APPLICATION NOTE

TITLE:	Multiplex Controller, Migrating Between Versions V2.0 & V3.0	AN-104
		REV -
CATEGORY:	Controller Operation	

1. DESCRIPTION

This bulletin describes some of the key changes that were made between V2.0 (hereafter referred to as V2) and V3.0 (hereafter referred to as V3) of the Multiplex controller. These changes enhance the Multiplex controller but also impact the interfaces to external equipment such as PLCs. In some cases a V3 controller may directly substitute for V2 controller without modification to the existing interface. However, in other cases, modification to the existing interface will be necessary.

2. VERSIONS

2.1. Version Table

The following table identifies the part numbers for the different versions of the Multiplex controller. V3 does not distinguish between a Master and a Channel since V3 does not support this architecture. The "#"'s in the part number indicate tabulation fields which are described in the next section.

Version	Controller P/N	Description
V2 Master	520164-########	CONTROLLER MODULE, MULTIPLEX MASTER, VERSION 2.0
V2 Channel	520165-########	CONTROLLER MODULE, MULTIPLEX CHANNEL, VERSION 2.0
V3 Controller	520225-#####	CONTROLLER MODULE, MULTIPLEX, VERSION 3.0

2.2. Tabulations and Ordering

Both the V2 and V3 use tabulation fields to determine various options and configurations of the controller. V2 requires knowing the actuator beforehand so that it can be configured for the proper settings by the factory. V3, on the other hand, allows the end-user to modify the actuator selection; thereby, eliminating the need for factory pre-configuration. V3 also limits options, making certain items standard, in an attempt to minimize variations. The following table provides a migration path for ordering a V3 controller based on previous V2 options. The "#"'s in the tabulations represent place holders for other tabulation fields. The tabulations fields must be prefixed with the part numbers indicated in the previous section.

Note that the V2 tabulations below are for a Master controller. The Channel controller has similar tabulations, except for the Parameters Interface tabulation which is for Masters only. Due to this difference, the Channel tabulations are only 7 places instead of 8.

When you have any of the following V2 Tabulations	Order the following V3 Tabulation
Actuator Frame Size SF####### (Small Frame) or LF######## (Large Frame)	Motor Drive A#### (Servo, 3.6A)
Active Pumps ##01###### (1 Pump) or ##02###### (2 Pumps) or ##03###### (3 Pumps) or ##04###### (4 Pumps) or ##05###### (5 Pumps) or ##06###### (6 Pumps) or ##07###### (7 Pumps) or ##08###### (8 Pumps) or ##09###### (9 Pumps) or ##10###### (10 Pumps) or ##11###### (11 Pumps) or ##12###### (12 Pumps)	Active Pumps None, number of pumps is a software selection as part of the actuator configuration.
Logic Interface ####A### (PLC) or ####B### (PLC with Load)	Logic Interface #A### (PLC I/O with Load)
Parameters Interface (Master only) #####A## (RS232 Serial) or #####B## (Touchscreen, no enclosure) or #####C## (Touchscreen, stainless steel)	Communications and Front Panel ##A## (RS232, EtherNet/IP) and ###A# (Touchscreen)
Enclosure and Trim ######A# (Front handles and 19 in. brackets, style A) ######B# (Front handles, style A) ######C# (Trim, style A) ######D# (Front handles and 19 in., brackets, Style B) ######E# (Front handles, style B) ######F# (Trim, style B)	Enclosure and Trim None, enclosure and trim is 19 in. bracket only.
Line Cord & Agency Approval #######A (Domestic Cord, CE) or #######B (International Cord, CE)	Line Cord (all options are CE) ####A (Domestic Cord) or ####B (International Cord)

3. ACTUATOR COMPATIBILITY

The V3 controller is designed to operate the actuators that shipped with V2 controllers. The Multiplex actuators are often referred to by their frame size and number of pumps. For example, LF12 means the actuator is a Large Frame size with 12 pumps; whereas SF8 means the actuator is a Small Frame size with 8 pumps. The following lists the actuators and Ivek part numbers supported by both V2 and V3.

Frame Size	Part Number	Description
SF8	202394	Actuator Module, Ver 2.0 SF8 Multiplex
SF10	202393	Actuator Module, Ver 2.0 SF10 Multiplex
SF12	202392	Actuator Module, Ver 2.0 SF12 Multiplex
LF8	202397	Actuator Module, Ver 2.0 LF8 Multiplex
LF10	202396	Actuator Module, Ver 2.0 LF10 Multiplex
LF12	202395	Actuator Module, Ver 2.0 LF12 Multiplex

3.1. Actuators with new motors

Due to supply chain issues, there are actuators under development that use different motors than the presently shipping actuators. These motors are incompatible with the firmware settings of V2 and present firmware of V3. New firmware is under development for V3 to work with these new motors (and possibly new hardware). Once these new actuators are released, along with the new firmware, this section will be updated to list the new actuators and migration strategy. It is important to note that these actuators will be incompatible with V2 controllers.

3.2. Actuator Connections

The V3 controller connects to the same actuators as the V2 controller. However, the V3 controller has a motor connector on the rear panel that is different than that of V2. The V3 controller uses a round metal connector in place of the round plastic connector of V2. This means that the motor cables used with V2 controllers are not compatible with V3 controllers.

The existing control cables, on the other hand, are compatible with both V2 and V3 controllers.

Connection Type	V2 Cable to V2 Actuator	V3 Cable to V2 Actuator
Motor	540074-## (## is length in feet)	540270-### (### is length in decimeters)
Control A	540071-## (## is length in feet)	Same
Control B	540071-## (## is length in feet)	Same

3.3. Actuator Action

3.3.1. Unintended Drawback

The motor contained in the actuators is a servo motor controlled by a servo drive. The V2 controller uses a servo drive from a different manufacturer than V3. The pumping action of the actuator is controlled by the servo drive. The controller firmware determines the tuning parameters of the servo drive and those parameters may differ from actuator type to actuator type (e.g., tuning parameters of the SF actuators are different than the LF actuators).

Starting with firmware version 560006-0103, the tuning parameters of V3 controllers are quite a bit different than those contained in previous versions of V3 firmware, and also different than those contained in V2 controllers. Previous tuning parameters result in a slight overshoot at the end of movement, giving the fluidics a little bit of unintended drawback. While many applications benefit from this unintended drawback, it is more ideal to eliminate the overshoot (drawback) from the normal dispense cycle, and only provide drawback when intended by configuration of the Drawback parameters. Therefore, when substituting a V3 controller (with firmware 560006-0103 or later) in place of a V2 actuator, it may be necessary to add a little bit of intentional drawback to the pumping operation to achieve similar performance to the previous setup.

This elimination of the unintended drawback may also improve the accuracy or repeatability of some applications. How this change impacts the application depends much on the tubing setup, fluid being dispensed, tips, etc.

3.3.2. Low Voltage Stalls

The LF actuator is not capable of reaching full dispensing rates (150,000 inc/s) when the power supply is supplied by a nominal voltage less than 230V (e.g., 120V, 100V). This is due to there being too much Back EMF when the motor runs at high rates (typically > 75,000 inc/s, varies depending on specific motor, actual input voltage, etc.). Since the LF pumps are typically large, it is often not desirable to run these pumps at a such a high dispensing rate. However, when these rates are configured in the controller, V2 behaves differently than V3.

When the motor reaches the rate at which there is too much Back EMF, V2 simply limits the motor's speed so that it will not stall. There is no indication given that the motor speed is being limited. Therefore, in most cases this limitation is unnoticed.

V3, on the other hand, allows the motor to stall when there is too much Back EMF, generating a fault status in the controller. This, of course, is highly noticeable and desirable, as it provides indication that the desired dispensing rate is unachievable. When this situation happens, either the dispensing rate needs to be reduced or the input voltage needs to be increased.

4. CONFIGURATION AND CONTROL

There is much information on how to configure and control the Multiplex V3 controller in the User's manual and in Application Note An-103, "Setup of Multiplex V3 with PLCs and Gateways". The section below is going to highlight the key differences between V2 and V3.

4.1. Master and Channel Architecture

The V2 controller allowed for a single controller, designated the Master, to control up to eight other V2 controllers, designated the Channels. The V3 controller does not support this architecture; rather, each V3 controller operates independently of other Multiplex controllers. This means that the V3 controller may not substitute directly in place of all existing V2 controllers without some changes to the controlling infrastructure (e.g., PLC software). However, there are many use cases where a V2 controller is being controlled in a way that allows for a V3 to drop-in place with few, if any, change to the controlling infrastructure.

4.2. Touchscreen

4.2.1. Parameter Modification and Non-volatile Memory

A Touchscreen with non-volatile memory was an option, external to the enclosure, for V2. For V3, a Touchscreen with non-volatile memory is standard and contained in the enclosure.

The Touchscreen allows for modification of parameters at the controller. The parameter modifications are remembered through a power-cycle. This allows for commissioning of a controller without the need for a PLC to initialize parameters upon power-up. It also allows for operator control without having to provide such operator control on the PLC. For example, many applications have the PLC control the Multiplex during production operations but allow an operator to take control of the Multiplex to setup the system (e.g., Prime the pumps).

4.2.2. Status Indication

The Touchscreen on V3 also takes the place of the illuminated status indicators of V2. Status fields on the Touchscreen display indicate much more information than the indicators of V2. More detailed operation status and fault information make it easier to discern operating conditions and fault sources. Also, the Touchscreen provides the ability to initiate operations (e.g., Reference, Prime, etc.) at the unit. This gives the operator the ability to troubleshoot and fix problems local to the controller (the Touchscreen contains permission levels that may be configured to limit the operator's ability to operate the controller).

4.2.3. Using with Logic I/O

The inclusion of a Touchscreen as standard allows for easier substitution of V3 controllers in place of V2 Channel controllers that are being controlled by independent Logic I/O. In a typical V2 Master/Channel system, the Channel controllers (which do not have non-volatile memory) are configured upon power-up by the Master (which is configured by either a PLC or Touchscreen). Operations on the Channel are then triggered by either the Master or Logic I/O. V3 controllers may substitute in place of the V2 Channel controller if the parameters do not need to change during operation, and if the controller is triggered and monitored by Logic I/O.

4.2.4. External Touchscreens

Because the V3 controller has a built-in Touchscreen, it is not compatible with external touchscreens that interface the V2 controllers. The V3 controller does not include the rear panel connector for connection to an external touchscreen.

4.2.5. Volume and Rate Units

The V2 external touchscreen displays volumes in microliters (uL) and rates in microliters per second (uL/s). However, the V3 touchscreen displays all volumes in increments (inc) and all rates in increments per second (inc/s). Increments are the units of the RS232 protocol of V2 and V3, so the V3 touchscreen is consistent with those units.

No matter which pump is attached to the actuator, 40,000 increments is equivalent to a full pump chamber. This means that the amount of volume per increment is dependent on the pump size. The common pump sizes are given below.

Pump Size (uL)	Pump Chamber (inc)	Resolution (uL/inc)
200	40,000	0.005
400	40,000	0.010
2000	40,000	0.050
4000	40,000	0.100
5000	40,000	0.125

4.3. RS232 Interface

4.3.1. Connections

The V2 controller uses a 25-pin DSUB for the RS232 connection, while the V3 controller uses a 9-pin DSUB. Both versions of the controller use the same baud rate, parity, etc.

4.3.2. Protocol

The RS232 protocol of the V3 controller is backwards compatible with the V2 Master controller. This means that V3 controllers may substitute into existing installations of stand-alone V2 Master controllers with few, if any, changes to the PLC software.

4.3.2.1. Hardwired Ready Signal “h” Command

The “h” command of V2, which configures the hardwired ready signals, behaves differently on V3.

Hardwired Ready	V2 Command	V3 Command
Read the Hardwired Ready configuration	h	Not supported
Write the Hardwired Ready configuration	h0 through h255	Not supported
Read the Logic In configuration	Not supported	h11 through h15
Write the Logic In configuration	Not supported	h11,<value> through h15,<value>
Read the Logic Out configuration	Not supported	h21 through h26
Write the Logic Out configuration	Not supported	h21,<value> through h26,<value>
Read the Logic In Invert configuration	Not supported	h31 through h35
Write the Logic In Invert configuration	Not supported	h11,<value> through h15,<value>
Read the Logic Out Invert configuration	Not supported	h41 through h46
Write the Logic Out Invert configuration	Not supported	h41,<value> through h46,<value>

4.3.2.2. Totalizer “g” Command

The “g” command of V2, which returns the Totalizer Volume, is supported in V3. The command is enhanced in V3 by adding a “g0” command which behaves similar to the “g” command.

Totalizer	**V2 Command**	**V3 Command**
Read Totalizer Volume	g	g
Clear Totalizer Volume	g0	g0 or g0,0
Read Totalizer Cycles	Not supported	g1
Clear Totalizer Cycles	Not supported	g1,0

4.3.2.3. Mode “m” Command

The “m” command of V2, which configures the Mode, is supported in V3. However, a couple of the possible values are different in V3.

Mode	**V2 Command**	**V3 Command**
Disabled	Not supported	m0
Prime	m1	same
Dispense	m2	same
Meter	m3	same
Agitate	m6	m4
Dispense MCV	m7	m5

4.3.2.4. Valve Dwell “s11” Command

The default value for the “s11” valve dwell is 10 (100ms) in V2 and 20 (200ms) in V3. This is to better reflect the actual default dwell time.

4.3.3. Channels

It is not possible to substitute a V3 controller for a V2 channel.

The V2 Channel controller does not use RS232 for communication. Rather, the V2 Master controller configures the V2 Channel controller through the proprietary ARCNET interface. The V3 controller does not contain this ARCNET interface and is not able to communicate on the proprietary IVEK Master/Channel network. Therefore, it is not possible to either substitute a V3 controllers for a V2 Channel, or to control several V3 controllers from a single RS232 interface.

If it is desirable to substitute a V3 controller in place of a V2 Channel controller, while maintaining the ability to configure the V3 controller from a PLC RS232 interface, it will be necessary to add an additional RS232 interface and corresponding software onto the PLC for each Channel. The V3 controller contains other interfaces (e.g., Touchscreen, EtherNet/IP, and Logic I/O) that may be used instead but will also require modification to the PLC software.

4.4. Logic I/O Interface

4.4.1. Connections

The V2 controller has two different connection options for the Logic I/O interface: either dual 9-pin round connectors (discontinued) or a 24-pin round connector. The V3 controller has a 24-pin round connector only.

The dual 9-pin connectors version contains a 9-pin connector for System Logic I/O (System Trigger In, System Ready Out, System Fault Out) and another 9-pin connector for channel Logic I/O (Channel Trigger In, Channel Ready Out, Channel Fault Out). Replacing this version of a V2 controller requires modifying the connectors on any mating cables to match the 24-pin connector of the V3 controller.

The 24-pin connector of the V2 controller contains all of the System and Channel signals in a single 24-pin connector, and also adds signals to initiate and monitor Load operations (System Load In, System Load Out, Channel Load In, Channel Load Out). The 24-pin connector of the V3 controller is backwards compatible with the V2 controller.

4.4.2. Signals and Configuration

The Logic I/O interface of the V3 controller has some backwards compatibility with the V2 controller. This means that V3 controllers may substitute into some existing V2 applications with few, if any, changes to the PLC software or infrastructure. The most common direct-substitution scenario is replacing a stand-alone V2 Master controller (i.e., no Channels present) with a V3 controller. As long as the existing installation is using the System I/O signals, the existing logic cable and signals should correctly interface with the V3 controller without requiring modification.

4.4.2.1. Enhancements

The Logic I/O interface of the V3 controller is enhanced by the ability to configure the function of each Logic I/O signal. By default, the Logic I/O signals of V3 are configured to a function that is nearly equivalent to the corresponding System signals of V2. The v3 controller also contains new signals that allow additional control and monitoring (see the User's Manual).

4.4.2.2. Meter Mode Logic

The Trigger signal functions a little bit differently in V3 compared to V2. For V3, when the controller is configured for Meter mode, and the Logic input is configured for Trigger Production, the signal will start a Meter operation but will not stop it (V2 will both start and stop the Meter operation with the Trigger signal). When using Logic I/O to start and stop Metering operations with V3, it is necessary to configure the Logic Input for Gate Production rather than Trigger Production. In Meter mode, the Gate Production signal of V3 behaves similar to the Trigger In signal of V2.

4.4.2.3. Prime Mode Logic

The V3 controller may configure a Logic Input as either a Trigger or a Gate to start and stop Priming operations. It is recommended to configure the input as Gate Fluidic so that the activation of the signal will start the Priming operation and the deactivation of the signal will end it. If the input is configured as Trigger Fluidic, the activation of the signal will start the Priming operation but will not stop it. Instead, the Priming operation will stop when either the timer expires, or the operation is stopped by some other method (e.g., Stop signal).

Another enhancement the V3 controller offers is that activation of one of the Fluidic Trigger or Gate signals will temporarily change the Mode from either Dispense, Meter, or MCV to Prime. At the end of

the Prime operation, the Mode returns to the previous mode. This eliminates the need to modify the Mode via other interfaces (e.g., RS232).

4.5. E-Stop

The E-stop interface on the V3 controller is backwards compatible with the V2 controller.

Connection Type	V2 Connection	V3 Connection
E-stop	540108 (4-pin male connector kit for customer connections)	Same

4.6. Fieldbus

The V3 controller has an additional fieldbus interface that is not available on the V2 controller: EtherNet/IP. The V3 controller contains two RJ45 ports on the rear panel to ease the daisy chaining of several V3 controllers together with a PLC or gateway. The EtherNet/IP interface may be used to modify parameters, and to control and monitor operations.

When changes to the PLC software and/or hardware are necessary to substitute a V3 controller in place of a V2 controller, it is recommended to transition from the RS232 protocol to the EtherNet/IP protocol (especially when using a PLC that contains an EtherNet/IP interface already). Whereas fast control of V2 controllers often requires the use of discrete I/O in addition to the RS232, fast control of the V3 controller is achievable using EtherNet/IP alone. The EtherNet/IP interface allows the modifications of all the parameters available on the RS232 interface. It also allows the control and monitoring of all the signals on the Logic I/O interface. Also, there are a few parameters (e.g., Dispense Volume, Dispense Rate, Pump Enable) that are able to be updated at very fast cycle times (e.g., 10ms) to allow quicker modification to some parameters between operations. This may be very important in cases where, for example, it is important to enable and disable pumps between each operation.