

NOTE Simplex output modules used for energize to action applications can only be used for low demand applications.

Table 5 - Modules for SIL 2 Fail-Safe Architecture

Position	Module Type
I/P A	T9401/2 Digital Input Module, 24 Vdc, 8/16 Channel + T9801 Digital Input TA, 16 Channel, Simplex. or T9431/2 Analogue Input Module, 8/16 Channel + T9831 Analogue Input TA, 16 Channel, Simplex T9300 I/O Base Unit
CPU A	2 x T9110 Processor Module, T9100 Processor Base Unit
O/P A	T9451 Digital Output Module, 24 Vdc, 8 Channel, Isolated + T9851 Digital Output TA, 24 Vdc 8 Channel, Simplex 1 x T9481/T9842 Analogue Output Module, 3/8 Ch, Isolated + T9881 Analogue Output TA, 8 Ch, Simplex

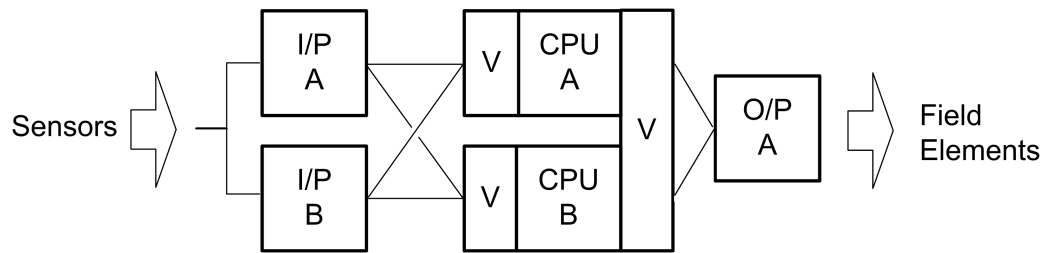
SIL 2 Fault Tolerant Input Architectures

A SIL 2 fault tolerant input architecture can have dual or triple input modules with a dual processor and single output modules. The illustration shows a dual input arrangement where the dual input modules operate in 1002D under no fault conditions, they degrade to 1001D on detection of the first fault in either module of the redundant pair, and when a fault occurs on the second module the controller fails-safe.

The processor operates 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. The output module operates in 1001D under no fault conditions and fail-safe on the first detected fault.

When a triple input module arrangement is configured the group of input modules operate in 2003D under no fault conditions, degrade to 1002D on the detection of first fault in any module, then degrade to 1001D on the detection of faults in any two modules and fail-safe when there are faults on all three modules.

NOTE Simplex output modules used for energize to action applications can only be used for low demand applications.



V = voting

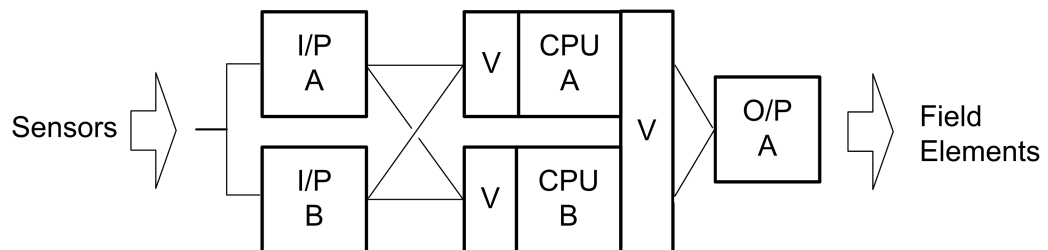
Table 6 - Modules for SIL 2 Architecture

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 × 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 × 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:

- The fail-safe state current of the analogue output module is less than 2 mA.
- A **safe state** is an output configured to go to a specific value, or configured to hold last state. If the required safe state is larger than 4 mA, you must use dual analogue output modules for **High Demand** applications.

Table 7 - Modules for SIL 2 Fault Tolerant Output Architecture

Position	Module Type
I/P A & B	T9401/2 Digital Input Module, 24 Vdc, 8/16 Channel + T9801 Digital Input TA, 16 Channel, Simplex or T9431/2 Analogue Input Module, 8/16 Channel + T9831 Analogue Input TA, 16 Channel, Simplex T9300 Base Unit
CPU A	2 x T9110 Processor Module, T9100 Processor Base Unit
O/P A	T9451 Digital Output Module, 24 Vdc, 8 Channel + T9851 Digital Output TA, 24 Vdc, 8 Channel, Dual and T9300 I/O Base Unit or 1 x T9481/T9842 Analogue Output Module, 3/8 Channel, Isolated + T9881 Analogue Output TA, 8 Ch, Simplex

SIL 2 Fault Tolerant Input and SIL 2 High Demand Architecture

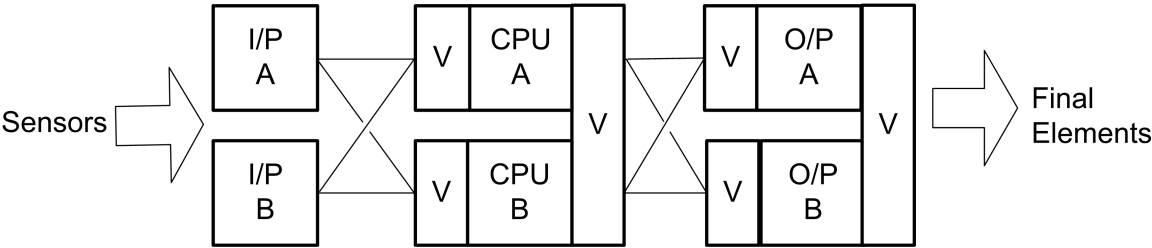
A SIL 2 fault tolerant "High Demand" architecture has dual input, dual processor and dual output modules. In a dual arrangement the input modules operate in 1002D under no fault conditions, degrade to 1001D on the detection of the first fault in either module, and will fail-safe when there are faults on both modules.

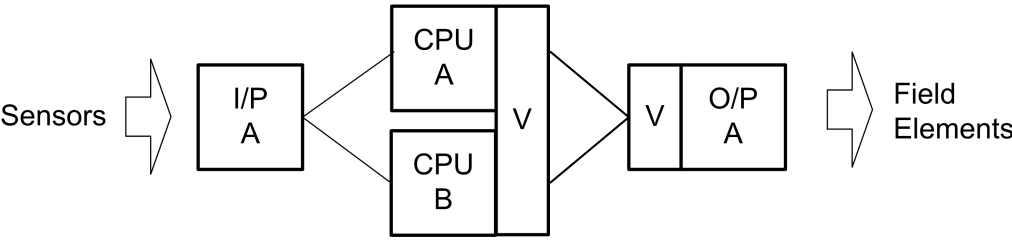
A triple input module arrangement can also be configured if it is required to increase the fault tolerance of the input. When a triple input module arrangement is configured the input modules operate in a 2003D under no fault conditions, degrade to 1002D on detection of the first fault in any module, then degrade to 1001D on the detection of faults in any two modules, and will fail-safe when there are faults on all three modules.

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. For high demand applications the processor must be repaired within the MTTR assumed in the PFD calculations or the high demand safety instrumented functions must be shut down.



WARNING: For **High Demand** applications you must use a minimum of a dual processor configuration. High demand energize to action applications will require dual output modules. (Analogue Output Modules where the normal output current is less than 4 mA are classed as energize to action applications).





If required you can configure triple processor modules as a variation of this SIL 3 architecture. Using this arrangement the processor modules operate in 2003D under no fault conditions and 1002D on the detection of the first fault in any module. They degrade to 1001D on the detection of faults in any two modules and fail-safe when there are faults on all three modules.

Digital Output Modules

- For de-energize to action operation one 9451 output module is sufficient for SIL 3 requirements. However, for energize to action operation, dual digital output modules are required.
- 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.

Analogue Output Modules

- The fail-safe state current of the analogue output module is less than 2 mA.
- If the required safe state is more than 4 mA, you must use dual analogue output modules for high demand applications.
- An analogue output module fault must be repaired within the MTTR which was used in the PFD calculation. This rule applies to simplex analogue output modules where the safe state is less than or equal to 4 mA and to dual analogue output modules where the safe state is more than 4 mA.

Table 9 - Modules for SIL 3 Fail-safe I/O, Fault Tolerant Processor

Position	Module Type
I/P A	T9401/2 Digital Input Module, 24 Vdc, 8/16 Channel + T9801 Digital Input TA, 16 Channel, Simplex or T9431/2 Analogue Input Module, 8/16 channel + T9831 Analogue Input TA, 16 Channel, Simplex T9300 Base unit
CPU A & CPU B	2 x T9110 Processor Module, T9100 Base Unit
O/P A	1 x T9451 Digital Output Module, 24 Vdc, 8 Channel + T9851 Digital Output TA, 24 Vdc, 8 Channel, Simplex or 1 x T9481/T9842 Analogue Output Module, 3/8 Ch, Isolated + T9881 Analogue Output TA, 8 Ch, Simplex

SIL 3 Fault Tolerant I/O Architectures

A SIL 3 fault tolerant I/O is achieved by dual input and output module configurations with dual or triple processor modules. The processor modules operate in 1002D under no fault conditions, degrade to 1001D on the detection of the first fault in either module and fail-safe when there are faults on both modules.

Table 13 - Input Modules

Modules	Certified Configuration	Conditions
Digital Inputs T9401/2, 24 Vdc, 8/16 Channel, isolated. + T9801/2/3 Digital Input TA, 16 channel, Simplex/Dual/TMR	1oo1D, 1oo2D, 2oo3D	De-energized to action (normally energized): SIL 3 with 1, 2 or 3 modules fitted. Energize to action (normally de-energized): with 1, 2 or 3 modules fitted Note: When the integrity level is at 1oo1D then the faulty module must be replaced to restore the integrity level back to 1oo2D.
Analogue Inputs T9431/2, 8/16 Channel, isolated + T9831/2/3 Analogue Input TA, 16 Channel, Simplex/Dual/TMR	1oo1D, 1oo2D, 2oo3D	Within the manufactures specified safety accuracy limits of 1 %. The safety state of the analogue input has to be set to a safe value which is a calculated value based on a count value of 0 mA. (refer to the AADvance Configuration Guide Doc Nos: ICSTT-RM405 and ICSTT-RM458 for more details) SIL 3 with 1, 2 or 3 modules fitted. Note: When the integrity level is at 1oo1D then the faulty module must be replaced within the MTTR assumed for the PFD calculations to restore the integrity level back to 1oo2D.

Table 14 - Output Modules

Modules	Certified Configuration	Conditions
Digital Outputs T8451, 24 Vdc, 8 channel + T9851/2 TA, 24 Vdc, 8 Channel, Simplex/Dual	1oo1, 1oo2 or 1oo2D	De-energize to action (normally energized): SIL 3 with 1 or 2 modules fitted. (1oo2D with dual output modules fitted). Energize to action (normally de-energized): SIL 2 with 1 module fitted and SIL 3 with 2 modules fitted. A faulty digital output module must be repaired or replaced within the MTTR which was used in the PFD calculation. This rule applies to all simplex digital output modules and to dual digital output modules in energize to action applications.
Analogue Outputs T9481/T9842 Analogue Output Module, 3/8 Ch, Isolated + T9881/T9882, TA, 8Ch, Simplex/Dual	1oo1, 1oo2 or 1oo2D	SIL 3 with 1 or 2 modules fitted where the safe state is less than or equal to 4 mA SIL 3 with 2 modules fitted where the safe state is more than 4 mA (1oo2D with dual output modules fitted). A faulty analogue output module must be repaired or replaced within the MTTR which was used in the PFD calculation. This rule applies to all simplex analogue output modules and to dual analogue output modules where the safe state is > 4 mA

Table 15 - Auxiliary Modules

Modules	Conditions
Processor Base T9100	Safety-related and can be used for safety critical applications in SIL 2 applications with 2 modules fitted or SIL 3 applications with 2 or 3 modules fitted
I/O Base T9300 (3-way)	Safety-related and can be used for safety critical applications in SIL 3.

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

T9481/2 Analogue Output Module Specification

Table 33 – Analogue Output Module Specification

Attribute	Value
Functional Characteristics	
Output channels	T9481: 3 T9482: 8
Performance Characteristics	
Safety integrity level	
Safety level degradation	1oo1D, 1oo2D
Safety accuracy	200 μ A
Self-test interval	< 1 hour, system dependent
Value of least significant bit (control)	0.98 μ A
Value of least significant bit (monitor)	3.9 μ A
Error at 25 °C $\pm$ 2 °C After 1 year at 40 °C After 2 years at 40 °C After 5 years at 40 °C	0.30 % + 10 μ A 0.35 % + 10 μ A 0.44 % + 10 μ A
Temperature drift	(0.01 % + 0.1 μ A) for each °C
Electrical Characteristics	
Module supply voltage:	
Voltage	Redundant +24 Vdc nominal; 18 Vdc to 32 Vdc range
Module supply power dissipation	3.6 W (12.3 BTU/hr.)
Output voltage:	
Maximum voltage without damage	$\pm$ 60 Vdc
Operating field supply voltage	18 - 32 Vdc
Output current	
Nominal	4 - 20 mA
Maximum range	0.1 - 24 mA
Calibrated accuracy at 25 °C	10 μ A
Output current control resolution	0.98 μ A, 15-bit
Output current control accuracy at 25 °C	$\pm$ 10 μ A
Output current monitoring resolution	3.9 μ A, 13-bit
Compliance voltage	3 Vdc to 32 Vdc
Maximum Compliance voltage slew rate	No limit identified within Compliance voltage range.
Load impedance	
Maximum range	0 - 750 Ω limited by compliance voltage
Typical	250 Ω
Maximum field loop power dissipation	0.77 W for each field loop (2.63BTU/hr.)
Mechanical Specification	
Dimensions (height $\times$ width $\times$ depth)	166 mm $\times$ 42 mm $\times$ 118 mm (6-1/2 in. $\times$ 1-21/32 in. $\times$ 4-21/32 in.)
Weight	290 g (10.5 oz.)
Casing	Plastic, non flammable

T9881/2 Termination Assemblies for Analogue Outputs

T9881 is a simplex 8 channel termination assembly and T882 is the dual termination assembly. Each channel has a capacitor in series with the output.

T9881/2 Analogue Output Termination Assembly Specification

Table 34 - Analogue Output Module TA Specification

Attribute	Value
Functional Characteristics	
Field connections	8; Wiring: Conductor cross section maximum 1.31 mm ² (16 AWG); Stripping length 6mm (¼ in.)
Modules supported	T9881: One T9882: Two
Electrical Characteristics	
Channel isolation	± 1.5 kVdc maximum withstand for 1 minute
Mechanical Specification	
Dimensions (height x width)	
T9881	132 mm × 42 mm (5-¼ in. × 1-21/32 in.)
T9882	132 mm × 84 mm (5-¼ in. × 3-5/16 in.)
Weight	
T9881	133 g (5 oz.)
T9882	260 g (10 oz.)

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