

V = voting

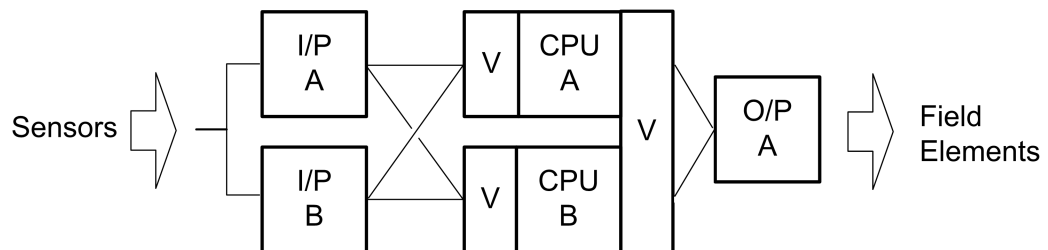
Table 6 - Modules for SIL 2 Architecture

Position	Module Type
I/P A and B	2 × T9401/2 Digital Input Module, 24 Vdc, 8/16 Channel + T9802 Digital Input TA, 16 Channel, Dual or 2 × T9431/2 Analogue Input Module, 8/16 Channel, Isolated, + T9832 Analogue Input TA, 16 Channel, Dual T9300 I/O Base Unit
CPU A	2 x T9110 Processor Module, T9100 Base Unit
O/P A	T9451 Digital Output Module, 24 Vdc, 8 Channel + T9851 Digital Output TA, 24 Vdc, 8 Channel, Simplex; T9300 I/O Base Unit or 1 x T9481/T9842 Analogue Output Module, 3/8 Ch, Isolated + T9881 Analogue Output TA, 8 Ch, Simplex

SIL 2 Fault Tolerant Output Architecture

A SIL 2 Fault Tolerant output architecture has a single output module with dual processor and single or redundant input modules.

The illustration shows a SIL 2 single output arrangement where the output module operates in 1001D under no fault conditions and fail-safe on the first detected fault. The processor will operate in 1002D under no fault conditions, will degrade to 1001D on the first fault in either processor module and will fail-safe when there are faults on both processor modules.



Digital Output

For digital output modules the following applies:

- If the required safe state is ON, you must use dual digital output modules for **High Demand** applications.

Analogue Output

For Analogue Output the following applies:



WARNING: For Continuous Mode applications the measures specified in this section for High Demand applications must be applied.

Table 8 - Modules for SIL 2 Fault Tolerant High demand Architecture

Position	Module Type
I/P A & B	2 × T9401/2 Digital Input Module, 24 Vdc, 8/16 Channel + T9802 Digital Input TA, 16 Channel, Dual or 2 × T9431/2 Analogue Input Module, 8/16 channel + T9832 Analogue Input TA, 16 Channel, Dual 1 × T9300 I/O Base unit
CPU A & CPU B	2 x T9110 Processor, T9100 Processor Base Unit
O/P A & B	2 × T9451 Digital Output Module, 24 Vdc, 8 Channel + T9852 Digital Output TA, 24 Vdc, 8 channel, T9300 Base Unit or 2 x T9481/T9842 Analogue Output Module, 3/8 Ch, Isolated + T9882 Analogue Output TA, 8 Ch, Dual and T9300 Base Unit

SIL 3 Architectures

SIL 3 architectures have at least two or three processor modules and are applicable for use with:

- SIL 3 de-energize to trip applications.
- SIL 3 energize to action applications when fitted with dual digital output modules.
- SIL 3 high demand applications where the required safe state is more than 4 mA, when fitted with dual analogue output modules (A 'safe state' is an output configured to go to a specific value, or configured to hold last state).

Faulted input modules in a SIL 3 arrangement can be replaced without a time limit; faulted output modules must be replaced within the MTTR assumed in the PFD calculations.

In all SIL 3 architectures, when the processor modules have degraded to 1001D on the first detected fault, the system must be restored to at least 1002D by replacing the faulty processor module within the MTTR assumed in the PFD calculations or all SIL 3 safety instrumented function and high demand safety instrumented functions must be shut down.

SIL 3 Fail-safe I/O, Fault Tolerant Processor

A SIL 3, fail-safe I/O with a fault tolerant processor architecture has a simplex input and output arrangement with dual or triple processor modules. The dual processor modules operate in 1002D under no fault conditions and degrade to 1001D on detection of the first fault in either module. When there are faults on both modules the configuration fails-safe.

Table 10 - Modules for SIL 3 Fault Tolerant Architectures

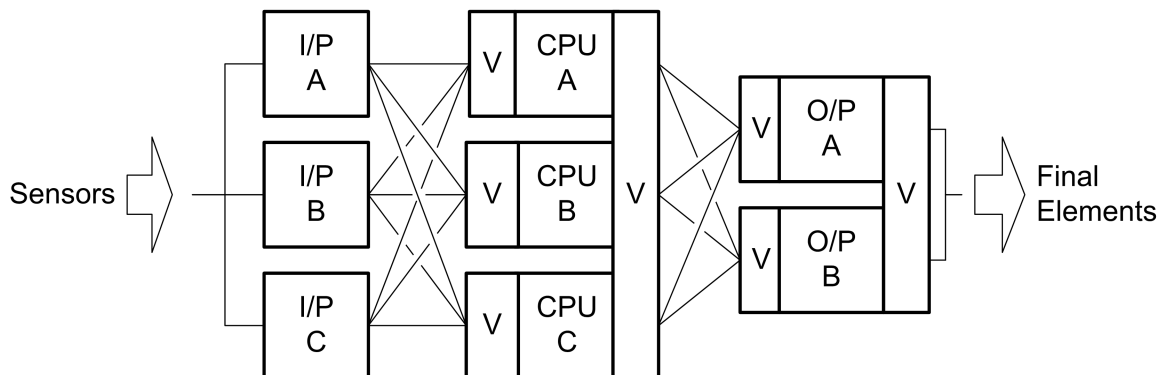
Position	Module Type
I/P A and I/P B	2 x T9401/2 Digital Input Module, 24 Vdc, 8/16 Channel + T9802 Digital Input TA, 16 Channel, Dual or 2 x T9431/2 Analogue Input Module, 8/16 Channel + T9832 Analogue Input TA, 16 Channel, Dual 2 x T9300 I/O Base Unit
CPU A & CPU B	2 x T9110 Processor Module, 9100 Processor Base Unit
O/P A and O/P B	1 x T9451 Digital Output Module, 24 Vdc, 8 Channel + T9851 Single Digital Output TA, 24 Vdc, 8 Channel for de-energize to action T9300 Base unit 2 x T9451 Digital Output Module, 24 Vdc, 8 Channel + T9852 Dual Digital Output TA for energize to action T9300 Base Unit Or 2 x T9481/T9842 Analogue Output Module, 3/8 Ch, Isolated + T9882 Analogue Output TA, 8 Ch, Dual T9300 Base Unit

SIL 3 TMR Input and Processor, Fault Tolerant Output

A SIL 3 TMR architecture offers the highest level of fault tolerance for an AADvance controller and consists of triple input modules, triple processors and dual output modules.

- The input and processor modules operate in a 2003D under no fault conditions, degrade to 1002D on detection of the first fault in any module, and degrade to 1001 on the detection of faults in any two modules and will fail-safe when there are faults on all three modules.

In the event of a failure in any element of a channel, the channel processor will still produce a valid output which could be voted on because of the coupling between the channels. This is why the triple modular redundant implementation supplies a configuration that is inherently better than a typical 2003 voting system.



Digital Output Modules

A digital output module fault must be repaired within the MTTR which was used in the PFD calculation. This rule applies to simplex digital output modules in de-energize to trip applications and to dual digital output modules in energize to action applications.

Specify I/O Base Units

The T9300 I/O base unit (3 way) is a single, standardized design which suits all termination assemblies and I/O modules. The base unit can have one triple modular redundant assembly, one dual assembly and one simplex assembly or up to three to simplex assemblies. The dual and triple modular redundant assemblies can bridge adjacent base units, so two base units can (for example) hold three dual assemblies.

Choosing Termination Assemblies

The use of termination assemblies gives the AADvance system flexibility for creating different architectures and expanding the system. Each termination assembly is a very simple circuit that is matched to a type of I/O module and to a specified module configuration. This table shows a summary of the termination assemblies which are available and the related I/O module configurations.

Table 17 - Choosing a Termination Assembly

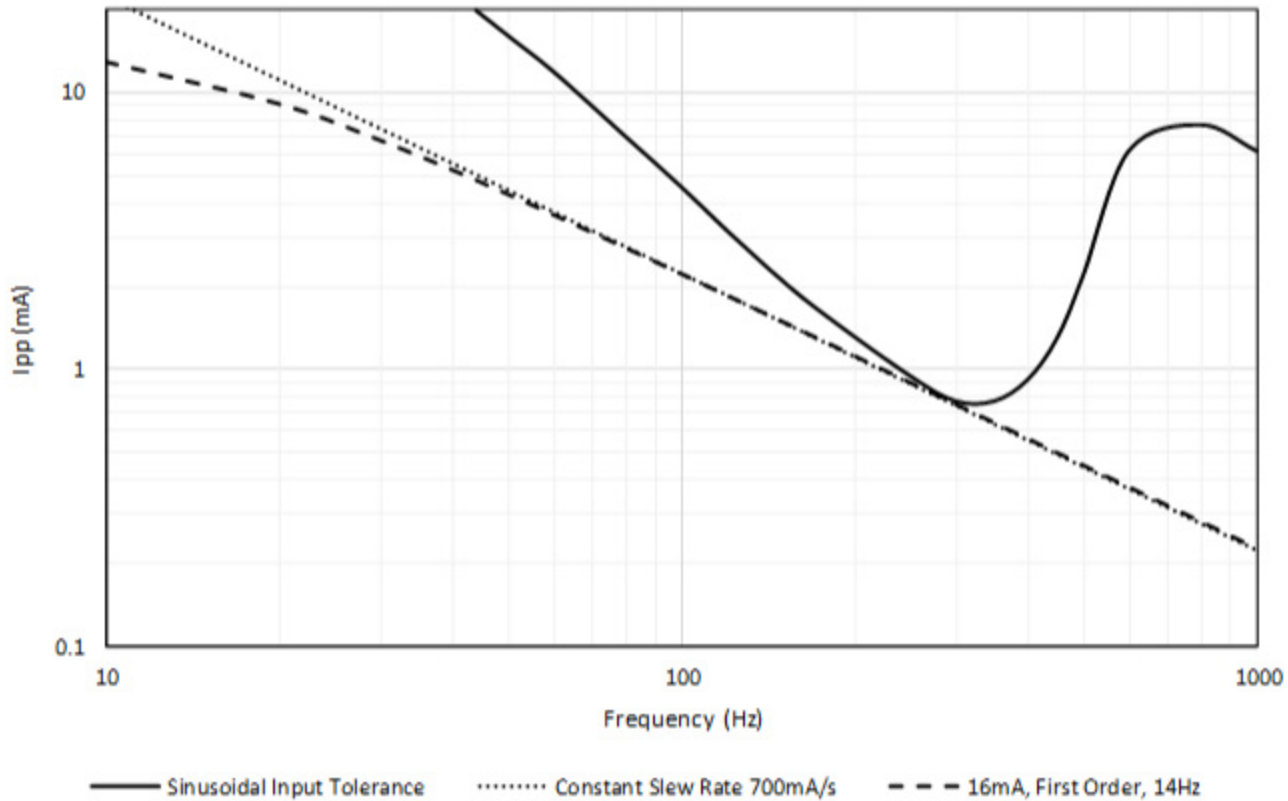
	Simplex I/O Module Configuration	Dual I/O Module Configuration	Triple I/O Module Configuration
Digital input	T9801, Digital Input TA, 16 channel, Simplex Commoned (non-isolated)	T9802, Digital Input TA, 16 channel, Dual	T9803, Digital Input TA, 16 channel, Triple
Analogue input	T9831, Analogue Input TA, 16 channel, Simplex, commoned (non-isolated)	T9832, Analogue Input TA, 16 channel, Dual	T9833, Analogue Input TA, 16 channel, Triple
Digital output	T9851, Digital Output TA, 8 channel, Simplex, commoned (non-isolated)	T9852, Digital Output TA, 8 channel, Dual (non-isolated)	Not applicable
Analogue Output	T9881, Analogue Output TA, 8 Channel, Simplex, commoned	T9882, Analogue Output TA, 8 channel, Dual	Not applicable

IMPORTANT The termination assemblies for inputs have 8-channel I/O modules and 16-channel I/O modules. A dual or triple arrangement can be made of 8- or 16-channel modules, but not a mixture of the two.

You need one termination assembly for each group of related modules. For example:

- Four T9401 digital input modules used in two, dual redundant configurations need two T9802 termination assemblies — one for each pair of modules
- Four T9401 digital input modules used for simplex inputs need four T9801 termination assemblies — one for each module

Figure 32 - Analogue Input Slew Tolerance



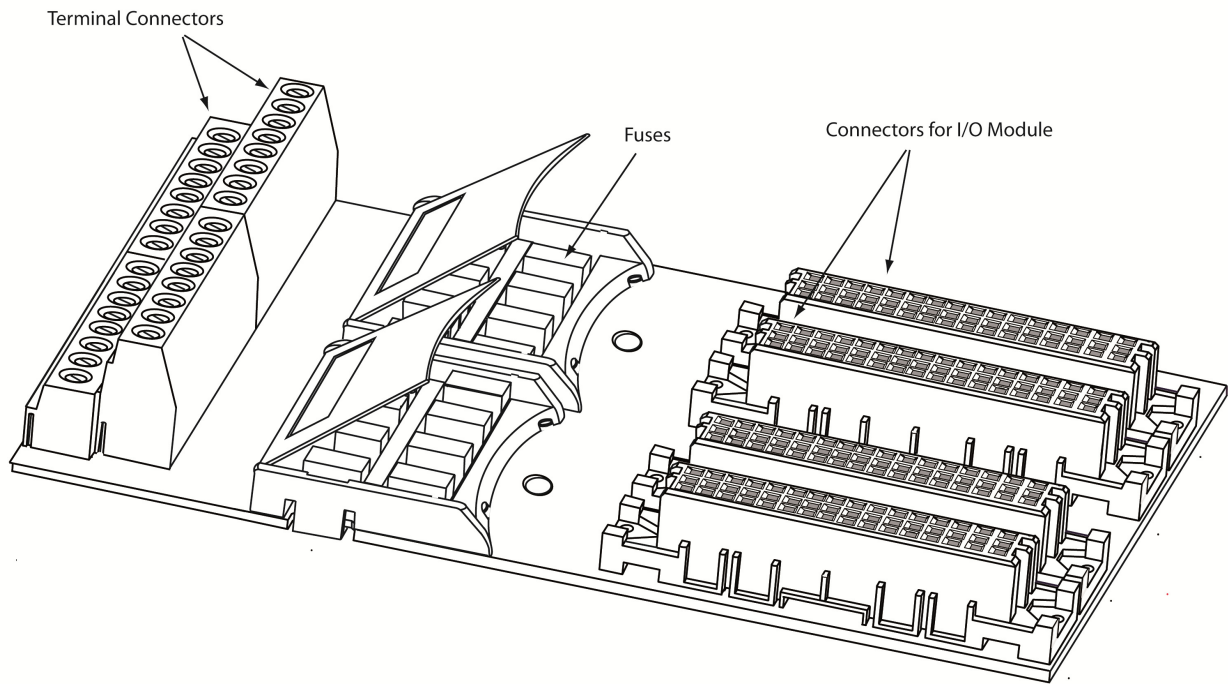
Transgression of the slew rate limits identified above may lead to channel failure resulting from diagnostics otherwise designed to verify that channels are operating within their defined safety accuracy.

T9831/2/3 Termination Assemblies for Analogue Inputs

There are three termination assemblies for use with analogue input modules for simplex, dual and triple modular redundant configurations.

A T9831 termination assembly is for a simplex application and has terminations for 16 non-isolated analogue inputs. It supports one T9431 or T9432 analogue input module. The T9832 and T9833 termination assemblies support 16 isolated analogue inputs for dual and triple modular redundant arrangements of analogue input modules. Illustrated is the T9832 termination assembly:

Figure 33 - Digital/Analogue Input Termination assembly



The termination assembly protects each sensor input signal by a 50 mA fuse. Fuses can be replaced without removing an I/O module or termination assembly.

Analogue Input Termination Assembly

A T9831 termination assembly is for a simplex configuration and has terminations for 16 non-isolated digital inputs. The T9832 and T9833 termination assemblies support 16 isolated digital inputs for dual and triple modular redundant arrangements of digital input modules.

Table 30 - T9831/2/3 Analogue Input TA Specification

Attribute	Value
Functional Characteristics	
Field connections	16; Wiring: Conductor cross section maximum 1.31mm ² (16 AWG); Stripping length 6mm (¼ in.)
Number of input modules supported	
T9831	One
T9832	Two
T9833	Three
Electrical Characteristics	
Input channel fuses	50 mA, 125 V, Type T manufactured by Littelfuse
Channel load	(135 ± 0.2 %) Ω
Channel isolation:	

Table 30 - T9831/2/3 Analogue Input TA Specification

Attribute	Value
T9831	None
T9832/T9833	± 1.5 kVdc Maximum withstanding for 1 minute
Maximum field loop power dissipation	0.08 W for each field loop (0.27 BTU/hr)

T9451 Digital Output Module, 24Vdc, 8 channel

The T9451 digital output module has 8 channels for a maximum of 8 field elements and can switch 1 A at 32 Vdc for each device. It features voltage and load current monitoring on each channel, reverse current protection and short and open circuit line monitoring. It is designed to always be able to switch off an output when demanded. No single failure in the module can cause a stuck-on failure. The module supports dual redundant power feeds for field devices without the need for external diodes.

The output module isolates the processor module from the output channel control and data management circuits, thus protecting the processor module from possible faults in the output control circuits and field connections. An output channel protection activates when the channel load exceeds a safe limit. And, a reverse voltage protection circuit in each output channel verifies that externally applied voltages do not supply current flow into the module outputs.

The module has self-checking functionality. Short circuit and open circuit line monitoring is supplied on all outputs (see article [605753](#) on the Rockwell Automation Knowledgebase website). Internal diagnostics do ongoing functionality checks ensuring that the output channel command data is correctly transferred to the output. The processor module initiates a test sequence on each output channel, checking for 'stuck-on' and 'stuck-off' conditions on the output switch pairs. Front panel LEDs give module, channel and field connection status indications. These status indications can also be connected to application variables and viewed at the Workbench.

When a controller uses a pair of digital output modules in a dual configuration, the two fail-safe output switches on each channel are combined in a parallel arrangement so that they automatically form a fault-tolerant output configuration.

The AADvance Workbench has settings for individual digital output channels:

- You can specify a shutdown state for an output channel that defines how the output will behave when the module is in a shutdown mode.
- You can disable the line test feature for an output that disables detection of a no-load condition (e.g. for used output channels).

T9451 Digital Output Module Specification

Table 31 - Digital Output Module Specification

Attribute	Value
Functional Characteristics	
Output channels	8
Performance Characteristics	

Parts List

Base Units

Part No.	Part Description
T9100	Processor base unit
T9300	I/O base unit (3 way)

Modules

Part No.	Part Description
T9110	Processor module
T9401	Digital input module, 24 Vdc, 8 channel, isolated
T9402	Digital input module, 24 Vdc, 16 channel, isolated
T9451	Digital output module, 24 Vdc, 8 channel, isolated, commoned
T9431	Analogue input module, 8 channel, isolated
T9432	Analogue input module, 16 channel, isolated
T9481	Analogue output module, 3 channel, isolated
T9482	Analogue output module, 8 channel, isolated

Special Application Modules

Part No.	Part Description
T9441	Frequency Input Module (Product not yet released. Contact Sales for more information)

Termination Assemblies

Part No.	Part Description
T9801	Digital input TA, 16 channel, simplex, commoned
T9802	Digital input TA, 16 channel, dual
T9803	Digital input TA, 16 channel, TMR
T9831	Analogue input TA, 16 channel, simplex, commoned
T9832	Analogue input TA, 16 channel, dual
T9833	Analogue input TA, 16 channel, TMR
T9851	Digital output TA, 24Vdc, 8 channel, simplex, commoned
T9852	Digital output TA, 24Vdc, 8 channel, dual
T9881	Analogue output TA, 8 channel, simplex commoned