in the non-volatile memory.

The second string loads an aspirate and dispense sequence into program 2 of the non-volatile memory. The second non-volatile memory program string fills the syringe, then performs 10 dispenses of 300 increments each. The dispenses are triggered by an [R] command. This string is repeated endlessly until the pump is powered down.

On power-up the pump will automatically initialize, prime and perform the multiple dispenses until it is again powered down.

3.5.7 Report Commands

Report commands do not require an [R] command.

All Report commands are invalid in CAN communication. The frame type 6 is provided to retrieve information from the pump. For more information, see Appendix F, "CAN Communication Commands".

?   Report Absolute Plunger Position

The [?] command reports the absolute position of the plunger in half-steps [N0] or in microsteps [N1, N2].

?1   Report Start Speed

The [?1] command reports the start speed in pulses/sec [50..1000].

?2   Report Top Speed

The [?2] command reports the top speed in pulses/sec [5..6000].

?3   Report Cutoff Speed

The [?3] command reports the cutoff speed in pulses/sec [50..2700].

?4   Report Actual Position of Plunger

The [?4] command reports the plunger encoder position in increments.

?10 or F   Report Command Buffer Status

The [?10] or [F] command reports the command buffer status. If the buffer is empty, the pump returns status code 0. If the buffer is not empty, the pump returns a 1. If a program string is sent to the pump without an [R] command, the string is loaded into the buffer and the buffer status becomes 1. An [R] command will then execute the command stored in the buffer.

    0 = empty
    1 = commands in buffer

?12   **Report Number of Backlash Increments**

The [?12] command reports the number of backlash increments as set by the "K" command.

?13   **Report Status of Auxiliary Input #1 (J5, Pin 7)**

0 = low
1 = high

?14   **Report Status of Auxiliary Input #2 (J5, Pin 8)**

0 = low
1 = high

?15   **Report Number of Pump Initializations**

Command [?15] reports the number of pump initializations. This value cannot be reset.

?16   **Report Number of Plunger Movements**

Command [?16] reports the number of plunger moves. This value cannot be reset.

?17   **Report Number of Valve Movements**

Command [?17] reports the number of valve movements. This value cannot be reset.

?18 or % Report Number of Valve Movements (Since Last Report)

The [?18] or [%] command reports the number of valve movements since the last [?18] or [%] command.

?20 or # Report Firmware Checksum

The [?20] or [#] command reports back the firmware checksum. The checksum is the same for all part numbers at the same revision level.

?23 or & Report Firmware Version

The [?23] or [&] command reports the firmware part number and version in ASCII characters.

?24   **Report the Zero Gap increments**

The [?24] command reports the value set by the "k" command.The value reported is in half steps (N=0) or in microsteps (N=1, N=2).

?25   **Report Slope Code Setting**

The [?25] command reports the slope code setting as set by the "L" command.

?26 or *   Report Voltage

The [*] command reports the value of the device power supply. The value is multiplied by 10. For example, if V = 24.0 VDC, the * command reports 240.

?28   Report Current Mode

The [?28] command reports the current mode as set by the "N" command (normal, fine positioning, or microstep).

?29 or Q Report the Device Status

The [?29] command reports device status (error code).

?76   Report Pump Configuration

The [?76] command reports pump configuration in ASCII text.

<   Report User Data

The [<] command returns the value of user data stored in the EEPROM. The value <n> is between 0 and 15; 0 is the default.

3.6   Error Codes and Pump Status

The [Q] command is used for serial communications and reports error codes and pump status (ready or busy). The user should send a [Q] command before sending a program string or individual command to ensure that the pump has completed the previous command successfully.

Note: [Q] is the only valid method for obtaining pump status in serial mode.

Note: The Query command is invalid in CAN communication.

The response to the [Q] command (the status byte) provides two items of information: Pump status (bit 5) and error code (bits 0-3).

3.6.1   Status Bit

Bit 5 is the status bit. It indicates when the pump is busy or not busy. The designations for bit 5 are listed below.

Status Bit 5	Description
X = 1	Pump is ready to accept new commands.
X = 0	Pump is busy and will only accept Report and Terminate commands.

In response to uppercase Move commands ([A], [P], and [D]), the [Q] command reports that the pump is busy. In response to lowercase Move commands ([a], [p], and [d]), the [Q] command reports that the pump is not busy. Additionally, commands addressed to multiple pumps at once cannot be used to obtain pump status; pumps must be queried separately.

Note: Although the answer block for other commands contains a status bit, it should not be used for determining pump status. A [Q] command is the only valid method to determine if the pump is busy. The error information in the status byte of the answer block is always valid.

3.6.2 Error Codes

Error codes describe problem conditions that may be detected in the XMP 6000 (excluding error code 0). Error codes are returned in the least significant four bits of the status byte. If an error occurs, the pump stops executing commands, clears the command buffer, and inserts the error code into the status byte.

Some errors continue to appear, such as syringe overloads, until they are cleared by the Initialization command. On a plunger overload, the device will not execute another valve or syringe Move command until it is reinitialized. The last error has precedence in the status byte. For example, if a command overflow occurs, an error 15 results. If the next command causes an error #3, the status byte reflects the error #3 (invalid operand).

Table 3-7   *Error Codes*

Error Code	Description
0 (00h)	Error Free Condition.
1 (01h)	Initialization error. This error occurs when the pump fails to initialize. Check for blockages and loose connections before attempting to reinitialize. The pump will not accept commands until it has been successfully initialized. This error can only be cleared by successfully initializing the pump.
2 (02h)	Invalid Command. This error occurs when an unrecognized command is issued. Correct the command and operation will continue normally.
3 (03h)	Invalid Operand. This error occurs when an invalid parameter (<n>) is given with a command. Correct the parameter and pump operation will continue normally.
6 (06h)	EEPROM Failure. This error occurs when the EEPROM is faulty. If you receive this error, please call Tecan Systems Technical Service.
7 (07h)	Device Not Initialized. This error occurs when the pump is not initialized. To clear the error, initialize the pump.

Error Code	Description
8 (08h)	Internal failure. If this error occurs, please call Tecan Systems Technical Services. See Chapter 6, "Technical Service."
9 (09h)	Plunger Overload. This error occurs when movement of the syringe plunger is blocked by excessive backpressure. The pump must be reinitialized before normal operation can resume. This error can only be cleared by reinitializing the pump.
10 (0Ah)	Valve Error
11 (0Bh)	Plunger Move Not Allowed. When the valve is in the bypass or throughput position, Plunger Movement commands are not allowed.
12 (0Ch)	Internal failure. If this error occurs, please call Tecan Systems Technical Services. See Chapter 6, "Technical Service."
14 (0Eh)	A/D converter failure. This error occurs when the internal A/D converter is faulty. If this error occurs, please call Tecan Systems Technical Services. See Chapter 6, "Technical Service."
15 (0Fh)	Command Overflow. This error occurs when action commands are sent to the pump before it has completed the current action. Commands in the buffer must be executed before more commands can be sent.

3.6.3 Error Types

The pump handles errors differently, depending on the error type. There are four error types, which are described below.

Immediate Errors

These include "Invalid Command" (error 2), "Invalid Operand" (error 3). After the command is sent, the answer block immediately returns an error. Once a valid command is sent, the pump will continue to function normally. Since the [Q] command is a valid command, the pump will not return an error. In this case, the [Q] command is not required.

Note: There is no need to reinitialize the pump following this error type.

Initialization Errors

These include "Initialization errors" (error 1) and "Device not Initialized" (error 7). If the pump fails to initialize or if an Initialization command has not been sent, subsequent commands will not be executed.

To ensure that the pump initializes successfully, send a [Q] command after the Initialization command.

● If the [Q] command indicates both a successful initialization and that the pump is ready, subsequent Move commands can be sent.

● If the [Q] command indicates the pump has not initialized, the pump must be reinitialized until the [Q] command indicates successful initialization.

● If initialization is not successful, a "Device Not Initialized" error is returned as soon as the next Move command is sent. A successful reinitialization must be executed before subsequent commands can be sent.

Command Overflow Error

This is error 15, and it occurs if a Move command, Set command (except [V]), or Valve command is sent while the plunger is moving. The pump ignores the command and issues an error 15. The [Q] command allows the controller to determine when the command is complete and the pump is ready to accept new commands.

Note: There is no need to reinitialize the pump following this error type.

Report commands, Control commands, and the Top Speed command [V] will not return an error 15. Report and Control commands are considered valid commands during a Move. Because the pump can change speed while the plunger is moving in the 5-1024 pulses/sec range, the [V] commands will not return a "Command Overflow" error.

Caution! *All errors reported by the pump should be captured by the user software and the physical cause corrected before continuing operation. Failure to do so may result in damage to the pump or adversely affected pump performance, and void the warranty*

Table 3-8 *Error Codes and ASCII and Hexadecimal Values*

Status Byte	Hex # if Bit 5 =		Dec # if Bit 5 =		Error Code	
7 6 5 4 3 2 1 0	**0**	**or 1**	**0**	**or 1**	**Number**	**Error**
0 1 X 0 0 0 0 0	40h	60h	64	96	0	No Error
0 1 X 0 0 0 0 1	41h	61h	65	97	1	Initialization
0 1 X 0 0 0 1 0	42h	62h	66	98	2	Invalid Command
0 1 X 0 0 0 1 1	43h	63h	67	99	3	Invalid Operand
0 1 X 0 0 1 1 0	46h	66h	70	102	6	EEPROM Failure
0 1 X 0 0 1 1 1	47h	67h	71	103	7	Device not Initialized
0 1 X 0 1 0 0 0	48h	68h	72	104	8	Internal failure
0 1 X 0 1 0 0 1	49h	69h	73	105	9	Plunger Overload
0 1 X 0 1 0 1 0	4Ah	6Ah	74	106	10	Valve Error

Status Byte	Hex # if Bit 5 =		Dec # if Bit 5 =		Error Code	
0 1 X 0 1 0 1 1	4Bh	6Bh	75	107	11	Plunger Move Not Allowed
0 1 X 0 1 1 0 0	4Ch	6Ch	76	108	12	Internal Failure
0 1 X 0 1 1 1 0	4Eh	6Eh	78	110	14	A/D converter failure
0 1 X 0 1 1 1 1	4Fh	6Fh	79	111	15	Command Overflow

Error Reporting Examples

[A7000R]	Does not move the plunger and reports a "No Error" status; when queried ([Q] command), returns error. A second try returns error 3 (67).
[P6000P1000R]	Moves to position 6000, then stops. A [Q] command returns an error.
[t2000R]	Returns an invalid command error immediately. The pump status is "Not Busy."
[A6000t2000R]	Returns an invalid command error immediately. The pump is "Not Busy."
Valve in Bypass [A1000R]	Returns an error immediately; when queried ([Q] command), does not return an error.

This page has been intentionally left blank.

4 Setting Up the XMP 6000 for Your Application

The XMP 6000 is capable of providing precision pumping in a wide variety of liquid handling systems. The interplay of fluid viscosity, aspiration and dispense speeds, and system geometry (syringe size, tubing inner diameter, and valve inner diameter) determine the behavior of the XMP 6000 in a particular application. Following is a description of the hardware, fluid, and pump control parameters to be evaluated and optimized in managing these interdependencies for optimal pump performance.

4.1 Glossary

air gap

A small volume of air at the end of the output tubing or sandwiched between two fluids in the pump system tubing. Air gaps may be created by aspirating air (programmed air gaps) or by the spring action of the fluid system (inertial air gaps).

aspirate/dispense tubing

Connects the valve output port (1/4-28 thread or M6 fitting) to a sample source and destination. To ensure good breakoff, aspirate/dispense tubing tends to have a smaller I.D. than reagent tubing, and a necked-down or tapered end.

backlash

Mechanical play in the syringe drive created by accumulated mechanical clearances.

backpressure

The pressure which must be exceeded to move fluid through tubing. Backpressure is created by a combination of fluid inertia and friction.

breakoff

Describes how the last droplet of fluid exits the end of the output tubing following a dispense. Rapid or sharp breakoff means that the droplet exits cleanly with high inertia.

breakup

Undesired air gaps created by overly rapid aspiration.

---

carryover

Contamination of a volume of fluid by residual fluid from a previous aspiration or dispense. Carryover causes variability in final volume and concentration.

cavitation

Formation of air bubbles due to rapid pressure changes. Often caused by aspirating fluid into the syringe too quickly.

dilution effect

Reduction in sample or reagent concentration, caused by contact with system fluid or residual fluid from a previous aspiration or dispense.

I.D. ("inner diameter")

Diameter of the constraining wall of a fluid path.

priming

Completely filling the pump tubing and syringe with bubble-free fluid to allow sustained, reproducible pumping action. The air in an unprimed line acts as a spring, adversely affecting accuracy and precision.

reagent tubing

Connects the valve input port (1/4-28 thread or M6 fitting) to a reagent source. Reagent tubing is used to fill the pump syringe; it tends to have a larger I.D. than aspirate/dispense tubing, and a blunt-cut end which extends into the reagent.

system fluid

A fluid used to prime the pump system that does not act as sample or reagent. Typically the system fluid is de-ionized water or a wash buffer and is isolated from sample or reagent fluid by an air gap to avoid intermixing.

syringe speed profile

Typically, the syringe plunger begins moving slowly, then ramps up to top speed. This allows the plunger to start moving gradually, without overloading the motor, and still provide maximum flowrate. The syringe plunger stops by ramping down in speed. This results in the most reproducible fluid breakoff for accurate dispensing.

Figure 4-1   *Syringe Speed*
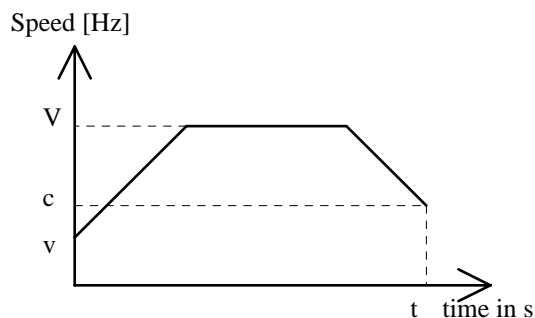
start speed (v)

> The speed at which the syringe plunger starts moving.

top speed (V)

> The maximum speed at which the syringe plunger moves.

cutoff speed (c)

> The speed of the syringe plunger just before stopping.

slope (L)

> Acceleration (deceleration) of the syringe plunger between start speed, top speed, and cutoff speed.

volume calculation

> The volume aspirated or dispensed when the syringe plunger moves a specified number of increments depending on the syringe size. To determine the number of increments required to aspirate or dispense a given volume, use the following formula:

$$\text{\# of increments} = \frac{(\text{pump resolution}) \times \text{volume}}{\text{syringe size})}$$

> For example, to aspirate 100 μL using an XMP 6000 pump with 1 mL syringe, move the plunger as follows:

$$\text{\# of increments} = \frac{6000 \text{ increments} \times 100 \ \mu\text{L}}{1 \text{ mL} \times 1000 \ \mu\text{L/mL}} = 300 \text{ increments}$$

4.2   Optimizing XMP 6000 Performance

Caution! *Run the pump only in the upright position. Do not move the pump valve or syringe plunger without first wetting or priming the pump.*

For command details, see Chapter 3, "Software Communication".

To optimize XMP 6000 performance, follow these steps:

1   Check chemical compatibility.

Check the chemical compatibility chart in Appendix D, "Multichannel Pump Chemical Resistance Chart" to determine if the fluids in your application are compatible with the XMP 6000 syringe and valve materials. If not, a system fluid is required. Complete the optimization procedure with the fluids you will use in your final system.

Note that the system fluid is used to prime the syringe and tubing from inlet to outlet. After the tubing is primed (and before any sample or reagent is aspirated), an air gap must be taken into the aspirate/dispense tubing to separate the system fluid from subsequently aspirated sample or reagent. Air gaps should be aspirated slowly to avoid break-ups, and they should be one-tenth the volume of the aspirated fluid—or at least 10 μL—to avoid any dilution effect. Similar air gaps should separate each aspirated fluid when performing multiple aspirates with no intervening dispenses, in order to prevent premature mixing and/or contamination. In addition, the aspirate/dispense tubing must be long enough to hold the total aspirate volume without coming in contact with the valve or syringe.

2   Select syringe size.

Determine your volume and flowrate requirements. Select a syringe that accommodates the smallest and largest volumes to be dispensed without refill, as well as the desired flowrate (see Table 4-1, Flowrate Ranges). While smaller syringes allow better accuracy and precision, a larger syringe allows more aliquots when multiple aspirations or multiple dispenses are required, and they allow better breakoff and longer seal life.

Table 4-1   *Flowrate Ranges*

Syringe Size	Theoretical Minimum Flow Rate (mL/min)	Theoretical Maximum Flow Rate (mL/min)
100 µL	6.25×10^{-4}	5.0
250 µL	1.563×10^{-3}	12.5
500 µL	3.125×10^{-3}	25.0
1 mL	6.25×10^{-3}	50.0
5 mL	3.125×10^{-2}	250.0

Caution! *The maximum flow rates specified in Table 4-1 are theoretical. Care must be taken not to exceed the maximum operating pressure rating of the solenoid valves (20 psi). Failure to do so may result in valve damage.*

3 Select tubing.

In tubing selection, the general rule is that smaller syringes work best with smaller I.D. tubing and larger syringes with larger I.D. tubing. The 3-port XMP 6000 valve has an internal I.D. of 0.059" (approx. 1/16"). For aspirate/dispense tubing, a thermal-drawn tip or tapered tip is most common, providing good breakoff and excellent accuracy and precision for most applications. A necked-down tip may be used when aspirating very small volumes of sample, i.e., 1 - 5 μL. A blunt-cut tip is better suited for large volume applications. For tubing recommendations, see Table 4-2, Tubing Recommendations; for a description of the various types of tubing, see Appendix A, "Ordering Information".

Table 4-2 *Tubing Recommendations*

Syringe Size	Aspirate/Dispense Tubing P/N	Reagent Tubing P/N
100 μL, 250 μL	5133	NA
	5723	NA
500 μL, 1 mL, 2.5 mL	5133	4609
	720595	5729
	720597	721370
5 mL	4333	720592
	720595	721370

4 Make pump connections.

Connect power and communications cables to the pump, install syringe and tubing. Place the end of the input tubing in a reservoir of particle-free fluid; place the end of the output tubing in a waste reservoir.

5 Check communications to the pump.

– Send the command [&] to read the pump's firmware part number and revision. Successful communication will return the firmware part number, firmware revision, and a "Ready" status.

Possible errors:

– No response. Check for loose or incorrectly connected cables, or connection to the wrong computer COM port. Retry.

6 Initialize pump and set initialization speed.

The following information assumes that your input tubing connects to the right valve port. If your input tubing connects to the left valve port, exchange [Y] for all instances of [Z] in the following commands.

– Send the command [ZR] to initialize the pump. Successful initialization will move the syringe plunger to the position "0" (fully dispensed) and return a "Ready" status.

Possible errors:

– Error 1 (initialization error). Check for tubing blockage and reinitialize. If you are using very narrow I.D. tubing or pumping a viscous fluid, the initialization speed may need to be reduced.

– This is accomplished (only if using a 1 mL or larger syringe) by sending the command [Z16R] (initializes at full-force, reduced speed). Repeat with decreasing initialization speed (increase "Z_" value) until the pump successfully initializes.

7 Prime the syringe.

– Send the command [IA6000OA0R] to pull fluid through the valve input position and into the syringe.

– Inspect the pump tubing and syringe for bubbles and re-prime until all bubbles are completely gone.
If bubbles remain after several priming strokes, disassemble the syringe and clean it with alcohol. Also check to ensure the fittings are tight and the syringe is tight within the Teflon fitting.

– Re-prime.

Possible errors:

– Error 9 (plunger overload). See step 8.

8 Check aspirate/dispense.

Send the command [IA6000OA0R] to aspirate a full syringe stroke (6000 increments) from input and dispense it to output. Successful execution will move the syringe plunger to position "6000" then back to "0," then it will return a "Ready" status.

Possible errors:

– Error 9 (plunger overload). The stepper motor is unable to move the syringe plunger, probably because of excessive backpressure caused by excessive flowrate, narrow tubing I.D., or valve or tubing blockage. Note whether the error occurred during aspiration or dispensing. To differentiate between blockage and flowrate limitation, reduce syringe plunger speed by sending the command [S12IA3000OA0R]. Repeat with decreasing plunger speed (increase "S_" value) until the pump aspirates and dispenses successfully.

9 Set start speed and top speed.

The XMP 6000 plunger speed can be controlled from 1.2 seconds per stroke to 160 minutes per stroke (top speed) using the [S] or [V] commands. (The [V] command allows a slightly larger speed range.) As a general rule, aspiration should be slow (to avoid cavitation) and dispense fast (to promote breakoff). Since cavitation and breakoff will affect both accuracy and precision, speed settings may be optimized separately for aspiration and dispense.

Using aspirate/dispense commands, set start speed [v] and top speed [V] to meet application throughput goals.

– Send the command [v50IA6000OA0R]. Repeat with increasing start speed (increase "v_" value) to find the maximum value.

–   Send the command [v*x*V*x*lA6000OA0R] to set top speed equal to start speed (*x*). Repeat with increasing top speed (increase "V_" value) to the maximum value that does not overload the plunger or cause cavitation.

Now optimize start speed and top speed for dispensing using a similar approach.

10 Set cutoff speed and slope.

Using aspirate/dispense commands, set slope [L] and cutoff speed [c] to attain reproducible breakoff. Note that cutoff speed controls only dispensing.

To optimize the slope, send the command [v*x*V*x*L14IA6000OA0R]. Repeat with modified slope ("L_" value) to achieve the overall time suited to your application without plunger overload.

To optimize the cutoff speed, start with the maximum cutoff speed allowed for your application (the lower of 2700 Hz or the top speed). Send the command [c*x*IA6000OA0R] and monitor the dispense for plunger overload or any splattering of the fluid dispensed outside of the dispense vessel. If any of these conditions occur, lower the cutoff speed until the pump can dispense the fluid with clean breakoff.

Another condition that affects breakoff is the formation of inertial air gaps. This is seen as a small air gap inside the tubing at the tip. This occurs to a greater extent on larger reagent syringes, and it enhances the breakoff of liquid from the tip of the tubing. If an inertial air gap is not desired in the application, lowering the cutoff speed and/or the top speed will remove the inertial air gap. However, this may not give a clean breakoff of the fluid.

In some instances it may not be possible to improve fluid breakoff. Clean breakoff is important to accuracy and precision; it is a concern especially when using slow speeds because drops will usually adhere to the tip.

For example, using a 2.5 mL reagent syringe (P/N 5133, dispense tubing and de-ionized water with a surfactant added):
–   [S24IA6000OA0R] - will leave a drop on the tip
–   [S24IA6000OA5S1A0R] - no drop will be left
–   [V100IA6000OA0R] - will leave a drop on the tip
–   [V100IA6000OA5V5500A0R] - no drop will be left

Increasing the cutoff speed and ramp (slope) may also improve the fluid breakoff. Smaller I.D. tubing may improve breakoff, especially for smaller syringes.

Note: It may not be possible to achieve good fluid breakoff under any circumstance, especially with syringes smaller than 500 µL or with some fluids.

4.3   Helpful Hints

To maintain pump performance, keep the following in mind when operating the XMP 6000:

◆   Wipe up all spills immediately.

- ◆ Pumping cold fluids may cause leaks, the result of differing coefficients of expansion of Teflon and glass. Leaks may occur when pumping fluids that are at or below 15°C (61°F).
- ◆ To reduce the amount of carryover, a ratio of three parts reagent to one part sample is recommended.
- ◆ Before pumping any organic solvent, please refer to Appendix D, "Multichannel Pump Chemical Resistance Chart" in this manual. Using organic solvents may reduce tubing and seal life.
- ◆ Replace the valves and syringe seals as needed. (Interval may vary depending on the application.)

5 Maintenance

Although required maintenance may vary with your application, the following procedures are recommended for optimal performance of the Cavro® XMP 6000 Multichannel Syringe Pump.

Perform maintenance tasks in these intervals:
- daily
- weekly
- periodically

5.1 Daily Maintenance

To ensure proper operation of the XMP 6000, perform these tasks daily:
- Inspect the pump(s) for leaks, and correct any problems.
- Wipe up all spills on and around the pump.
- Flush the pump(s) thoroughly with distilled or de-ionized water after each use and when the pump is not in use.

Note: Do not allow the pump(s) to run dry for more than a few cycles.

5.2 Weekly Maintenance

The fluid path of the XMP 6000 must be cleaned weekly to remove precipitates such as salts, eliminate bacterial growth, and so on. Any of the three following cleaning procedures can be used:
- Weak detergent
- Weak acid and base
- 10% bleach

The procedures using these solutions are described in the following sections.

5.2.1 Weak Detergent Cleaning

To clean the pump with weak detergent, follow these steps:

1 Prime the pump with a weak detergent solution (e.g., 2% solution of CONTRAD®, or RoboScrub) and allow the solution to remain in the pump with the syringe fully lowered for 30 minutes.

2 After the 30-minute period, remove the reagent tubing from the detergent and cycle all the fluid from the syringe and tubing into a waste container.

---

3   Prime the pump a minimum of 10 cycles with distilled or de-ionized water. Leave the fluid pathways filled for storage.

Note: CONTRAD® 100 can be purchased through Fisher Scientific. Order catalog number 04-355-27 for a 1 gallon container.

Note: RoboScrub is a phosphate-free detergent for cleaning and conditioning liquid handling systems. RoboScrub is available from Tecan (PN 70-736) in a 16 oz. container.

5.2.2   Weak Acid-Base-Sequence Cleaning

To clean the pump with weak acid and base, follow these steps:

1   Prime the pump with 0.1 N NaOH and allow the solution to remain in the pump(s) for 10 minutes with the syringes fully lowered.
2   Flush the pump with distilled or de-ionized water.
3   Prime the pump with 0.1 N HCl, and allow the solution to remain in the pump for 10 minutes with the syringes fully lowered.
4   After a 10-minute period, remove the reagent tubing from 0.1 N HCl solution and cycle all the fluid from the syringes and tubing into a waste container.
5   Prime the pump a minimum of 10 cycles with distilled or de-ionized water.

5.2.3   10% Bleach Cleaning

To clean the pump with 10% bleach, follow these steps:

1   Make a solution of 10% bleach by adding one part of commercial bleach to nine parts of water.
2   Prime the pump with the 10% bleach and allow the solution to remain in the pump with the syringes fully lowered for 30 minutes.
3   After the 30-minute period, remove the reagent tubing from 10% bleach solution and cycle all the fluid from the syringes and tubing into a waste container.
4   Prime the pump a minimum of 10 cycles with distilled or de-ionized water.

5.3   Periodic Maintenance

Tubing, syringe seals, and valves require periodic maintenance. If they become worn, you are likely to notice these symptoms:
*   Poor precision and accuracy
*   Variable or moving air gap
*   Leakage

If any of these symptoms occurs and it is not obvious which component is causing the problem, it is easiest and most economical to replace one component at a time in the following order:

1 input and output tubing

2 plunger seal

3 valve

The frequency of replacement will depend on the duty cycle, fluids used, and instrument maintenance.

5.3.1 Quality Control Assurance

Check the accuracy and precision of the XMP 6000 on a regular basis.

Tecan Systems recommends checking both accuracy and precision gravimetrically, using an analytical balance with the capability to measure to 0.1 mg. Gravimetric measurements should be corrected for the specific gravity of water at the ambient temperature.

The syringe can be checked by programming in the desired volume and determining the weight of fluid dispensed.

To determine precision and accuracy, run a minimum of 20 replicates. The Mean, Standard Deviation and Coefficient of Variation (see formula below) can then be calculated. The calculations to determine accuracy must take into account the specific gravity of water, which is dependent upon temperature. In addition, to prevent a false reading caused by fluid adhering to the tip of the aspirate tubing, a small amount of surfactant should be added to the water (e.g., Fluorad® at a 0.01% concentration).

% Coefficient of Variation = (Standard Deviation/Mean) * 100

$$\%CV = \left(\frac{\sqrt{\frac{1}{n-1}\left\{ \sum_{i=1}^{n} X_i^2 - n\,\overline{X}^2 \right\}}}{\overline{X}} \right) * 100$$

$$\% \text{ Accuracy} = \left[\frac{\left(\dfrac{\overline{X}}{sg} \right) * 100}{Vol_{\exp ected}} \right] - 100$$

where:

sg = specific gravity of $H_2 0$ @ 25°C = 0.99707

$Vol_{expected}$ = Expected volume to be dispensed

n = number of replicate

X = individual result

$\overline{X}$ = mean of all results

5.3.2 Replacing Dispense or Reagent Tubing

To replace dispense or reagent tubing, follow these steps:

1 To remove the tubing, use a 5/16" wrench and gently loosen the fittings.

2 Unscrew the fittings and remove the tubing.

3 To install new tubing, insert the fitting into the valve and tighten it finger tight.

4 Using a 5/16" wrench, turn the fitting another ¼ to ½ turn.

5.3.3 Replacing a Syringe

To replace a syringe, follow these steps:

1 Remove the liquid from the syringe.

2 Lower the plunger drive by sending the [A6000R] command.

3 Remove the plunger lock screw.

4 Unscrew the syringe from the valve.

5 Install the syringe by following these steps:

a. Slide the plunger button through the drive pin.

b. Pull the syringe barrel up and screw the syringe into the valve.

c. Fasten plunger lock screw.

6 Re-initialize the pump.

Note: Make sure the plunger lock screw is securely tightened and the plunger button is free to move on the plunger drive pin.

5.3.4 Replacing the Reagent Syringe Seals

Note: See Chapter 2, "Hardware Setup", for an illustration of the syringe components.

To replace the reagent syringe seals, follow these steps:

1 Remove the syringe from the pump.

2 Remove the plunger guide.

3 Remove the syringe plunger from the barrel.

4 Using a single edged razor or precision knife, carefully slice the old seal lengthwise and remove them from the plunger.

5 Replace the "O"-ring and wet the new "O" ring and plunger tip with distilled or deionized water.

6 Place the seal in the installation tool with the open end facing up. Press the plunger tip firmly into the hole until it snaps into position.

7 Lay the plunger on a flat table top, and position it so that the seal (from the "O"-ring up) hangs over the edge.

8 Slowly roll the plunger along the table edge pressing firmly on the portion of the seal below the "O"-ring.

Figure 5-1   *Syringe Seal Assembly*
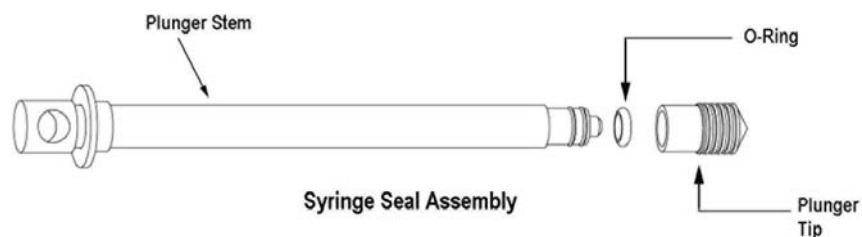
9 Rotate the plunger three complete turns. This is necessary to make the sharp raised edge of the plunger bite into the seal for a secure fit.

10 Wet the seal with distilled or deionized water, then insert the plunger/seal assembly into the glass barrel.

Note: Syringe sizes 1 mL and above have "O"-rings.

5.3.5 Replacing the XMP 6000 Solenoid Valve

To install the XMP 6000 valve, follow these steps:

1 Remove as much fluid as possible from the system by cycling the pump and using air as the system fluid.

2 Move the syringe plunger to the bottom of travel and power down the unit.

3 Remove the syringe and tubing from the valve that will be replaced.

4 Remove the valve manifold plate by loosening the socket head screws on either side of it.

5 With one hand, grasp the top and bottom of the valve and gently pull the assembly forward and remove it from the instrument.

6 With one hand, grasp the top and bottom of the *new* valve and plug it into the pump by lining up the valve with the valve mounting pins and gently pushing it into place.

7 Install the valve manifold cover and tighten the screws. Do not overtighten.

8 Install the syringe and tubing on the valve.

9 Power up the unit and initialize.

TECAN.

6   Technical Service

For information or questions regarding ordering or operating the Cavro® XMP 6000 Multichannel Syringe Pump, please contact Tecan Systems Technical Service using one of the methods listed below.

By phone   408-953-3100 or
                        800-231-0711

By fax   408-953-3101

By e-mail   helpdesk-sy@tecan.com

Technical support is available 7:00 a.m. to 5:30 p.m. PST, Monday – Friday.

Our mailing address is:

Tecan Systems, Inc.
2450 Zanker Road
San Jose, CA   95131
USA

When calling for technical service, please have the following information ready:
- Part number
- Serial number
- Model type
- Description of the problem

Note: See the following diagram for the location of the label containing part number and serial number information.

Figure 6-1   *XMP 6000 Label Location*

TECAN.
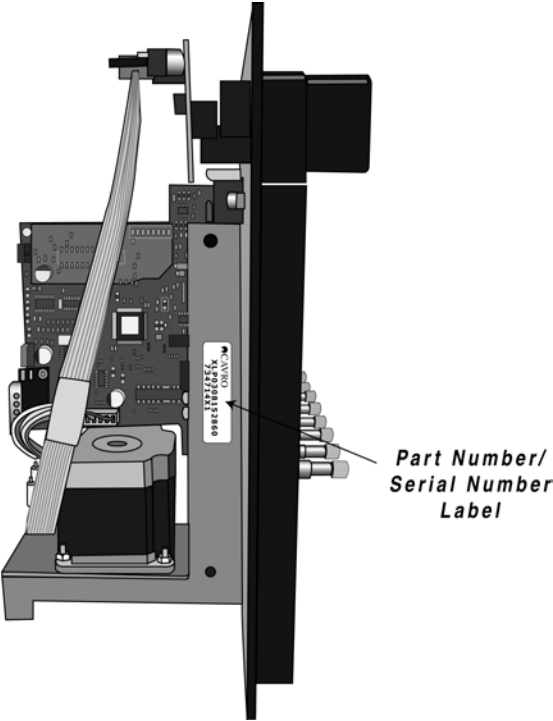
A Ordering Information

This appendix is a summary of available XMP 6000 configurations and spare parts.

A.1 Available Configurations

All configurations support RS-232, RS-485, and CAN communications.

Table A-1 *XMP 6000 Configurations*

Description	Valve Type	Part Number
XMP 6000 8-channel ¼-28 Bypass	3-way Bypass	737363
XMP 6000 8-channel M6 Bypass	3-way Bypass	737365
XMP 6000 8-channel ¼-28	3-way	737367
XMP 6000 8-channel M6	3-way	737369*
XMP 6000 6-channel ¼-28	3-way	737371*
XMP 6000 6-channel M6	3-way	737373*
XMP 6000 4-channel ¼-28	3-way	737422*
XMP 6000 4-channel M6	3-way	737424*
XMP 6000 2-channel ¼-28	3-way	737375*
XMP 6000 2-channel M6	3-way	737377*

* Part numbers followed by an asterisk (*) have been reserved pending release. Please check with your local Tecan Systems representative for availability.

A.2   XMP 6000 Spare Parts

The following spare parts are available:

- Syringes
- Seals
- Valves

- Interconnect Tubing
- Printed Circuit Boards
- Miscellaneous Parts

A.2.1   Syringes

Table A-2   *Syringes*

Part Number	Description
734802	Syringe, 100 µL
734803	Syringe, 250 µL
734804	Syringe, 500 µL
734805	Syringe, 1.0 mL
734806	Syringe, 2.5 mL
734807	Syringe, 5.0 mL

A.2.2   Seals and Seal Kits

Table A-3   *Seals*

Part Number	Description
734811	Seal, 100 µL (4/pkg)
734812	Seal, 250 µL (4/pkg)
734813	Seal, 500 µL (4/pkg)
734814	Seal, 1.0 mL (4/pkg)
734815	Seal, 2.5 mL (4/pkg)
734816	Seal, 5.0 mL (4/pkg)

A.2.3   Valves

Table A-4 *Valves*

Part Number	Description
738719	Valve, 3-way 1/4-28
738721	Valve, 3-way bypass 1/4-28
738723	Valve, 3-way M6
738725	Valve, 3-way bypass M6

* Part numbers followed by an asterisk have been reserved pending release. Please check with your local Tecan Systems representative for availability.

A.2.4   Printed Circuit Board

Table A-5 *PCB*

Part Number	Description
738727	PCB XMP 6000 main

A.2.5   Interconnect Tubing

Table A-6 *Tubing*

Part Number	Description	Material	Length (Inches)	Units	Tube Ends
1067	Reagent tube	TFE	16"	.063	1/4-28" to blunt cut
4333	Aspirate/Dispense tube	TFE	33"	.055	Necked
4410	Aspirate/Dispense tube	FEP	40"	.031	Thermal drawn
4609	Reagent tube	FEP	12"	.027	1/4-28" to blunt cut
5133	Aspirate/Dispense tube	FEP	29"	.031	Thermal drawn
5723	Aspirate/Dispense tube	FEP	33"	.031	Necked
5729	Reagent tube	TFE	21"	.031	1/4-28" to blunt cut
5402	Aspirate/Dispense coiled tube	FEP	64"	.027	Thermal drawn
6865	Interconnect tube	FEP	3"	.054	1/4-28" to 1/4-28"

Part Number	Description	Material	Length (Inches)	Units	Tube Ends
720592	Reagent tube	TFE	61.5"	.063	1/4-28" to blunt cut
720595	Aspirate/Dispense tube	FEP	61.5"	.055	Necked
720597	Aspirate/Dispense tube	FEP	60"	.031	Thermal drawn
721370	Reagent tube	TFE	27"	.055	1/4-28" to blunt cut
722540	Reagent tube	FEP	36"	.076	M6 to blunt cut
724169	Aspirate/Dispense tube	FEP	33"	.027	Thermal drawn, M6
724170	Reagent tube	TFE	27"	.051	M6 to blunt cut
724275	Aspirate/Dispense tube	FEP	22"	.051	1/4-28" to M6
724780	Aspirate/Dispense tube	FEP	39"	.076	1/4-28" to 1/4-28"
725788	Interconnect tube	FEP	8"	.051	1/4-28" to 1/4-28"
725876	Aspirate/Dispense tube	FEP	30"	.059	1/4-28" to M6
725896	Interconnect tube	TFE	20"	.060	1/4-28" to 1/4-28"
726172	Aspirate/Dispense tube	TFE	24"	.060	1/4-28" to 1/4-28"

Note: Custom tubing is available upon request.

A.2.6   Miscellaneous Parts

Table A-7   *Miscellaneous Parts*

Part Number	Description
1590	Fitting, Tube, 0.076 ID, (2/pk)
1589	Fitting, Tube, 0.138 ID, (2/pk)
724757	Wrench, 5/16" and 9/64"
737847	Manual, Operator's XMP 6000
724052	Packaging
725772	Connector, DA-15
973309	Fitting, Tube, 0.085 ID, M6
973308	Fitting, Tube, 0.100 ID, M6
973307	Fitting, Tube, 0.125 ID, M6

A.3   Mating Connector Suppliers

Tecan Systems does not sell mating connectors beyond those found on its evaluation power supply. For customer convenience, a list of DA-15 mating connectors and their suppliers is provided below.

Table A-8   *DA-15 Mating Connectors*

Manufacturer	Description	Manufacturing Part Number
Cable Connector, Receptacle		
AMP	15 pin female - solder cup, receptacle	747909-2
Cinch	15 pin female - solder cup, receptacle	DA-15S
Cable Connector, Housing		
AMP	Plastic housing with locks	207908-4
Cinch	Plastic housing with locks	SDH-15GL-CS
Circuit Board Connectors		
AMP	15 pin female - straight for .62 to .93 mm thick PCB	745411-1
Flat Ribbon		
3M	15 pin female - 15 pin flat ribbon receptacle	89815-8000
3M	15 pin female - strain relief	3448-8D15A

This page has been intentionally left blank.

B Plunger Information

B.1   Typical Plunger Force

Tecan Systems specifies that all new XMP 6000 Pumps running at a speed of 5600 pulses/sec will lift a 15-pound weight attached to the plunger drive pin. Tecan Systems cannot warrant the pump for use beyond these specifications.

B.2   Plunger Time Calculations

Following are calculations for determining XMP 6000 plunger speeds. Four different cases are presented below.

1   Start, top, and cutoff speeds are equal, or top speed is less than 50 Hz.

2   Typical move with ramp up, constant speed and ramp down.

3   Move is too small to reach cutoff speed.

4   Move is too small to reach top speed.

Note: Plunger move times have been calculated with backlash compensation set to 0. [K<0>]

B.2.1   Symbol Definitions

Table B-1   *Symbol Definitions*

Symbol	Name	Range (n)	Unit
v <n>	Start Speed	50..1000	Pulses/sec or Hz
V<n>	Top Speed	5..6000	Pulses/sec or Hz
c<n>	Cutoff Speed	50..2700	Pulses/sec or Hz
L<n>	Slope	1..20	n*2500 pulses/sec²
A	Move Distance	0..6000 0..48000	Full increments Microsteps
t_1	Ramp Up Time		Seconds
t_2	Constant Speed Time		Seconds
t_3	Ramp Down Time		Seconds

Symbol	Name	Range (n)	Unit
t	Total Move Time	$t_1+t_2+t_3$	Seconds
A_1	Ramp Up increments		Half increments
A_2	Ramp Up increments		Half increments
A_3	Ramp Up increments		Half increments

Note:

- *Cutoff speed cannot be less than start speed.*
- *During aspiration, v is used in place of c.*
- *The* XMP 6000 *uses 6000 full increments per stroke.*

B.2.2   Move Calculations

Case 1. Start, Top, and Cutoff Speeds are Equal or Top Speed is Less than 50 Hz

Case 1 is used when $v = V = c$ or $V \leq 50$

Diagram of move:
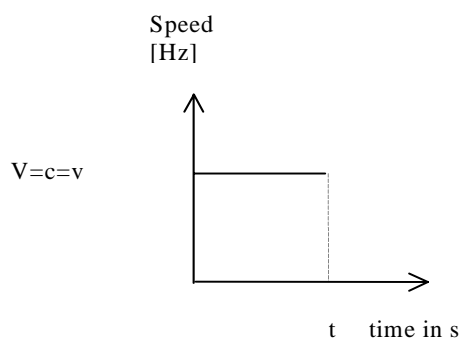
Calculation:

v = 900 Hz   L = 14

V = 900 Hz   A = 3000 full increments

c = 900 Hz

Total Move Time:

$$t = \frac{2*A}{V} = \frac{2*3000}{900} = 6.67 \text{ seconds}$$

Case 2. Ramp Up, Constant Speed, Ramp Down

Case 2 is used when $A_1 + A_3 < 2A$

Diagram of Move:
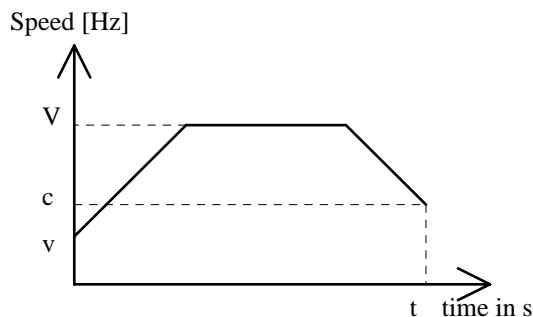
Calculation:

v = 50 Hz	L = 14
V = 5800 Hz	A = 3000 full increments
c = 500 Hz	

Ramp Up increments

$$A_1 = \frac{V^2 - v^2}{2L} = \frac{5800^2 - 50^2}{2*14*2500} = 481 \quad \text{half increments}$$

Ramp Down increments

$$A_3 = \frac{V^2 - c^2}{2L} = \frac{5800^2 - 500^2}{2*14*2500} = 477 \quad \text{half increments}$$

If $A_1 + A_3 < 2A$ (481 + 477 < 6000) then:

Ramp Up Time

$$t_1 = \frac{V - v}{L} = \frac{5800 - 50}{14*2500} = .16 \quad \text{seconds}$$

Ramp Down Time

$$t_3 = \frac{V - c}{L} = \frac{5800 - 500}{14*2500} = .15 \quad \text{seconds}$$

Constant Speed increments

$$A_2 = 2A - A_1 - A_3 = 2*3000 - 481 - 477 = 5042 \quad \text{half increments}$$

Constant Speed Time

$$t_2 = \frac{A_2}{V} = \frac{5042}{5800} = .87 \quad \text{seconds}$$

Total Move Time

$$t = t_1 + t_2 + t_3 = .16 + .87 + .15 = 1.18 \quad \text{seconds}$$

Case 3. Move Too Small to Reach Cutoff Speed

Case 3 is used when Vn < c

Diagram of Move:
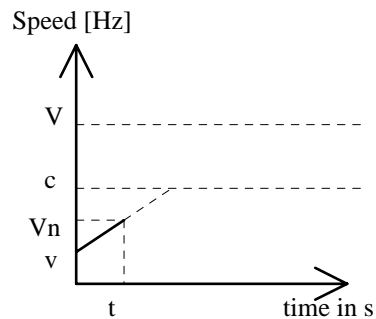
Calculation:

v = 50 Hz	L = 14
V = 5800 Hz	A = 5 full increments
c = 900 Hz	

Theoretical Top speed

$$Vn = \sqrt{4AL + v^2} = \sqrt{4*5*14*2500 + 50^2} = 838 \quad \text{Hz}$$

If $Vn < c$ then:

Total Move Time

$$t = \frac{Vn - v}{L} = \frac{838 - 50}{14 * 2500} = .023 \text{ seconds}$$

Ramp Up increments

$$A_1 = A = 5 \text{ full increments}$$

Case 4. Move Too Small to Reach Top Speed

Case 4 is used when Vn < V and Vn > c

Diagram of Move:
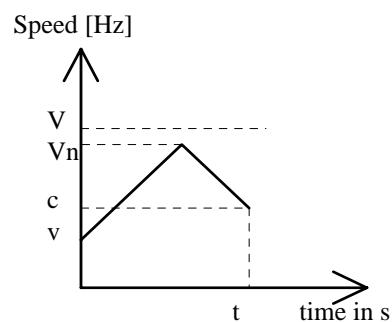
Calculation:

v = 50 Hz	L = 14
V = 5800 Hz	A = 350 full increments
c = 900 Hz	

Top speeds

$$Vn = \sqrt{2AL + \frac{v^2 + c^2}{2}} = \sqrt{2 * 350 * 14 * 2500 + \frac{50^2 + 900^2}{2}} = 4991 \text{ Hz}$$

Total Move Time

$$t = \frac{1}{L}(2Vn - v - c) = \frac{1}{L}(2 * 4991 - 50 - 900) = .26 \text{ Hz}$$

This page has been intentionally left blank.

C   ASCII Chart of Codes for U.S. Characters

Table C-1   *ASCII Chart of Codes for U.S. Characters*

Decimal	Hexadecimal	Character or Function	Decimal	Hexadecimal	Character or Function
0	00	none	65	41	A
1	01	SOH	66	42	B
2	02	STX	67	43	C
3	03	ETX	68	44	D
4	04	EOT	69	45	E
5	05	ENQ	70	46	F
6	06	ACK	71	47	G
7	07	BEL	72	48	H
8	08	BS	73	49	I
9	09	HT	74	4A	J
10	0A	LF	75	4B	K
11	0B	VT	76	4C	L
12	0C	FF	77	4D	M
13	0D	CR	78	4E	N
14	0E	SO	79	4F	O
15	0F	SI	80	50	P
16	10	DLE	81	51	Q
17	11	DC1	82	52	R
18	12	DC2	83	53	S
19	13	DC3	84	54	T
20	14	DC4	85	55	U
21	15	NAK	86	56	V
22	16	SYN	87	57	W
23	17	ETB	88	58	X
24	18	CAN	89	59	Y

Decimal	Hexadecimal	Character or Function	Decimal	Hexadecimal	Character or Function
25	19	EM	90	5A	Z
26	1A	SUB	91	5B	[
27	1B	ESC	92	5C	\ (backslash)
28	1C	FS	93	5D	]
29	1D	GS	94	5E	^ (control)
30	1E	RS	95	5F	— (emdash)
31	1F	US	96	60	` (tick)
32	20	SP	97	61	a
33	21	!	98	62	b
34	22	"	99	63	c
35	23	#	100	64	d
36	24	$	101	65	e
37	25	%	102	66	f
38	26	&	103	67	g
39	27	' (apostrophe)	104	68	h
40	28	(	105	69	i
41	29	)	106	6A	j
42	2A	*	107	6B	k
43	2B	+	108	6C	l
44	2C	, (comma)	109	6D	m
45	2D	- (en dash)	110	6E	n
46	2E	. (period)	111	6F	o
47	2F	/	112	70	p
48	30	0	113	71	q
49	31	1	114	72	r
50	32	2	115	73	s
51	33	3	116	74	t
52	34	4	117	75	u

Decimal	Hexadecimal	Character or Function	Decimal	Hexadecimal	Character or Function
53	35	5	118	76	v
54	36	6	119	77	w
55	37	7	120	78	x
56	38	8	121	79	y
57	39	9	122	7A	z
58	3A	:	123	7B	{ (left brace)
59	3B	;	124	7C	| (vertical bar)
60	3C	<	125	7D	} (right brace)
61	3D	=	126	7E	~ (tilde)
62	3E	>	127	7F	DEL
63	3F	?			
64	40	@			

This page has been intentionally left blank.

D   Multichannel Pump Chemical Resistance Chart

The information provided in the table that starts on the next page has been supplied to Tecan Systems by other reputable sources and is to be used ONLY as a guideline. Before permanent installation, test the equipment with the chemicals under the specific conditions of your application.

Ratings of chemical behavior listed in this chart apply to a 48-hour exposure period; Tecan Systems has no knowledge of possible effects beyond this period. Tecan Systems does not warrant (neither express or implied) that the information in this chart is accurate or complete or that materials are suitable for any purpose.

Caution! Failure to test chemicals used in individual applications with the XMP 6000 may result in damage to the pump and/or test results.

*DANGER! Variations in chemical behavior during handling due to factors such as temperature, pressure and concentration can cause equipment to fail, even though it passed an initial test. **SERIOUS INJURY MAY RESULT**. Use suitable guards and/or personal protection when handling chemicals.*

The materials listed in this section are used in the following areas of the XMP 6000:

***Table D-1**   Plastic Materials Used in the XMP 6000 Pump*

Teflon® (PTFE)	Tubing, syringe seals
Kalrez®	Valve diaphragm
PEEK™	Valve body

Ratings – Chemical Effect

A = Excellent

B = Good – Minor Effect, slight corrosion or discoloration

C = Fair – Moderate Effect, not recommended for continuous use. Softening, loss of strength, swelling may occur.

D = Severe Effect, not recommended for **ANY** use.

N/A = Information Not Available

Explanation of Footnotes

1. Satisfactory to 72°F (22°C)

2. Satisfactory to 120°F (48°C)

Table D-2   *XMP 6000 Multichannel Pump Chemical Compatibility Results*

Chemical	Kalrez	PEEK	Teflon
Acetaldehyde	C-Poor	A- Excellent	A- Excellent
Acetamide	N/A	A1- Excellent	A- Excellent
Acetate Solvent	N/A	N/A	A- Excellent
Acetic Acid	A-Excellent	A- Excellent	A- Excellent
Acetic Acid 20%	A-Excellent	A- Excellent	A- Excellent
Acetic Acid 80%	A-Excellent	A- Excellent	A- Excellent
Acetic Acid, Glacial	A-Excellent	A- Excellent	A- Excellent
Acetic Anhydride	A-Excellent	N/A	A- Excellent
Acetone	A-Excellent	A- Excellent	A- Excellent
Acetyl Bromide	N/A	N/A	A- Excellent
Acetyl Chloride (dry)	N/A	N/A	A- Excellent
Acetylene	C-Poor	A- Excellent	A- Excellent
Acrylonitrile	A-Excellent	A1- Excellent	A- Excellent
Adipic Acid	N/A	N/A	A- Excellent
Alcohols:Amyl	A-Excellent	A1- Excellent	A- Excellent
Alcohols:Benzyl	N/A	A1- Excellent	A- Excellent
Alcohols:Butyl	A-Excellent	A1- Excellent	A- Excellent
Alcohols:Diacetone	N/A	A1- Excellent	A- Excellent
Alcohols:Ethyl	A-Excellent	A1- Excellent	A- Excellent
Alcohols:Hexyl	A-Excellent	A1- Excellent	A- Excellent
Alcohols:Isobutyl	A-Excellent	A1- Excellent	A2- Excellent
Alcohols:Isopropyl	A-Excellent	A1- Excellent	A2- Excellent
Alcohols:Methyl	A-Excellent	A1- Excellent	A- Excellent
Alcohols:Octyl	N/A	N/A	N/A
Alcohols:Propyl	N/A	A1- Excellent	A- Excellent
Aluminum Chloride	A-Excellent	A- Excellent	A- Excellent
Aluminum Chloride 20%	A-Excellent	A- Excellent	A- Excellent
Aluminum Fluoride	N/A	N/A	A- Excellent

Chemical	Kalrez	PEEK	Teflon
Aluminum Hydroxide	N/A	N/A	A- Excellent
Aluminum Nitrate	N/A	N/A	A- Excellent
Aluminum Potassium Sulfate 10%	N/A	A- Excellent	A- Excellent
Aluminum Potassium Sulfate 100%	N/A	A- Excellent	A- Excellent
Aluminum Sulfate	A-Excellent	A- Excellent	A- Excellent
Alums	N/A	A- Excellent	A- Excellent
Amines	N/A	A1- Excellent	A2- Excellent
Ammonia 10%	A-Excellent	A- Excellent	A- Excellent
Ammonia Nitrate	A-Excellent	N/A	A- Excellent
Ammonia, anhydrous	A-Excellent	A- Excellent	A- Excellent
Ammonia, liquid	A-Excellent	B- Good	A- Excellent
Ammonium Acetate	N/A	N/A	A- Excellent
Ammonium Bifluoride	N/A	N/A	A- Excellent
Ammonium Carbonate	A-Excellent	A1- Excellent	A- Excellent
Ammonium Caseinate	N/A	N/A	N/A
Ammonium Chloride	N/A	A- Excellent	A- Excellent
Ammonium Hydroxide	A-Excellent	A1- Excellent	A- Excellent
Ammonium Nitrate	A-Excellent	A- Excellent	A- Excellent
Ammonium Oxalate	N/A	N/A	N/A
Ammonium Persulfate	N/A	N/A	A- Excellent
Ammonium Phosphate, Dibasic	A-Excellent	N/A	A2- Excellent
Ammonium Phosphate, Monobasic	A-Excellent	N/A	A- Excellent
Ammonium Phosphate, Tribasic	A-Excellent	N/A	A- Excellent
Ammonium Sulfate	A-Excellent	N/A	A- Excellent
Ammonium Sulfite	N/A	N/A	A2- Excellent
Ammonium Thiosulfate	N/A	N/A	N/A
Amyl Acetate	A-Excellent	A- Excellent	A- Excellent
Amyl Alcohol	A-Excellent	A1- Excellent	A- Excellent
Amyl Chloride	N/A	N/A	A- Excellent

Chemical	Kalrez	PEEK	Teflon
Aniline	A-Excellent	B- Good	A- Excellent
Aniline Hydrochloride	N/A	N/A	A- Excellent
Antifreeze	N/A	A- Excellent	N/A
Antimony Trichloride	N/A	A- Excellent	A- Excellent
Aqua Regia (80% HCl, 20% HNO3)	N/A	D- Severe Effect	A- Excellent
Arochlor 1248	N/A	A1- Excellent	A- Excellent
Aromatic Hydrocarbons	A-Excellent	A- Excellent	N/A
Barium Carbonate	N/A	N/A	A- Excellent
Barium Chloride	N/A	A1- Excellent	A- Excellent
Barium Cyanide	N/A	N/A	A1- Excellent
Barium Hydroxide	N/A	N/A	A- Excellent
Barium Nitrate	N/A	N/A	A- Excellent
Barium Sulfate	N/A	B- Good	A- Excellent
Barium Sulfide	N/A	A1- Excellent	A- Excellent
Beer	A-Excellent	A- Excellent	A- Excellent
Benzaldehyde	N/A	A1- Excellent	A1- Excellent
Benzene	A-Excellent	A- Excellent	A- Excellent
Benzene Sulfonic Acid	N/A	C- Fair	A- Excellent
Benzoic Acid	C-Poor	A- Excellent	A2- Excellent
Benzol	N/A	N/A	A- Excellent
Benzonitrile	N/A	N/A	A2- Excellent
Benzyl Chloride	N/A	N/A	N/A
Bleaching Liquors	A-Excellent	N/A	A- Excellent
Borax (Sodium Borate)	A-Excellent	A1- Excellent	A- Excellent
Boric Acid	A-Excellent	A- Excellent	A- Excellent
Bromine	A-Excellent	C- Fair	A- Excellent
Butadiene	A-Excellent	N/A	A2- Excellent
Butane	A-Excellent	A1- Excellent	A- Excellent
Butanol (Butyl Alcohol)	A-Excellent	A1- Excellent	A2- Excellent

Chemical	Kalrez	PEEK	Teflon
Butter	N/A	N/A	A- Excellent
Buttermilk	N/A	N/A	A- Excellent
Butyl Amine	N/A	A1- Excellent	A2- Excellent
Butyl Ether	N/A	N/A	A1- Excellent
Butyl Phthalate	N/A	A1- Excellent	A2- Excellent
Butylacetate	N/A	A1- Excellent	A- Excellent
Butylene	N/A	A1- Excellent	A- Excellent
Butyric Acid	N/A	A- Excellent	A- Excellent
Calcium Carbonate	A-Excellent	A1- Excellent	A- Excellent
Calcium Chlorate	N/A	N/A	A- Excellent
Calcium Chloride	A-Excellent	A- Excellent	A- Excellent
Calcium Hydroxide	A-Excellent	A- Excellent	A- Excellent
Calcium Hypochlorite	A-Excellent	A- Excellent	A- Excellent
Calcium Nitrate	N/A	A1- Excellent	A2- Excellent
Calcium Oxide	N/A	A- Excellent	A- Excellent
Calcium Sulfate	N/A	A- Excellent	A- Excellent
Carbolic Acid (Phenol)	N/A	D- Severe Effect	A- Excellent
Carbon Bisulfide	N/A	D- Severe Effect	N/A
Carbon Dioxide (dry)	N/A	A- Excellent	A- Excellent
Carbon Dioxide (wet)	N/A	A- Excellent	A- Excellent
Carbon Disulfide	A-Excellent	C- Fair	A- Excellent
Carbon Monoxide	A-Excellent	B- Good	A- Excellent
Carbon Tetrachloride	A-Excellent	A- Excellent	A- Excellent
Carbonic Acid	A-Excellent	A- Excellent	A- Excellent
Chloric Acid	N/A	N/A	A- Excellent
Chlorine (dry)	A-Excellent	A1- Excellent	A- Excellent
Chlorine Water	A-Excellent	A- Excellent	A- Excellent
Chlorine, Anhydrous Liquid	N/A	D- Severe Effect	A- Excellent
Chloroacetic Acid	N/A	A- Excellent	A- Excellent

Chemical	Kalrez	PEEK	Teflon
Chlorobenzene (Mono)	N/A	A- Excellent	B- Good
Chlorobromomethane	N/A	A- Excellent	A- Excellent
Chloroform	A-Excellent	A- Excellent	A1- Excellent
Chlorosulfonic Acid	A-Excellent	A- Excellent	A- Excellent
Chromic Acid 10%	A-Excellent	A- Excellent	A- Excellent
Chromic Acid 30%	A-Excellent	A1- Excellent	A- Excellent
Chromic Acid 5%	A-Excellent	A- Excellent	A- Excellent
Chromic Acid 50%	B-Fair	A1- Excellent	A- Excellent
Citric Acid	A-Excellent	A- Excellent	A- Excellent
Citric Oils	N/A	N/A	N/A
CloroxÆ (Bleach)	N/A	A- Excellent	A- Excellent
Cresylic Acid	A-Excellent	A1- Excellent	A- Excellent
Cyclohexane	N/A	A- Excellent	A- Excellent
Cyclohexanone	N/A	A1- Excellent	A- Excellent
Detergents	N/A	A- Excellent	A- Excellent
Diacetone Alcohol	N/A	N/A	A- Excellent
Dichlorobenzene	N/A	A1- Excellent	A- Excellent
Dichloroethane	N/A	A1- Excellent	A1- Excellent
Diesel Fuel	A-Excellent	A1- Excellent	A- Excellent
Diethyl Ether	N/A	A- Excellent	A- Excellent
Diethylamine	N/A	A1- Excellent	D- Severe Effect
Diethylene Glycol	A-Excellent	A1- Excellent	A2- Excellent
Dimethyl Aniline	N/A	A1- Excellent	A- Excellent
Dimethyl Formamide	N/A	A1- Excellent	A- Excellent
Diphenyl	A-Excellent	N/A	A- Excellent
Diphenyl Oxide	N/A	N/A	A1- Excellent
Ethane	A-Excellent	B- Good	A- Excellent
Ethanol	A-Excellent	A- Excellent	A- Excellent
Ethanolamine	N/A	N/A	A1- Excellent

Chemical	Kalrez	PEEK	Teflon
Ether	N/A	A- Excellent	A- Excellent
Ethyl Acetate	C-Poor	A1- Excellent	A- Excellent
Ethyl Benzoate	A-Excellent	N/A	A- Excellent
Ethyl Chloride	A-Excellent	A1- Excellent	A- Excellent
Ethyl Ether	A-Excellent	N/A	A- Excellent
Ethyl Sulfate	N/A	N/A	A- Excellent
Ethylene Bromide	N/A	N/A	A- Excellent
Ethylene Chloride	N/A	A1- Excellent	A- Excellent
Ethylene Chlorohydrin	N/A	A1- Excellent	A- Excellent
Ethylene Diamine	N/A	A1- Excellent	A- Excellent
Ethylene Dichloride	A-Excellent	A1- Excellent	A- Excellent
Ethylene Glycol	A-Excellent	A- Excellent	A- Excellent
Ethylene Oxide	A-Excellent	A1- Excellent	A- Excellent
Fluorine	N/A	D- Severe Effect	D- Severe Effect
Formaldehyde 100%	A-Excellent	A- Excellent	A- Excellent
Formaldehyde 40%	A-Excellent	A- Excellent	A- Excellent
Formic Acid	N/A	C- Fair	A- Excellent
Freon 113	A-Excellent	A1- Excellent	A- Excellent
Freon 12	A-Excellent	A1- Excellent	A- Excellent
Freon 22	A-Excellent	A1- Excellent	A- Excellent
Freon TF	D- Severe Effect	A1- Excellent	A- Excellent
FreonÆ 11	A-Excellent	A1- Excellent	A- Excellent
Fuel Oils	A-Excellent	A1- Excellent	B- Good
Furfural	A-Excellent	N/A	A- Excellent
Gallic Acid	N/A	N/A	B- Good
Gasoline (high-aromatic)	A-Excellent	A1- Excellent	B- Good
Gelatin	A-Excellent	A- Excellent	A- Excellent
Glucose	A-Excellent	N/A	A- Excellent
Glycerin	A-Excellent	A1- Excellent	A- Excellent

Chemical	Kalrez	PEEK	Teflon
Glycolic Acid	A-Excellent	N/A	A- Excellent
Grease	N/A	N/A	A- Excellent
Heptane	A-Excellent	A1- Excellent	A- Excellent
Hexane	A-Excellent	A1- Excellent	A- Excellent
Hydraulic Oil (Petro)	N/A	A- Excellent	A- Excellent
Hydraulic Oil (Synthetic)	N/A	A- Excellent	A- Excellent
Hydrazine	A-Excellent	A- Excellent	A- Excellent
Hydrobromic Acid 100%	C-Poor	D- Severe Effect	A- Excellent
Hydrobromic Acid 20%	B-Fair	D- Severe Effect	N/A
Hydrochloric Acid 100%	A-Excellent	A- Excellent	A- Excellent
Hydrochloric Acid 20%	A-Excellent	A- Excellent	A- Excellent
Hydrochloric Acid 37%	A-Excellent	A- Excellent	A- Excellent
Hydrochloric Acid, Dry Gas	A-Excellent	A- Excellent	A- Excellent
Hydrocyanic Acid	N/A	A- Excellent	A- Excellent
Hydrocyanic Acid (Gas 10%)	N/A	A- Excellent	A- Excellent
Hydrofluoric Acid 100%	A-Excellent	D- Severe Effect	A- Excellent
Hydrofluoric Acid 20%	A-Excellent	D- Severe Effect	A- Excellent
Hydrofluoric Acid 50%	A-Excellent	D- Severe Effect	A- Excellent
Hydrofluoric Acid 75%	A-Excellent	D- Severe Effect	A- Excellent
Hydrogen Gas	N/A	N/A	A- Excellent
Hydrogen Peroxide 10%	A-Excellent	A- Excellent	A- Excellent
Hydrogen Peroxide 100%	A-Excellent	A- Excellent	A- Excellent
Hydrogen Peroxide 30%	A-Excellent	A- Excellent	A- Excellent
Hydrogen Peroxide 50%	A-Excellent	A- Excellent	A- Excellent
Hydroquinone	N/A	N/A	A- Excellent
Hydroxyacetic Acid 70%	N/A	N/A	A- Excellent
Iodine	A-Excellent	C- Fair	A- Excellent
Iodine (in alcohol)	A-Excellent	A1- Excellent	N/A
Isooctane	C-Poor	A1- Excellent	A- Excellent

TECAN.

Chemical	Kalrez	PEEK	Teflon
Isopropyl Acetate	A-Excellent	N/A	A- Excellent
Isopropyl Ether	A-Excellent	A1- Excellent	A1- Excellent
Jet Fuel (JP3, JP4, JP5)	A-Excellent	A1- Excellent	A- Excellent
Kerosene	A-Excellent	A1- Excellent	A- Excellent
Ketones	N/A	A- Excellent	A- Excellent
Lacquer Thinners	A-Excellent	N/A	A- Excellent
Ligroin	N/A	A- Excellent	A- Excellent
Lime	N/A	A- Excellent	A1- Excellent
Linoleic Acid	N/A	N/A	A- Excellent
Lubricants	N/A	A1- Excellent	A- Excellent
Lye: Ca(OH)2 Calcium Hydroxide	A-Excellent	B- Good	A- Excellent
Maleic Acid	A-Excellent	A- Excellent	A- Excellent
Mercuric Chloride (dilute)	A-Excellent	A- Excellent	A- Excellent
Mercuric Cyanide	N/A	N/A	B- Good
Mercurous Nitrate	N/A	N/A	A- Excellent
Mercury	A-Excellent	A- Excellent	A- Excellent
Methane	A-Excellent	A- Excellent	A- Excellent
Methanol (Methyl Alcohol)	A-Excellent	A- Excellent	A- Excellent
Methyl Acetate	A-Excellent	A1- Excellent	A- Excellent
Methyl Acetone	N/A	N/A	A- Excellent
Methyl Acrylate	A-Excellent	N/A	N/A
Methyl Alcohol 10%	A-Excellent	A- Excellent	A- Excellent
Methyl Bromide	A-Excellent	N/A	A- Excellent
Methyl Butyl Ketone	A-Excellent	A1- Excellent	N/A
Methyl Cellosolve	A-Excellent	N/A	A- Excellent
Methyl Chloride	A-Excellent	N/A	A- Excellent
Methyl Ethyl Ketone	A-Excellent	A- Excellent	A- Excellent
Methyl Isobutyl Ketone	A-Excellent	A1- Excellent	A- Excellent
Methyl Methacrylate	N/A	N/A	N/A

Chemical	Kalrez	PEEK	Teflon
Methylene Chloride	A-Excellent	A1- Excellent	A- Excellent
Mineral Spirits	N/A	N/A	A- Excellent
Motor oil	N/A	A- Excellent	A- Excellent
Naphtha	A-Excellent	N/A	B- Good
Naphthalene	A-Excellent	A- Excellent	A- Excellent
Natural Gas	A-Excellent	N/A	A- Excellent
Nitric Acid (20%)	A-Excellent	C- Fair	A- Excellent
Nitric Acid (50%)	A-Excellent	D- Severe Effect	A- Excellent
Nitric Acid (5-10%)	A-Excellent	C- Fair	A- Excellent
Nitric Acid (Concentrated)	A-Excellent	D- Severe Effect	A- Excellent
Nitrobenzene	A-Excellent	A1- Excellent	A- Excellent
Nitromethane	A-Excellent	A1- Excellent	A- Excellent
Oils:Diesel Fuel (20, 30, 40, 50)	A-Excellent	A1- Excellent	A- Excellent
Oils:Fuel (1, 2, 3, 5A, 5B, 6)	N/A	A1- Excellent	A- Excellent
Oleic Acid	A-Excellent	A- Excellent	A- Excellent
Oleum 100%	A-Excellent	D- Severe Effect	A- Excellent
Oleum 25%	A-Excellent	C- Fair	A- Excellent
Oxalic Acid (cold)	A-Excellent	A- Excellent	A1- Excellent
Pentane	N/A	A1- Excellent	A- Excellent
Perchloric Acid	N/A	A- Excellent	A- Excellent
Perchloroethylene	N/A	A- Excellent	A- Excellent
Petroleum	N/A	A- Excellent	A2- Excellent
Phenol (10%)	A-Excellent	C- Fair	A- Excellent
Phenol (Carbolic Acid)	A-Excellent	D- Severe Effect	A- Excellent
Phosphoric Acid (>40%)	A-Excellent	A- Excellent	A- Excellent
Phosphoric Acid (40%)	A-Excellent	A- Excellent	A- Excellent
Phosphoric Acid (crude)	A-Excellent	A- Excellent	A- Excellent
Phosphoric Acid (molten)	A-Excellent	A- Excellent	N/A
Phosphoric Acid Anhydride	A-Excellent	A- Excellent	N/A

Chemical	Kalrez	PEEK	Teflon
Picric Acid	N/A	A- Excellent	A- Excellent
Potassium Bicarbonate	N/A	A1- Excellent	A- Excellent
Potassium Bromide	N/A	A- Excellent	A- Excellent
Potassium Chlorate	N/A	A- Excellent	A- Excellent
Potassium Chloride	N/A	A- Excellent	A- Excellent
Potassium Nitrate	A-Excellent	N/A	A- Excellent
Propylene	A-Excellent	N/A	A2- Excellent
Propylene Glycol	N/A	N/A	A- Excellent
Resorcinal	N/A	A- Excellent	A2- Excellent
Salicylic Acid	N/A	N/A	A2- Excellent
Salt Brine (NaCl saturated)	A-Excellent	A- Excellent	A2- Excellent
Sea Water	A-Excellent	A- Excellent	A- Excellent
Silver Nitrate	A-Excellent	A- Excellent	A- Excellent
Sodium Acetate	N/A	A1- Excellent	A- Excellent
Sodium Benzoate	N/A	A1- Excellent	A2- Excellent
Sodium Bicarbonate	A-Excellent	A1- Excellent	A- Excellent
Sodium Borate (Borax)	N/A	A1- Excellent	A- Excellent
Sodium Bromide	N/A	A1- Excellent	A2- Excellent
Sodium Carbonate	A-Excellent	A- Excellent	A- Excellent
Sodium Chlorate	N/A	A- Excellent	A- Excellent
Sodium Chloride	A-Excellent	A- Excellent	A- Excellent
Sodium Hydroxide (20%)	A-Excellent	A- Excellent	A- Excellent
Sodium Hydroxide (50%)	A-Excellent	A- Excellent	A- Excellent
Sodium Hydroxide (80%)	A-Excellent	A- Excellent	A1- Excellent
Sodium Hypochlorite (<20%)	N/A	A1- Excellent	A- Excellent
Sodium Hypochlorite (100%)	N/A	B- Good	A- Excellent
Sodium Nitrate	N/A	A- Excellent	A- Excellent
Sodium Perborate	N/A	A1- Excellent	A- Excellent
Sodium Peroxide	N/A	A- Excellent	A- Excellent

Chemical	Kalrez	PEEK	Teflon
Stearic Acid	A-Excellent	A1- Excellent	A- Excellent
Stoddard Solvent	A-Excellent	A1- Excellent	A- Excellent
Styrene	A-Excellent	A1- Excellent	A- Excellent
Sulfur Chloride	A-Excellent	A- Excellent	A- Excellent
Sulfur Dioxide	A-Excellent	A- Excellent	A- Excellent
Sulfur Dioxide (dry)	A-Excellent	A- Excellent	A- Excellent
Sulfur Hexafluoride	N/A	A1- Excellent	N/A
Sulfur Trioxide	A-Excellent	A- Excellent	A- Excellent
Sulfuric Acid (<10%)	A-Excellent	A- Excellent	A- Excellent
Sulfuric Acid (10-75%)	A-Excellent	B- Good	A- Excellent
Sulfuric Acid (75-100%)	A-Excellent	C- Fair	A- Excellent
Sulfuric Acid (cold concentrated)	A-Excellent	C- Fair	A- Excellent
Sulfuric Acid (hot concentrated)	N/A	D- Severe Effect	A- Excellent
Sulfurous Acid	A-Excellent	A- Excellent	A- Excellent
Tallow	N/A	A- Excellent	A- Excellent
Tannic Acid	A-Excellent	A- Excellent	A- Excellent
Tartaric Acid	A-Excellent	A- Excellent	A- Excellent
Tetrahydrofuran	A-Excellent	A1- Excellent	A- Excellent
Toluene (Toluol)	A-Excellent	A1- Excellent	A- Excellent
Trichloroacetic Acid	N/A	N/A	A- Excellent
Triethylamine	N/A	N/A	A- Excellent
Turpentine	A-Excellent	A1- Excellent	A- Excellent
Uric Acid	N/A	N/A	A- Excellent
Vinegar	A-Excellent	A- Excellent	A- Excellent
Water, Deionized	A-Excellent	A- Excellent	A2- Excellent
Water, Distilled	A-Excellent	A- Excellent	A- Excellent
Water, Fresh	A-Excellent	A- Excellent	A- Excellent
Water, Salt	A-Excellent	A- Excellent	A- Excellent
Xylene	A-Excellent	A1- Excellent	A- Excellent

TECAN.

E   XMP 6000 Physical Specifications

Table E-1   *XMP 6000 Physical Specifications*

Note: Specifications listed here are subject to change without notice.

Dimensions	No. Channels	2	4	6	8
	Height	10.00 in. (254 mm)	10.00 in. (254 mm)	10.00 in. (254 mm)	10.00 in. (254 mm)
	Width	2.56 in (65 mm)	5.12 in (130 mm)	6.48 in (163 mm)	7.72 in (196 mm)
	Depth	6.01 in (152.7 mm)	6.01 in (152.7 mm)	6.01 in (152.7 mm)	6.01 in (152.7 mm)
Resolution		6,000 steps in standard mode and 48,000 steps in fine-positioning and microstep mode			
Plunger Drive	Principle	Stepper motor driven lead screw with quadrature encoder for step loss detection and home flag			
	Travel	60 mm			
	Plunger Speed	5 - 6000 pulses per second			
Syringes	Sizes	100 μL, 250 μL, 500 μL, 1.0 mL, 2.5 mL, and 5.0 mL			
	Barrel Material	Borosilicate glass			
	Plunger Material	Stainless steel			
	Seal Material	Virgin Teflon (PTFE, TFE)			
	Precision	≤0.05% CV at full stroke (250 μL syringe and above) ≤0.1% CV at full stroke (50 μL and 100 μL syringe)			
	Accuracy	<1% at full stroke			
Valve Drive	Switch time	≤250 ms			
	Drive	Independently operated solenoid			
Valves	Diaphragm Material	Kalrez			
	Body Material	PEEK			
	Fittings	1/4-28" or M6 tubing fittings			
		1/4-28" syringe fitting			
	Valve Positions	3-way, 3-way with bypass option			

Power Requirements	Voltage	24V DC $\pm$ 2%
	Current	2.0 A (peak) for standard configurations 2.25 A (peak) for bypass configurations
Interface	Type	RS-232, RS-485 or CAN
	Baud Rate	9600 or 38400 (RS-232 and RS-485) 100K, 125K, 250K, 500K, and 1M (CAN)
	Format	Data bits: 8
		Parity: No
		Stop bit: 1
		Half duplex
Communications	Addressing	Up to 15 individual addresses available
	Communica-tions	Data terminal and OEM protocol (with error recognition)
Firmware		Programmable ramps
		Programmable plunger speeds
		Programmable backlash compensation
		Programmable delays and loops
		Change speed on the fly
		Terminate moves
		Diagnostics
		Absolute or relative positions
		Programmable non-volatile memory
Inputs		Two TTL level inputs with 4.7k pull-ups
Outputs		Three outputs, CMOS (HC) level

Environmental	Operating temperature (mechanism)	59°F (15°C) to 104°F (40°C)
	Operating humidity (mechanism)	20-80% RH at 104°F (40°C)
	Storage temperature	-4°F (20°C) to 149°F (65°C)
Safety and Regulatory Compliance		The XMP 6000 uses only UL recognized electronic components and bears the UL Recognized component mark: Tecan Systems' UL customer file number is E164638. Tecan Systems operates a manufacturing facility with an ISO 13485 and QSR compliant quality system certified by Underwriters' Laboratories, Inc.

This page intentionally left blank.

F CAN Communication Commands

Command Type	Command	Valid/Invalid	CAN Equivalent
Initialization	Z, Y	Valid	None
Initialization	z	Valid	None
Plunger Movement	A, a, P, p, D, d	Valid	None
Valve	I, O, B, E	Valid	None
Set	S, V, v, c, L, K, k, x	Valid	None
Microstep Mode	N	Valid	None
Control	G, g, M, H	Valid	None
Control	X	Valid	Frame type = 2 Command = "3" (ASCII)
Control	R	Valid	Frame type = 2 Command = "1" (ASCII)
Control	T	Valid	Frame type = 2 Command = "4" (ASCII)
Control	Reset	Invalid	Frame type = 2 Command = "0" (ASCII)
Control	Clear loaded command	Invalid	Frame type = 2 Command = "2" (ASCII)
Control	J, s, e, U	Valid	None
Report	?0 through ?29	Invalid	Frame type = 6 Command = "0" through "29" (ASCII)
Report	F	Invalid	Frame type = 6 Command = "10" (ASCII)
Report	&	Invalid	Frame type = 6 Command = "23" (ASCII)
Report	Q	Invalid	Frame type = 6 Command = "29" (ASCII)
Report	#	Invalid	Frame type = 6 Command = "20" (ASCII)
Report	%	Invalid	Frame type = 6 Command = "18" (ASCII)
Report	*	Invalid	None

This page intentionally left blank.

G Command Quick Reference

G.1   Pump Configuration Commands

Command	Values of <n>	Description
N	0 = fine positioning mode off 1 = fine positioning mode on 2 = microstep mode on	Enables or disables microstepping or fine positioning mode.
U	16 = XMP 2 Channel 17 = XMP 2 Channel Bypass 18 = XMP 4 Channel 19 = XMP 4 Channel Bypass 20 = XMP 6 Channel 21 = XMP 6 Channel Bypass 22 = XMP 8 Channel 23 = XMP 8 Channel Bypass 30 = Set Non-Volatile Memory Auto Mode 31 = Clear Non-Volatile Memory Mode 41 = Set RS baud rate to 9600 47 = Set RS baud rate to 38400 51 = Set CAN baud rate to 100K 52 = Set CAN baud rate to 250K 53 = Set CAN baud rate to 500K 54 = Set CAN baud rate to 1M 57 = Set CAN baud rate to 125K	Writes configuration information to non-volatile memory.
!		Sets device to a new configuration after U command has been issued
K	0..62 in full step mode (default 48) 0..496 in fine positioning mode (default 384)	Sets number of backlash increments.

G.2 Initialization Commands

Command	Values of <n>	Description
Z	<n> 0 = initializes at default speed 10 – 40 = initializes at the defined speed	Sets valves to the left or input position and initializes the plunger drive
Y	<n> 0 = initializes at default speed 10 – 40 = initializes at the defined speed	Sets valves to the right or output position and initializes the plunger drive
z		Simulates initialization and sets the current position of the plunger as the home position.
k	0..255 in standard mode (108 default) 0..2040 in fine positioning or microstep mode (864 default)	Set zero gap (increments).
x	25..100	Initialization force as a percentage of the plunger drive maximum force

G.3 Valve Commands

Command	Description
I	Switch valves to input position
O	Switch valves to output position
B	Switch valves to bypass position (Bypass configuration only)
E	Switch each valve independently

G.4 Plunger Movement Commands/Status Bit Reports

Command	Value of <n>	Description	Status
A <n>	0..6,000 0..48,000 in fine positioning or microstep mode	[A]bsolute Position	Busy
a <n>	0..6,000 0..48,000 in fine positioning or microstep mode	[a]bsolute Position	Ready
P <n>	0..6,000 0..48,000 in fine positioning or microstep mode	Relative [P]ickup	Busy
p <n>	0..6,000 0..48,000 in fine positioning or microstep mode	Relative [p]ickup	Ready
D <n>	0..6,000 0..48,000 in fine positioning or microstep mode	Relative [D]ispense	Busy
d <n>	0..6,000 0..48,000 in fine positioning or microstep mode	Relative [d]ispense	Ready

G.5 Set Commands

Command	Value of <n>	Description	Default Setting
L <n>	1..20	Slope	(7)
v <n>	50..1000	Start speed (Hz/sec.)	(901)
V <n>	5..6000	Peak speed (Hz/sec.)	(901)

Command	Value of <n>	Description	Default Setting
S <n>	0..40	Speed	(16)
c <n>	50..2700 (standard and microstep mode) 40..900 (fine positioning mode)	Cutoff speed	(901) (500)
K <n>	0..62 (standard and microstep mode) 0..496 (fine positioning mode)	Backlash steps	(48) (384)
> <n$_1$, n$_2$>	n$_1$ = 0..15 (Location in EEPROM) n$_2$ = 0..255 (Data to load into EEPROM)	Load user data to EEPROM	(0) (0)

G.6 Control Commands

Command	Value of <n>	Description
R		Executes command or command string
X		Repeats last command string
G <n>	0..48000	Repeats command sequence
g		Marks start of a repeat sequence
M <n>	0..30000	Delay in milliseconds
H <n>	0..2	Halts command string execution
T		Terminate command
J <n>	0..7	Auxiliary outputs

G.7 Non-Volatile Memory (EEPROM) Commands

Command	Value of <n>	Description
s <n>	0..14	Loads command string in Non-Volatile Memory
e <n>	0..14	Executes Non-Volatile Memory command string
U31		Clears "Run from Non-Volatile Memory" flag
U30		Sets "Run from Non-Volatile Memory" flag

G.8 Report Commands

Command	Description
Q	Query, Status, and Error Bytes
?	Report absolute plunger position in increments
?1	Report start speed
?2	Report top speed
?3	Report cutoff speed
?10 or F	Report command buffer status

Command	Description
?12	Report number of backlash increments
?13	Report status of input #1 (J5, Pin7)
?14	Report status of input #2 (J5, Pin 8)
?15	Report number of pump initializations
?16	Report number of plunger movements
?17	Report number of valve switches
?18 or %	Report number of valve switches (since last report)
?20 or #	Report firmware checksum
?23 or &	Report firmware part number and revision
?24	Report zero gap increments
?25	Report slope code setting
?26 or *	Report supply voltage
?28	Report operating mode (N=0, 1, or 2)
?29	Same as Q (query, status and error bytes)
?76	Report pump configuration
< <n>	Report user data (0..15)

G.9   Error Codes

Command	Description	Notes
0	Error free condition	
1 (01h)	Initialization error	Fatal error. Reinitialize pump before resuming normal operation.
2 (02h)	Invalid command	
3 (03h)	Invalid operand	
6 (06h)	EEPROM failure	
7 (07h)	Device not initialized	
9 (09h)	Plunger overload	Fatal error. Reinitialize pump before resuming normal operation.
10 (0Ah)	Valve error	
11 (0Bh)	Plunger move not allowed	Valve in bypass position
14 (0Eh)	A/D converter failure	
15 (0Fh)	Command overflow	

G.10 Error Codes and Status Byte

Status Byte	Hex # if Bit 5 =		Dec # if Bit 5 =		Error Code	
7 6 5 4 3 2 1 0	0	or 1	0	or 1	Number	Description
0 1 X 0 0 0 0 0	40h	60h	64	96	0	No error
0 1 X 0 0 0 0 1	41h	61h	65	97	1	Initialization
0 1 X 0 0 0 1 0	42h	62h	66	98	2	Invalid command
0 1 X 0 0 0 1 1	43h	63h	67	99	3	Invalid operand
0 1 X 0 0 1 1 0	46h	66h	70	102	6	EEPROM failure
0 1 X 0 0 1 1 1	47h	67h	71	103	7	Device not initialized
0 1 X 0 1 0 0 1	49h	69h	73	105	9	Plunger overload
0 1 X 0 1 0 1 0	4Ah	6Ah	74	106	10	Valve error

Status Byte	Hex # if Bit 5 =		Dec # if Bit 5 =		Error Code	
0 1 X 0 1 0 1 1	4Bh	6Bh	75	107	11	Plunger move not allowed
0 1 X 0 1 1 0 0	4Ch	6Ch	76	108	12	Internal failure
0 1 X 0 1 1 1 0	4Eh	6Eh	78	110	14	A/D converter failure
0 1 X 0 1 1 1 1	4Fh	6Fh	79	111	15	Command overflow

G.11 DA-15 Connector Pin Assignments

Pin	Function	Remarks
1	24 V DC	
2	RS-232 TxD line	Output data
3	RS-232 RxD line	Input data
4	Unused	
5	CAN high signal line	
6	CAN low signal line	
7	Auxiliary input #1	TTL level
8	Auxiliary input #2	TTL level
9	Ground	Power and logic
10	Ground	Power and logic
11	RS-485 A line	Data +
12	RS-485 B line	Data -
13	Auxiliary output #1	TTL level
14	Auxiliary output #2	TTL level
15	Auxiliary output #3	TTL level

TECAN