DATASHEET

NI 9351

4-Ch 0 mA to 20 mA 16-bit AI, 4-Ch 24 V Sinking DI, 4-Ch 24 V Sourcing DO, SIL3 Capable

- Certified SIL3 capable
- DI/DO safety response time <250 µs
- AI safety response time <2.1 ms
- Contains user-programmable and automatic self-diagnostics
- 60 V DC, CAT I, channel-to-earth isolation
- Spring terminal connectivity
- Only compatible with CompactRIO Scan Mode on CompactRIO Controllers and CompactRIO ENET Chassis

The NI 9351 is a C Series Functional Safety module for any NI CompactRIO controller system. The NI 9351 employs self-contained logic operations supporting boolean logic with state machines. This module drives a 24 V digital signal to control safety devices such as contactors, gate switches, and control valves.

Caution This icon denotes a caution advising you to take precautions to avoid injury.

Note The Functional Safety Editor only runs on 64-bit Windows 7, Windows 8.1, or later. The application is not compatible with 32-bit Windows versions.

C Series Functional Safety Module Kit Contents

- NI 9351
- NI 9351 Getting Started Guide
- Strain Relief and Protection with Connector for 26-Position Connector Blocks, (Connector Backshell) NI part number 785525-01

- 3 kΩ external pull-down resistors
- NI PS-14 power supply

C Series Functional Safety Overview

C Series Functional Safety modules can connect to sensors or final elements and allow for fast safety response that meets the demands of the process industry and production engineering.

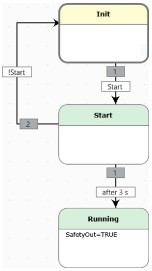
- SIL3 capability and measurement class I/O in a single module
- Combine safety automation with monitoring and control applications using the same platform
- -40 °C to 70 °C temperature range to meet a variety of application and environmental needs

CompactRIO

CompactRIO combines an open-embedded architecture with small size, extreme ruggedness, and C Series modules in a platform powered by the NI LabVIEW reconfigurable I/O (RIO) architecture. Each system contains an FPGA for custom timing, triggering, and processing with a wide array of available modular I/O to meet any embedded application requirement.

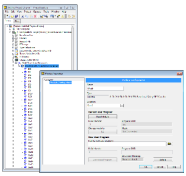
Functional Safety Software

Functional Safety Editor



- Design state machines to monitor and control safety systems
- Configure Fail-safe diagnostics
- Define output behavior by state
- Connect states with Boolean text-based transitions and wait timers
- Create and compile User Programs that download to C Series Functional Safety modules

LabVIEW Professional Development System for Windows

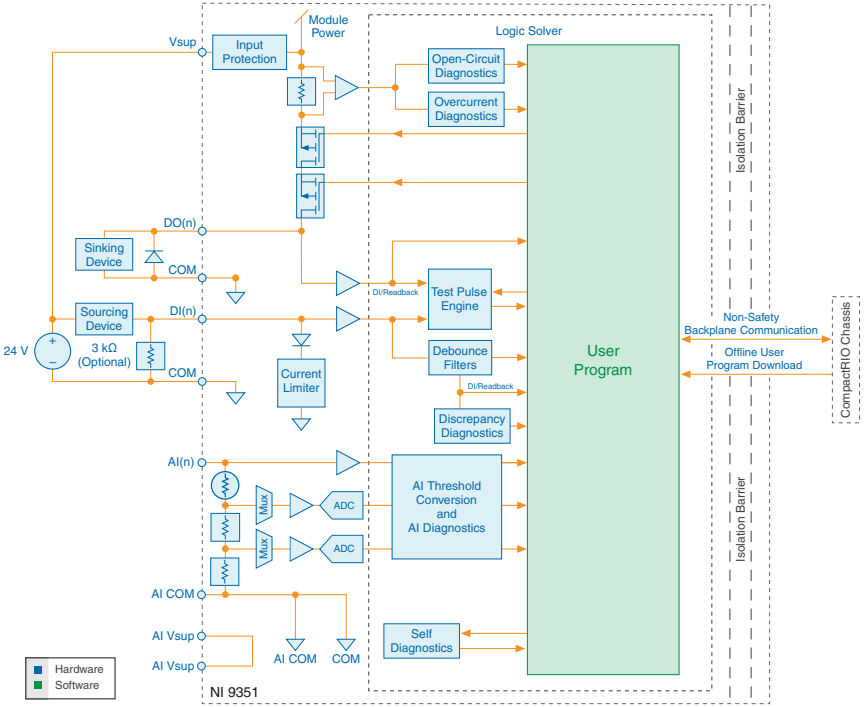


- Create projects to monitor C Series Functional Safety modules
- Download User Programs to C Series Functional Safety modules
- Read faults and module operating modes

NI LabVIEW Real-Time Module

- Develop VIs to monitor safety modules
- Read Boolean diagnostics and operating modes
- Read inputs and variables from the C Series Functional Safety module
- Configure non-safety digital output

NI 9351 Input/Output Circuitry



The analog input signals are scanned, amplified, conditioned, and then sampled by two independent ADCs. The module provides overvoltage protection for each channel. Only one channel can be in an overvoltage condition at a time.

NI 9351 Specifications

The following specifications are typical for the range -40 °C to 70 °C unless otherwise noted.

Caution Do not operate the NI 9351 in a manner not specified in this document. Product misuse can result in a hazard. You can compromise the safety protection built into the product if the product is damaged in any way. If the product is damaged, return it to NI for repair.

Input/Output Characteristics

Number of channels	4 analog input 4 digital input 4 digital output

Analog Input

Analog input range	
Minimum	0 mA to 24 mA
Typical	0 mA to 25.5 mA
ADC resolution	16 bit
Type of ADC	Successive approximation register (SAR)
Sampling mode	Scanned
AI V_{sup}	
Current	2 A, maximum
Voltage	30 V, maximum

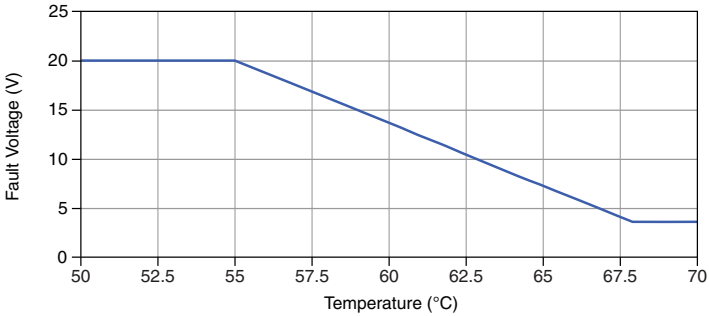
Table 1. Accuracy

Calibrated Measurement Conditions	Percent of Reading (Gain Error)	Percent of Range[1] (Offset Error)
Typical (25 °C ± 5 °C)	±0.12%	±0.03%
Maximum (-40 °C to 70 °C, 2 years)	±0.47%	±0.13%
Typical (-40 °C to 70 °C, 20 years)	±0.90%	±0.20%

Sample rate	1 kS/s
Input noise	400 nA RMS
Overvoltage protection, channel-to-COM	20 V, single-channel, up to 55 °C
Fault voltage derating	Refer to the following figure.

[1] Range equals 24 mA

Figure 1. Fault Voltage Derating Across Operating Temperature Range

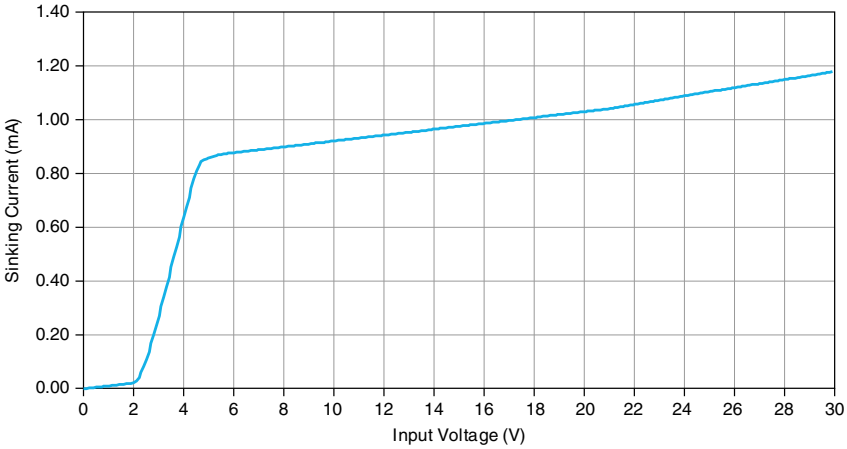


Stability	
Gain drift	22 ppm/°C
Offset drift	174 nA/°C
Input bandwidth (-3 dB)	12.4 kHz
Input impedance	82 Ω, typical 200 Ω, maximum

Digital Input

Input type	Sinking
Input voltage range	0 V to 30 V
Digital logic levels	
OFF	
Input voltage	≤6.0 V
ON	
Input voltage	≥11.0 V
Input current at 24 V	1.1 mA
Hysteresis	3.0 V
Digital input sinking current	Refer to the following figure.

Figure 2. Digital Input Sinking Current vs Digital Input Voltage



Input voltage protection	±30 V DC

Digital Output

Output type	Sourcing
Minimum ON time	190 µs

Caution You must enforce minimum ON time or the channel may fail to de-energize in an overcurrent or short-circuit condition. Failure to de-energize in an overcurrent or short-circuit condition may damage the module.

Minimum OFF time	170 µs

Caution You must enforce minimum OFF time except when the channel is configured with test pulses. Test pulse width may be smaller than the minimum OFF time.

Continuous output current (per channel)	250 mA, maximum
ON state voltage drop (V_{sup} pin to DO pin)	45 mV + (channel output current) × 0.3 Ω, maximum
OFF state leakage current	0.2 mA, maximum
Required external load	50 kΩ, maximum

Note The required external load must be present on DO configurations with internal readback or internal test pulse. A readback fault or test pulse fault may occur if the required external load is not present.

Load capacitance	0.5 µF, maximum
Cable length	200 m, maximum
Open circuit detection	11 mA 2 mA, minimum 20 mA, maximum
Protection	
Voltage	0 V to V_{sup}, maximum
Reverse Voltage	None
Overcurrent channel disable	>250 mA, minimum 340 mA, maximum

Note Transient loads exceeding overcurrent protection will trigger an overcurrent fault. This does not apply to inrush currents required to drive the specified load capacitance and cable length.

Safety Response Times

Note These specifications list *minimum guaranteed* times unless otherwise noted.

Note For more information on how to calculate response times, refer to the *C Series Functional Safety Manual* on *ni.com/manuals*.

Total C Series Functional Safety Module Response Time

Digital Configurations	
Single input and dual input	122 µs
Single input with test pulse and dual input with test pulse	230 µs
Analog Configurations	
Single input (1oo1)	2.065 ms
Dual input (1oo2)	2.065 ms
Triple input (2oo3)	2.065 ms
Application processing time	60 µs
Output signal response time[2]	5 µs, maximum

[2] Includes delay time from a change in safety processing logic output to the digital output turning off. This does not include the discharge time for the output load.

Digital Input Signal Response Time

Input signal response time (1 to 0)	
Single or dual input	57 µs
Single or dual input with test pulses	165 µs

Note Input signal response time (1 to 0) assumes a 3 kΩ external pull-down, 50 m cable length with capacitance <180 pF/m, and the debounce filter and test pulse width set to the minimum values for the given configuration.

Input signal response time (0 to 1)	
Single input	20 µs
Dual input	122 µs
Single input with test pulses	346 µs
Dual input with test pulses	649 µs

Note Input signal response time (0 to 1) assumes the debounce filter, test pulse width, and discrepancy time are set to minimum values for the given configuration.

Input discharge time (1 to 0)	40 µs

Note Input discharge time represents a 30 V to low state voltage threshold crossing. The maximum input discharge time assumes a 3 kΩ external pull-down, 50 m cable length with a capacitance <180 pF/m.

Analog Input Signal Response Time

Single input	2 ms
Dual input (1oo2)	2 ms
Triple input (2oo3)	2 ms

Automatic Self-Diagnostics Test Interval

Temperature fault	1.01 s
Analog input self-diagnostic faults	2 ms
Other automatic self-diagnostic faults	160 µs
Power down response time[3]	435 µs

[3] Includes delay time from a change in safety processing logic output until power down activates. This does not include the discharge time for the internal 40 µF bulk capacitance or the output load.

User-Configurable Diagnostic Response Time	
Digital Configurations	
Overcurrent	145 µs
Open circuit	145 µs
Test pulse	340 µs with output line load configured to very light
Internal readback	150 µs with output line load configured to very light
External readback	149 µs
Dual input discrepancy	159 µs

Note Test pulse and internal readback diagnostic response times depend on the output line load. Output line load is a configurable parameter for digital outputs in the Functional Safety Editor. For more information on configuring output line loads, refer to the *C Series Functional Safety Manual* on *ni.com/manuals*.

Analog Configurations	
Overcurrent fault	2 ms
Discrepancy fault	3.002 ms
Discrepancy warning	3.002 ms

Note User-configurable diagnostics assume the minimum values for test pulse width, test pulse period, discrepancy time, read back delay, and output line load.

Power Requirements

Power consumption from chassis	
Active mode	60 mW, maximum
Sleep mode	200 µW, maximum
Thermal dissipation (at 70 °C)	
Active mode	1.5 W, maximum
Sleep mode	1.5 W, maximum

External Power Supply Requirements

Caution You must use an appropriate power source to limit output power in case of a fault. For a list of required power supply categories, refer to the *C Series Functional Safety Manual* on *ni.com/manuals*.

Voltage input range	19 V DC to 30 V DC

Note The NI 9351 includes input power protection circuitry. If the voltage at V_{sup} falls outside the voltage input range, the module will power down and all channels will de-energize. You must cycle external power to the module to resume operation.

Power consumption, active or sleep mode	
No DO load	1.05 W, maximum
Full DO load, 30 V input	31.3 W, maximum

Physical Characteristics

If you need to clean the module, wipe it with a dry towel.

Tip For two-dimensional drawings and three-dimensional models of the C Series module and connectors, visit *ni.com/dimensions* and search by module number.

Spring terminal wiring	
Wire length	30 cm (12 in.), minimum
COM jumper length	30 cm (12 in.), minimum
Gauge	0.50 mm^2 to 1.5 mm^2 (20 AWG to 16 AWG) copper conductor wire, if using single wire per spring terminal; 0.34 mm^2 (22 AWG) copper conductor wire, if using two wires per spring terminal
Wire strip length	10 mm (0.39 in.) of insulation stripped from the end
Insulation temperature rating	90 °C, minimum
Wires per spring terminal	One solid or stranded wire per spring terminal; two stranded wires per spring terminal using a two-wire ferrule
Ferrules	
Single ferrule, uninsulated	0.50 mm^2 to 1.5 mm^2 (20 AWG to 16 AWG), 10 mm barrel length
Single ferrule, insulated	0.50 mm^2 to 1.0 mm^2 (20 AWG to 18 AWG), 12 mm barrel length
Two-wire ferrule, insulated	2x 0.34 mm^2 (2x 22 AWG), 12 mm barrel length
Connector securement	
Securement type	Screw flanges provided
Torque for screw flanges	0.25 N · m (2.2 lb · in.)

Weight[4]	210 g (7.4 oz)

Safety Voltages

Connect only voltages that are within the following limits:

Caution Do not connect hazardous voltages to the NI 9351. A hazardous voltage is a voltage greater than 42.4 V peak voltage or 60 V DC to earth ground.

Maximum voltages	
V_{sup}-to-COM	30 V DC
DI-to-COM	30 V DC
DO-to-COM	0 V DC to V_{sup}
AI-to-COM	20 V DC
AI V_{sup}-to-COM	30 V DC

Caution DO channels are not protected for negative voltages or voltages greater than V_{sup}.

Isolation voltages	
Channel-to-earth[5] (up to 5,000 m)	
Continuous	60 V DC, Measurement Category I
Withstand	1,000 V RMS, verified by a 5 s dielectric withstand test

Measurement Category I is for measurements performed on circuits not directly connected to the electrical distribution system referred to as *MAINS* voltage. MAINS is a hazardous live electrical supply system that powers equipment. This category is for measurements of voltages from specially protected secondary circuits. Such voltage measurements include signal levels, special equipment, limited-energy parts of equipment, circuits powered by regulated low-voltage sources, and electronics.

Caution Do not connect the NI 9351 to signals or use for measurements within Measurement Categories II, III, or IV.

Note Measurement Categories CAT I and CAT O are equivalent. These test and measurement circuits are for other circuits not intended for direct connection to the MAINS building installations of Measurement Categories CAT II, CAT III, or CAT IV.

[4] Includes 26-pin spring terminal and connector backshell.
[5] Channels include V_{sup}, AI V_{sup}, and COM.

Hazardous Locations

U.S. (UL)	Class I, Division 2, Groups A, B, C, D, T4; Class I, Zone 2, AEx nA IIC T4 Gc
Canada (C-UL)	Class I, Division 2, Groups A, B, C, D, T4; Ex nA IIC T4 Gc
Europe (ATEX) and International (IECEx)	Ex nA IIC T4 Gc

Functional Safety Standards

This product is designed for Functional Safety applications and meets the following standards:

- IEC/EN 61508:2010; Functional Safety of Electrical Systems, Second Edition
- IEC/EN 62061; Safety of Machinery
- IEC/EN 61511; Safety Instrumented Systems for the Process Industry Sector

Functional Safety Certification

Safety Integrity Level	SIL3 (IEC 61508)
Hardware fault tolerance	0
Useful lifetime	
At 55 °C	20 years
At 70 °C	10 years

Note Useful lifetime specifications assume constant operation at the given temperature. If temperatures periodically drop below the given temperature, the useful lifetime will be longer than specified.

Table 2. IEC 61508 Failure Rates in FIT[6]

Failure Categories	λ_{SD}	λ_{SU}	λ_{DD}	λ_{DU}
Common, sea level	419	10	282	10
Common, 2,000 m	858	11	720	10
Common, 5,000 m	4,100	14	3,970	13
AI common	70.1	0.9	110	1.4
AI per channel	0.8	0.01	1.4	0.3
DI common	7.0	0.1	19	0.2

[6] 1 FIT = 1 failure/10^9 hours

Table 2. IEC 61508 Failure Rates in FIT[6] (Continued)

Failure Categories	λ_{SD}	λ_{SU}	λ_{DD}	λ_{DU}
DI per channel	14	2.2	15	0.5
DO per channel	39	0.7	0.2	0.2

Safety Compliance and Hazardous Locations Standards

This product is designed to meet the requirements of the following electrical equipment safety standards for measurement, control, and laboratory use:

- IEC 61010-1, EN 61010-1
- UL 61010-1, CSA C22.2 No. 61010-1
- EN 60079-0:2012, EN 60079-15:2010
- IEC 60079-0: Ed 6, IEC 60079-15; Ed 4
- UL 60079-0; Ed 6, UL 60079-15; Ed 4
- CSA C22.2 No. 60079-0, CSA C22.2 No. 60079-15

Note For UL and other safety certifications, refer to the product label or the *Product Certifications and Declarations* section.

Electromagnetic Compatibility

This product meets the requirements of the following EMC standards for electrical equipment for measurement, control, and laboratory use:

- EN 61326-1 (IEC 61326-1): Class B emissions; Basic immunity
- EN 61326-3-1 (IEC 61326-3-1): Functional Safety Industrial Locations; Class B emissions; Industrial immunity
- EN 55011 (CISPR 11): Group 1, Class A emissions
- EN 55022 (CISPR 22): Class A emissions
- EN 55024 (CISPR 24): Immunity
- AS/NZS CISPR 11: Group 1, Class A emissions
- AS/NZS CISPR 22: Class A emissions
- FCC 47 CFR Part 15B: Class A emissions
- ICES-001: Class A emissions

Note In the United States (per FCC 47 CFR), Class A equipment is intended for use in commercial, light-industrial, and heavy-industrial locations. In Europe, Canada, Australia and New Zealand (per CISPR 11) Class A equipment is intended for use only in heavy-industrial locations.

[6] 1 FIT = 1 failure/10^9 hours

Note Group 1 equipment (per CISPR 11) is any industrial, scientific, or medical equipment that does not intentionally generate radio frequency energy for the treatment of material or inspection/analysis purposes.

Note For EMC declarations and certifications, and additional information, refer to the *Online Product Certification* section.

CE Compliance CE

This product meets the essential requirements of applicable European Directives, as follows:

- 2014/35/EU; Low-Voltage Directive (safety)
- 2014/30/EU; Electromagnetic Compatibility Directive (EMC)
- 2014/34/EU; Potentially Explosive Atmospheres (ATEX)

Product Certifications and Declarations

Refer to the product Declaration of Conformity (DoC) for additional regulatory compliance information. To obtain product certifications and the DoC for NI products, visit *ni.com/certification*, search by model number or product line, and click the appropriate link in the Certification column.

Shock and Vibration

To meet these specifications, you must panel mount the system.

Operating vibration	
Random	5 g_{rms}, 10 Hz to 500 Hz
Sinusoidal	5 g, 10 Hz to 500 Hz
Operating shock	30 g, 11 ms half sine; 50 g, 3 ms half sine; 18 shocks at 6 orientations

Environmental

Refer to the manual for the chassis you are using for more information about meeting these specifications.

Operating temperature (IEC 60068-2-1, IEC 60068-2-2)	-40 °C to 70 °C
Storage temperature (IEC 60068-2-1, IEC 60068-2-2)	-40 °C to 85 °C
Ingress protection	IP40
Operating humidity (IEC 60068-2-30)	10% RH to 90% RH, noncondensing
Storage humidity (IEC 60068-2-30)	5% RH to 95% RH, noncondensing

Pollution Degree	2
Maximum altitude	5,000 m

Indoor use only.

Environmental Management

NI is committed to designing and manufacturing products in an environmentally responsible manner. NI recognizes that eliminating certain hazardous substances from our products is beneficial to the environment and to NI customers.

For additional environmental information, refer to the *Minimize Our Environmental Impact* web page at *ni.com/environment*. This page contains the environmental regulations and directives with which NI complies, as well as other environmental information not included in this document.

Waste Electrical and Electronic Equipment (WEEE)

EU Customers At the end of the product life cycle, all NI products must be disposed of according to local laws and regulations. For more information about how to recycle NI products in your region, visit *ni.com/environment/weee*.

电子信息产品污染控制管理办法（中国 RoHS）

中国客户 National Instruments 符合中国电子信息产品中限制使用某些有害物质指令(RoHS)。关于 National Instruments 中国 RoHS 合规性信息，请登录 `ni.com/environment/rohs_china`。(For information about China RoHS compliance, go to `ni.com/environment/rohs_china`.)

Calibration

You can obtain the calibration certificate and information about calibration services for the NI 9351 at *ni.com/calibration*.

377936A-02 May 15, 2018