



# INSTRUCTION MANUAL

**AL-2000**

Dual Programmable Syringe Pumps



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## ABOUT THIS MANUAL

The following symbols are used in this guide:



This symbol indicates a CAUTION. Cautions warn against actions that can cause damage to equipment. Please read these carefully.



This symbol indicates a WARNING. Warnings alert you to actions that can cause personal injury or pose a physical threat. Please read these carefully.

NOTES and TIPS contain helpful information.

## INTRODUCTION

Need a pump for two syringes? Two Aladdin pumps when daisy-chained are more efficient and affordable than any competitor's dual syringe models. Two AL-1000 Aladdins (AL-2000) will perform as a dual infusion/withdrawal pump, a double pump for infusing at different rates, a push/pull pump with one infusing and one withdrawing at the same or different rates, two independent pumps, or a master/slave pump. One Aladdin can even control the second for continuous pumping with optional check valve set. The AL-DUALCBL cable synchronizes the operation of two pumps in one of the special communications modes.

## Parts List

After unpacking, verify that there is no visible damage to the sensor. Verify that all items are included:

(2) **AL-1000** Programmable syringe pumps

(1) **AL-DUALCBL** Dual/Reciprocating pumps RS-232 control cable kit (The operation of two pumps is synchronized in either Dual pump mode or Reciprocating pump mode, with one pump acting as the Master control pump.)

- (1) Master pump adapter (Fig. 2). (Alternative function: PC RS-232 COM port adapter)
- (1) Secondary pump adapter (Fig. 3)
- (2) Network cable, 7' (Fig. 1).

(1) Instruction Manual



Fig. 1—(Left) Network cable (7" or 25') with RJ-11 connectors on both ends.

## DUAL PUMP CABLE ATTACHMENT INSTRUCTIONS

1. Turn off power to both pumps.
2. Attach one end of the "Dual Pumps Cable" to the "To Computer" connector on the back of the Master Pump.
3. Attach the other end of the "Dual Pumps Cable" to the "To Computer" connector on the back of the Secondary Pump.

4. Attach either end of the other "Network Cable" (Fig. 1) to the "Secondary Pump Adapter (Fig. 3) RJ-11 connector.
5. Attach the "Network Cable" from the "Master Pump Adapter" to the "To Computer" connector on the back of the Master Pump.
6. Attach the "Network Cable" from the "Secondary Pump Adapter" to the "To Computer" connector on the back of the Secondary Pump.
7. Refer to the pump's Instruction Manual to setup the baud rate and network address. The computer and pump must have the same baud rate.

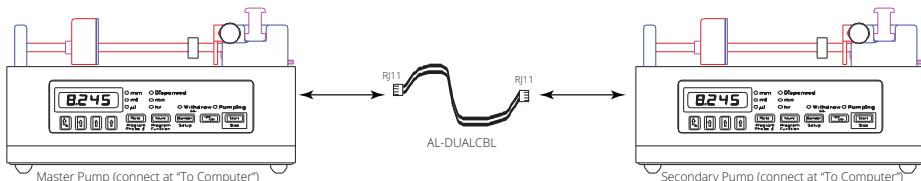


Fig. 2—The Secondary Pump (connect "To Computer") is shown on the left, and the Master Pump (connect "To Computer") is shown on the right.

## Detailed Setup Information

To select the Master pump control mode, enter Setup on the Master pump by pressing and holding the "Setup" key ("Diameter" key), until setup is entered. The pump will scroll through the setup parameters. When the pump address [Ad:00], or other current mode is displayed, press the left-most up arrow key to scroll through the communications modes:

Mode	Display in Setup	Description
Address mode	Addr	Communications with PC using cable GN-PC7.

## AL-DUALCBL Cable Special Communications Modes

Mode	Display in Setup	'X Firmware Version Only	Description
Dual Pumps	dUAL		Secondary pump duplicates the master pump
Reciprocating Pumps / Continuous Infusion	rECP		Continuous infusion / auto-refill
Alternating Pump Control	ALtr	Extra Features	Second pump starts when first pump stops.
Next Generation Continuous Infusion	COnt	□	Continuous infusion while minimizing flow rate pauses and drop outs when changing directions
Constant Flow Rate Gradient	GrAd	□	Dual pumps inverse linear functions combine for a constant flow rate

All modes (except Address) are set to 19,200 baud rate. In Address mode, the next setting is the baud rate setting.

Except for Alternating Pumps mode, the secondary pump should remain in Address mode [Ad:00] and 19,200 baud rate [1920] setting, which are the factory defaults. With Alternating Pumps mode, the secondary pump can also be set to Alternating Pumps mode.

## Default Program Selection

Use one pump as the Master control pump, and the other as the Secondary slave pump. After selecting a default program, the default parameters can be modified. Do not load program on second pump. Set the syringe diameter on both pumps.

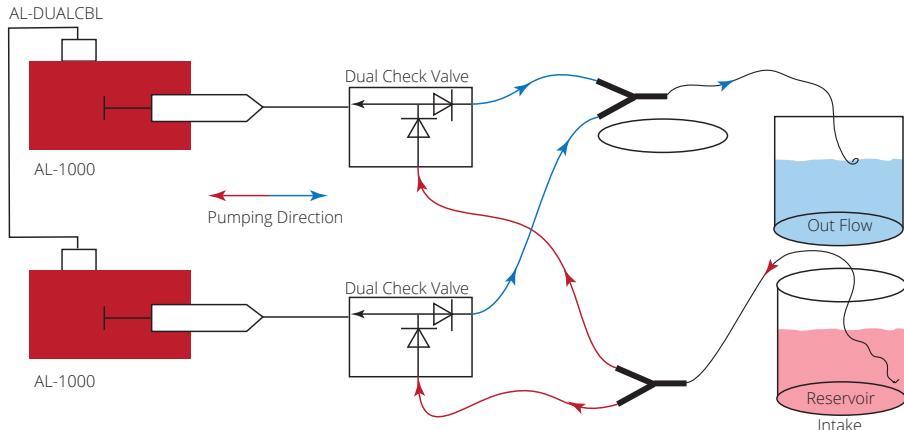
### Basic Pump Setup: Select Default Dual Pumps Program

1. On the Master Pump ONLY: Turn power off.
2. Press and hold the "Program Function" key (Volume key).
3. Turn power on, and then release the "Program Function" key.
4. Press any up-arrow key to select a default program. The default program will be loaded, and the communications mode will be set.

### Selectable Default Programs

Description	Displayed as	'X Version Only
Reciprocating Pumps / Auto Refill	rECP	
Next Generation Continuous Infusion	COnt	<input type="checkbox"/>
Gradient Inverse Linear Constant Rate	GrAd	<input type="checkbox"/>

## PLUMBING FOR A CONTINUOUS INFUSION SYSTEM



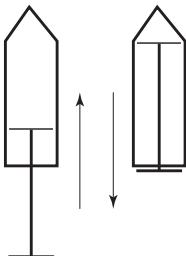
### Major Parts of the System

Quantity	Dual Pump Kit	Description
2		AL-1000 Programmable Syringe Pump
1		AL-DUALCBL
2	<input type="checkbox"/>	Syringes (60mL)
2	<input type="checkbox"/>	Dual Check Valves
2	<input type="checkbox"/>	Y Connectors
8	<input type="checkbox"/>	Sections of tubing



## Reciprocating and Dual Modes

### Reciprocating Mode Opposite Pumping Directions



### Dual Mode Same Pumping Directions

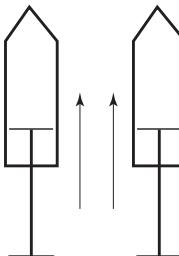


Fig. 3—Two modes of dual pump operations

**Syringes:** Each pump can have a different size syringe, but make sure that the pumping rates on the Master pump are within range of the syringe used on the Secondary pump. If an out-of-range pumping rate is sent to the Secondary pump, the rate will just be ignored by the Secondary pump without affecting the operation of the Master pump.

**Master Pump:** Pumping rate and direction are only transmitted to the Secondary pump from the Master pump while the Master pump is pumping. If the Master pump starts or stops, the Secondary pump will start or stop. Linear Function pumping rates will not be transmitted.

#### Secondary Pump Controlled as Follows:

Reciprocating Mode: Master pump Rate and opposite pumping direction.

Dual Mode: Master pump Rate and current pumping direction.

**Secondary Pump:** Changes to the pumping rate and direction on the secondary pump will not be transmitted to the Master pump. If the Secondary pump stops, the Master pump will also stop.

**Pump Stall:** If either pump stalls, then the other pump will also stop.

**Synchronization between pumps:** The secondary pump will lag approximately 30 milliseconds behind the Master pump due to communications delay.

## RECIPROCATING PUMP PROGRAM

Below are examples of how to setup the pumps for reciprocating, continuous flow operation. The Pump 1 program is the default program that is loaded as indicated in the "Default Program Selection" section.

Pump 1 is the Master pump which controls the Secondary pump's operation. In Reciprocating mode, Pump 2 will pump continuously in the opposite direction of Pump 1, at the same rate as Pump 1, and will change direction when Pump 1 changes direction.

### Pump 1

Phase	Function	Rate	Volume	Direction
1	RATE	500 mL/hr.	10.0 mL	Infuse
2	RATE	500 mL/hr.	10.0 mL	Withdraw
3	JP:OI			

## Pump 2

Phase	Function	Rate	Volume	Direction
1	RATE	500 mL/hr.	0.0 ml (off)	Withdraw
2	Stop			

## ALTERNATING PUMPS MODE

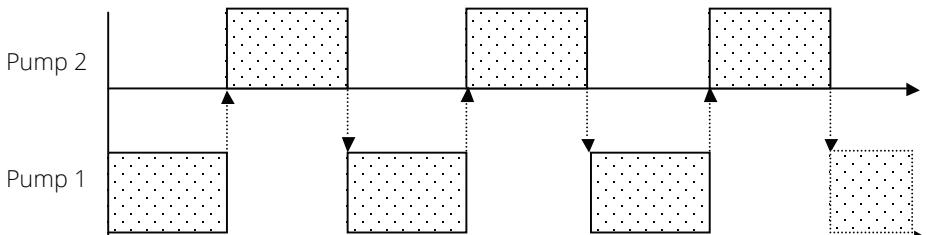


Fig. 4—Alternating pumps mode creates a semi-automated continuous infusion system using pre-loaded syringes.

The infusing pump will automatically start the alternate pump when the Pumping Program stops.

A Pause Function at the beginning of the alternate pump's program will delay the start of pumping.

The empty syringe can then be manually replaced during the infusion of the alternate pump.

Set both pumps to Alternating communications mode ("Altr") to create a continuous system.

## 'X Version Firmware Only (Enhanced Features)

- Starts alternate pump after either a Pause function or when the program stops.

Set the TTL setup setting: RUN.0. (Default setting)

Alternate pump will start on execution of Pause function.

Set the TTL setup setting: RUN.1

Alternate pump will start when the Pumping Program has stopped.

- Overlap start of alternate pump.

Pumping Program Function: OUT.0

Immediately sends start to alternate pump when OUT.0 function is executed.

Allows the creation of an overlap between the infusing and the alternate pump to allow the alternate pump to prime the syringe before the infusing pump stops.

Simultaneously start both pumps: If Phase 1 is set to function OUT.0, the alternate pump will immediately start when the Master pump starts.

Overrides sending a start command to the alternate pump when the pump stops.

- Stop Alternating Mode

Set TTL Trigger Mode to "Off". When trigger is set to "Off", start command will not be sent to alternate pump.

Within a Pumping Program, the trigger mode can be changed with the Trigger Off function: ("tr:of"). This allows a Pumping Program to limit the number of times that the alternate pump will execute its Pumping Program.

## “NEXT GENERATION” CONTINUOUS PUMPING MODE (‘X FIRMWARE VERSION ONLY)

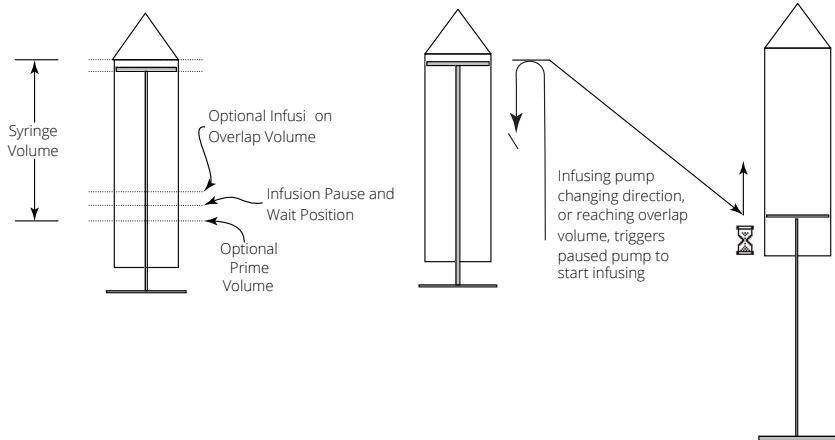


Fig. 5—A continuous pumping setup

The continuous pumping mode eliminates the problem of flow rate drop-off that is typical with continuous syringe pump systems, where one pump is refilling the syringe, while the other infuses, and then they switch directions.

In this system, the refilling pump refills at a faster rate than the infusing pump, giving it time to prime the syringe, then it pauses and waits for the infusing pump to empty.

Then, when the pumps switch directions, the refilled pump is primed and starts infusing at the set rate immediately. Additionally, an overlap can be set, whereby the refilled syringe begins infusing before the infusing pump is completely empty.

### Requirements

- 2 AL-1000 syringe pumps.
- 1 Dual pump cable, part #AL-DUALCBL.

### Set communications Mode to Continuous Mode [Cont]

On the Master Pump only: In setup, when the network address is displayed [Ad:00], or other address mode, press the left-most up arrow key to select [COn].

**NOTE:** Do not change the default settings on the second pump: Address 0 [Ad:00] and 19,200 baud rate [1920]. If unsure, reset the secondary pump: While turning on power, hold the left-most up arrow button. The display will show [rEST].

### Set Pumping Parameters on the Master Pump

Set syringe diameter and pumping parameters on the Master pump. The syringe diameter and pumping parameters are transmitted to the second pump when the Master pump starts. Both syringes start empty, unless pre-filled syringes are specified.

Pumping Parameters			
Phase #	Function	Rate	Volume
1	RATE	Infusion	Syringe Volume
2	RATE	Refill	Overlap
3	RATE	Prime	Prime
4	RATE	Pre-filled Syringe Mode (Optional Parameter)	
		00 = Both empty (default)	<- Optional parameters
		10 = Master only	11 = Both pre-filled
			01 = Secondary only

Set any optional parameter to 0.000 (off) if not used, or set the function to STOP. Pumping rates not set will default to the Infusion Pumping Rate.

## Hardware Setup

Attach the cable, AL-DUALCBL, to the "To Computer" connector on the back of both pumps.

## Operational Sequence

1. Both syringes start empty. Set Phase 4, pre-filled mode, to use pre-filled syringes.
2. Start the Master pump: Both pumps start filling, unless pre-filled syringes are specified.
3. When syringes are filled:
  - Master pump starts infusing
  - Second pump primes (if enabled), then pauses
4. When the infusing pump reaches the overlap position, if enabled, or changes pumping direction, the paused pump will start to infuse.
5. Sequence repeats:
  - Refilling pump fills, primes, pausing and waits for the other pump.
  - Infusing pump infuses to the overlap position or syringe empty, and then signals the other pump to start infusing. When empty, changes direction and starts refilling

## While Pumping

The pumping rate can be changed. The new pumping rate will be transmitted to the other pump, into the corresponding pumping sequence.

Pressing the Stop key on either pump, will Pause the sequence on both pumps. Pressing the Start key, on the Master pump, will continue the pumping sequence.

## Power Failure Mode - Auto-Synchronization

After a power failure restart, or to start the infusion with partially filled syringes, limit switches can be attached to the pump at the refill position of the syringes. Attach the limit switch wires between the Trigger Input (pin 2) and Ground (pin 9) on the pump's 9 pin TTL connector.

Then enable Power Failure Mode in the Master pump's setup menu.

When the pumps start, they will begin by filling the syringes until either the syringe volume target is reached or the limit switch is triggered. **Power Failure Mode overrides pre-filled syringe mode settings.**

## Notes

The refill rate needs to be fast enough so that the syringe is refilled and primed before the infusing pump has emptied.

If the refilling pump is still pumping when the infusing pump empties, an error message will be displayed and the pumps will stop.

[Er:41] Error message indicates invalid pumping parameters.

Default Continuous Pumping Program

To load the default program: On the Master pump, while turning on power:

Press and hold the "Volume"/"Program Function" key until [Cont] is displayed. Press the "Volume" button again to enter the selection.

Default Continuous Mode Pumping Parameters					
Phase #	Function	Rate	Volume		
1	RATE	Infusion	100.0 mL/hr	Syringe	10.00 mL
2	RATE	Refill	500.0 mL/hr	Overlap	0.000 mL
3	RATE	Prime	200.0 mL/hr	Prime	0.100 mL
4	RATE	Prefilled mode	0.000 mL/hr	(not used)	0.000 mL

Address Mode set to Continuous: [Cont]

## DUAL PUMPS INVERSE GRADIENT PUMPING MODE ('X FIRMWARE VERSION ONLY)

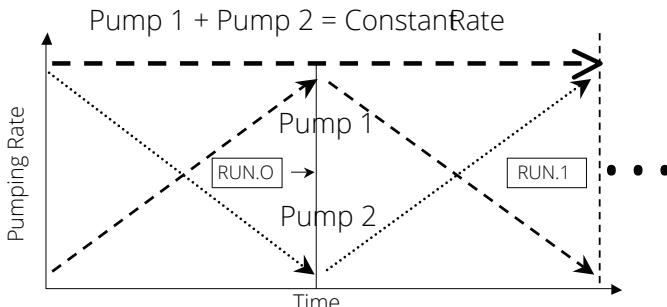


Fig. 6—The inverse gradient pump configuration

Maintains a constant total flow rate between 2 syringe pumps. A gradient (linear function) dispensing function is programmed into the Master pump. The secondary pump will be automatically programmed with the inverse of the Master pump's gradient function. The sum of the two pump's flow rates will be a constant. Both pumps will increase and decrease pumping rates in tandem.

## Two Modes of Operation

- Single cycle: Single ramp up or ramp down, then stop.  
Set TTL setup setting RUN.0
- Continuous cycle: Ramp up, then ramp down, and repeat continuously.  
Set TTL setup setting RUN.1

## Requirements

1. 2 Pumps from the AL-1000 syringe pump series with 'X' firmware upgrades.
2. AL-DUALCBL dual pump communications cable.

## Quick Setup

On the Master pump only – DO NOT change default settings on the second pump.

1. Attach the communications cable, AL-DUALCBL, to the “To Computer” port on the back of both pumps.
2. Select the default Gradient Mode pumping program:
  - Turn on power to the pump WHILE pressing the “Volume / Program Function” key.
  - Use any up-arrow key to select Gradient Mode, displayed as:
  - Press the **key** to select, or wait for the time out.
3. Set the syringe diameter on the Master pump. Both pumps will use the same diameter. (Default program assumes at least a 14.43 mm diameter).
4. Press on the Master pump to start the dual pump Gradient pumping program.

## Setup

On the Master pump only – DO NOT change default settings on the second pump.

1. Attach the dual pump cable, AL-DUALCBL, to the “To Computer” port on both pumps.
2. Select Gradient communications mode. From the Setup menu (Press and hold “Diameter / Setup” key), select Gradient communications Mode (displayed as Grad). When Ad:00 (or other communications mode) is displayed, use the left-most arrow key to select.
3. Set the syringe diameter.
4. Enter a Linear function pumping program as a 2 Phase Pumping Program:
  - Phase 1: Linear function starting rate, and [hours:minutes] portion of pumping time.
  - Phase 2: Linear function ending rate, and [seconds:tenths] portion of pumping time.
5. Change RUN.0 (default value), if needed to change from single cycle mode.

**NOTE:** The secondary pump is set to the default communications settings of Address 0 and 19,200 baud rate.

## Operation

When the Master pump is started, the Linear function will be expanded to a 3 or 5 Phase Pumping program, depending on mode, representing the forward and inverse of the linear function, then repeat. The second pump will then be programmed with the syringe diameter and the inverse of the linear pumping program. The Second pump will start pumping when the Master pump starts pumping.

With the starting and ending pumping rates reversed on the secondary pump, the sum of the flow rates of the two pumps will be virtually constant.

**NOTE:** The linear function updates the pumping rate every 100 ms, resulting in a synchronization error of up to 100 ms between the two pumps. This will cause a slight difference in the total volumes dispensed between the two pumps.

### Default Gradient Pumping Program

To load the default program: On the Master pump, while turning on power, press and hold the “Volume”/“Program Function” key until [Cont] is displayed, then use any up arrow key until [GrAd] is displayed. Press the “Volume” key again to enter the selection.

Default Gradient Mode Pumping Parameters			
Phase #	Function	Rate	Time
1	Linr (Linear)	Starting Rate 0.000 mL/hr	00 : 01 Hours : Minutes
2	Linr (Linear)	Ending Rate 500.0 mL/hr	00 : 00 Seconds : 1/10 Seconds
3	Stop		

RS-232 Communications Address Mode set to Gradient: [GrAd]  
 Assumes a syringe diameter of at least 14.43 mm.  
 RUN.0 set for single cycle Gradient.

## WARRANTY

WPI (World Precision Instruments) warrants to the original purchaser that this equipment, including its components and parts, shall be free from defects in material and workmanship for a period of two years\* from the date of receipt. WPI's obligation under this warranty shall be limited to repair or replacement, at WPI's option, of the equipment or defective components or parts upon receipt thereof f.o.b. WPI, Sarasota, Florida U.S.A. Return of a repaired instrument shall be f.o.b. Sarasota.

The above warranty is contingent upon normal usage and does not cover products which have been modified without WPI's approval or which have been subjected to unusual physical or electrical stress or on which the original identification marks have been removed or altered. The above warranty will not apply if adjustment, repair or parts replacement is required because of accident, neglect, misuse, failure of electric power, air conditioning, humidity control, or causes other than normal and ordinary usage. The driver nut button and other parts subject to normal wear are not covered by the warranty.

To the extent that any of its equipment is furnished by a manufacturer other than WPI, the foregoing warranty shall be applicable only to the extent of the warranty furnished by such other manufacturer. This warranty will not apply to appearance terms, such as knobs, handles, dials or the like.

WPI makes no warranty of any kind, express or implied or statutory, including without limitation any warranties of merchantability and/or fitness for a particular purpose. WPI shall not be liable for any damages, whether direct, indirect, special or consequential arising from a failure of this product to operate in the manner desired by the user. WPI shall not be liable for any damage to data or property that may be caused directly or indirectly by use of this product.

## Claims and Returns

Inspect all shipments upon receipt. Missing cartons or obvious damage to cartons should be noted on the delivery receipt before signing. Concealed loss or damage should be reported at once to the carrier and an inspection requested. All claims for shortage or damage must be made within ten (10) days after receipt of shipment. Claims for lost shipments must be made within thirty (30) days of receipt of invoice or other notification of shipment. Please save damaged or pilfered cartons until claim is settled. In some instances, photographic documentation may be required. Some items are time-sensitive; WPI assumes no extended warranty or any liability for use beyond the date specified on the container.

Do not return any goods to us without obtaining prior approval and instructions from our Returns Department. Goods returned (unauthorized) by collect freight may be refused. Goods accepted for restocking will be exchanged or credited to your WPI account. Goods returned which were ordered by customers in error are subject to a 25% restocking charge. Equipment which was built as a special order cannot be returned.

## Repairs

Contact our Customer Service Department for assistance in the repair of apparatus. Do not return goods until instructions have been received. Returned items must be securely packed to prevent further damage in transit. The Customer is responsible for paying shipping expenses, including adequate insurance on all items returned for repairs. Identification of the item(s) by model number, name, as well as complete description of the difficulties experienced should be written on the repair purchase order and on a tag attached to the item.

*\* Electrodes, batteries and other consumable parts are warranted for 30 days only from the date on which the customer receives these items.*



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