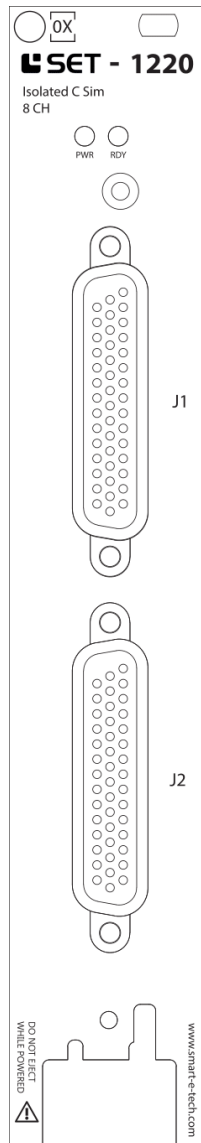


## TECHNICAL DESCRIPTION

# SET-1220

## 8 Channel Isolated Capacitance Emulation



This document 9040TDD0410 is a technical description of the SET-1220.



**Note** Before you begin, complete the Software and Hardware installation procedures applicable to your application.



**Note** The guidelines in this document are specific to the SET-1220. The other components in the system might not meet the same safety ratings. Refer to the documentation of each component in the system to determine the safety and EMC ratings for the entire system.

### MORE INFORMATION ON OUR WEBSITE:

[www.smart-e-tech.de/slsc](http://www.smart-e-tech.de/slsc)

# Safety Guidelines

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**Caution** Do not operate the SET-1220 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 for repair.

## Electromagnetic Compatibility Guidelines

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This product was tested and complies with the regulatory requirements and limits for electromagnetic compatibility (EMC). These requirements and limits provide reasonable protection against harmful interference when the product is operated in the intended operational electromagnetic environment.

This product is intended for use in industrial locations. However, harmful interference may occur in some installations, when the product is connected to a peripheral device or test object, or if the product is used in residential or commercial areas. To minimize interference with radio and television reception and prevent unacceptable performance degradation, install, and use this product in strict accordance with the instructions in the product documentation.

Furthermore, any changes or modifications to the product not expressly approved by SET GmbH could void your authority to operate it under your local regulatory rules.



**Caution** To ensure the specified EMC performance, operate this product only with shielded cables and accessories.



**Caution** To ensure the specified EMC performance, the length of any cable attached to connectors J1 and J2 must be no longer than 3 m (10 ft).



# Description


The SET-1220 card is a capacitive liquid level sensor emulation device for NI-SLSC. With 8 individually controlled emulation channels, a single SET-1220 card can emulate an entire liquid level sensor network for multi-tank and redundant-sensor applications. Each channel is galvanically isolated from each other channel, as well as the SLSC system ground. This allows the SET-1220 card to be used in concurrent test scenarios with multiple Devices Under Test (DUT) as well as in Hardware-in-the-Loop (HiL) applications.

To allow a wide capacitance emulation range over, the SET-1220 does not simulate a variable impedance between the drive input and the sense output. Instead, it exposes a constant impedance at the drive input and emulates a capacitance by providing a regulated current output at the sense terminal.

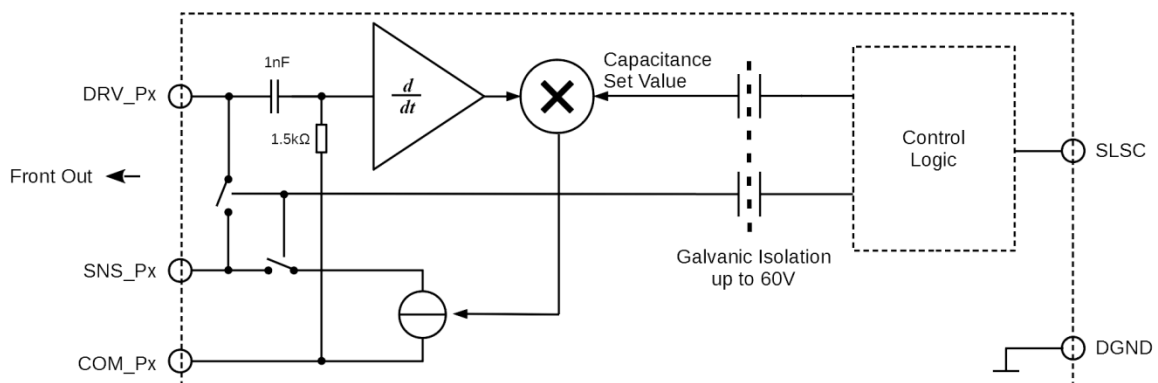
The SET-1220 features a wide excitation input voltage and frequency range as well as a wide capacitance emulation range from 10 pF to 800 pF. With 16-bit capacitance resolution and settling time of only 50  $\mu$ s, the SET-1220 provides precise and fast control, enabling dynamic testing.


Each emulation channel provides a relay to disconnect the sense output from the DUT. A second relay can short circuit the excitation input to the sense output. This allows for on-board fault injection or DUT calibration.

Emulation values and relays are controlled in software via the SLSC chassis. No RTI is required to operate the SET-1220.

 **Note** If no RTI is used, the chassis RTI slot must be covered with a filler plate (available from National Instruments) in order to meet EMC regulations.

# Circuitry



 **Note** Diagram only shows one channel.

# Theory of Operation

A typical capacitive liquid level sensing application circuit is shown in Figure 1. One electrode of the capacitive element (drive electrode) is connected to the excitation of the DUT. The other electrode (sense electrode) is connected to the sensing input of the measurement device.

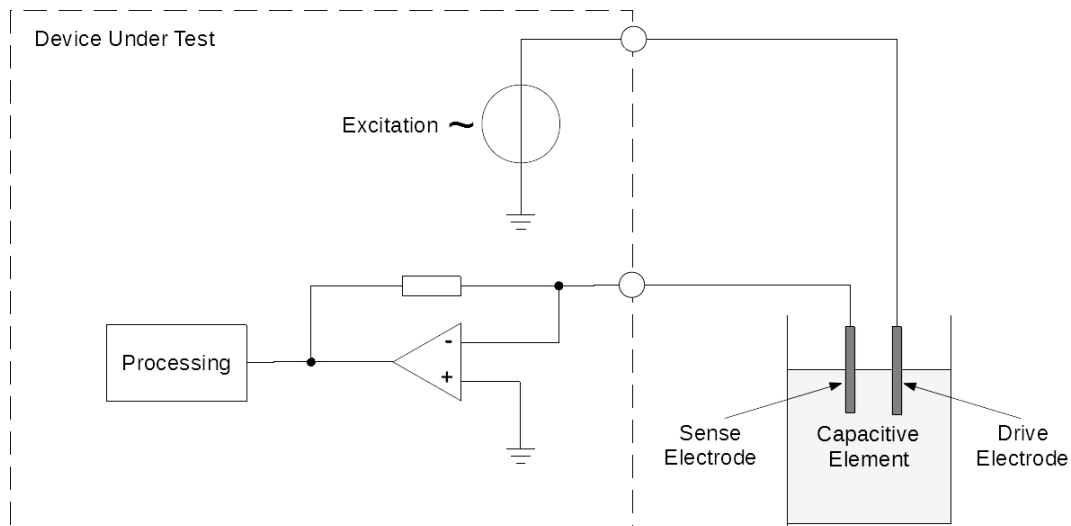


Figure 1. Typical capacitive liquid level sensor circuit.

Inside the DUT, the excitation generator is a sine-wave voltage source while the sensing input is connected to a transimpedance amplifier circuit. By measuring the current through the capacitor at a given voltage and frequency, the capacitance can be calculated using the equation for the current through a capacitor:  $i_C = C \frac{du_C}{dt}$ .

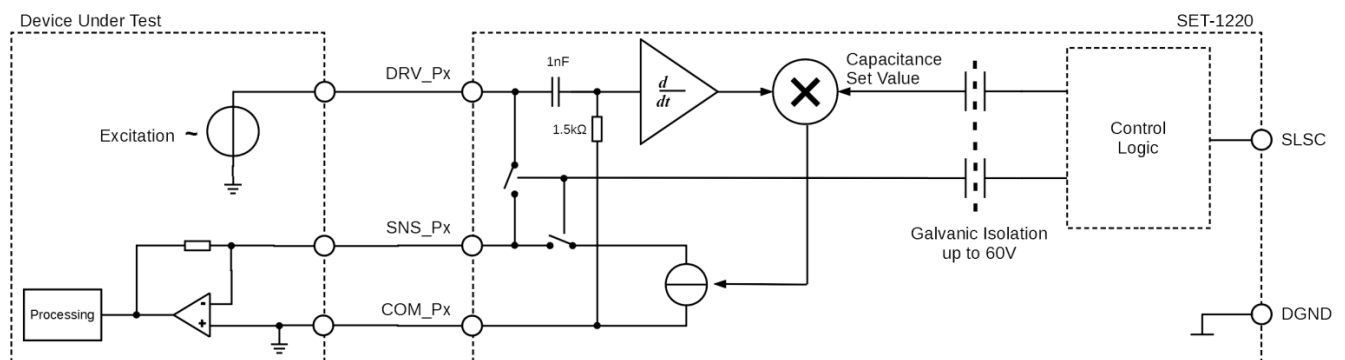


Figure 2. Typical application drawing.

The SET-1220 card emulates the capacitive element behavior at the sense electrode. At the excitation input (equivalent to the sense electrode) of the SET-1220 card, the excitation voltage is AC-coupled through a capacitor and connected to a wideband differentiator. The derivative signal is then multiplied with the configured capacitance. This product is then applied to a current buffer circuit connected to the sense output of the SET-1220 card.

The SET-1220 card does not act as a configurable impedance between drive input and sense output. The drive input has a fixed input capacitance of 1 nF, connected in series to a 1.5 kΩ resistor.



**Note** Because the SET-1220 drive input impedance is fixed, this card is unusable for applications where accurate load simulation of the DUT excitation is required. The DUT excitation output impedance must not exceed 1 k $\Omega$ .

The drive input DRV\_Px coupling capacitor can tolerate excitation DC offsets of  $\pm 25$  V relative to the common input COM\_Px. Note that connecting an excitation source with significant internal resistance will result in an input voltage error. For more details, see the **Characteristics** section of this manual.

Because of the galvanic isolation between channels and between any channel and chassis, the DUT ground may be free floating.



**Caution** The galvanic isolation barrier is limited to 60 V relative to chassis DGND **on any input**. Exceeding 60 V between chassis DNGD and any input may result in damage to the DUT, SLSC chassis or the SET-1220 card.

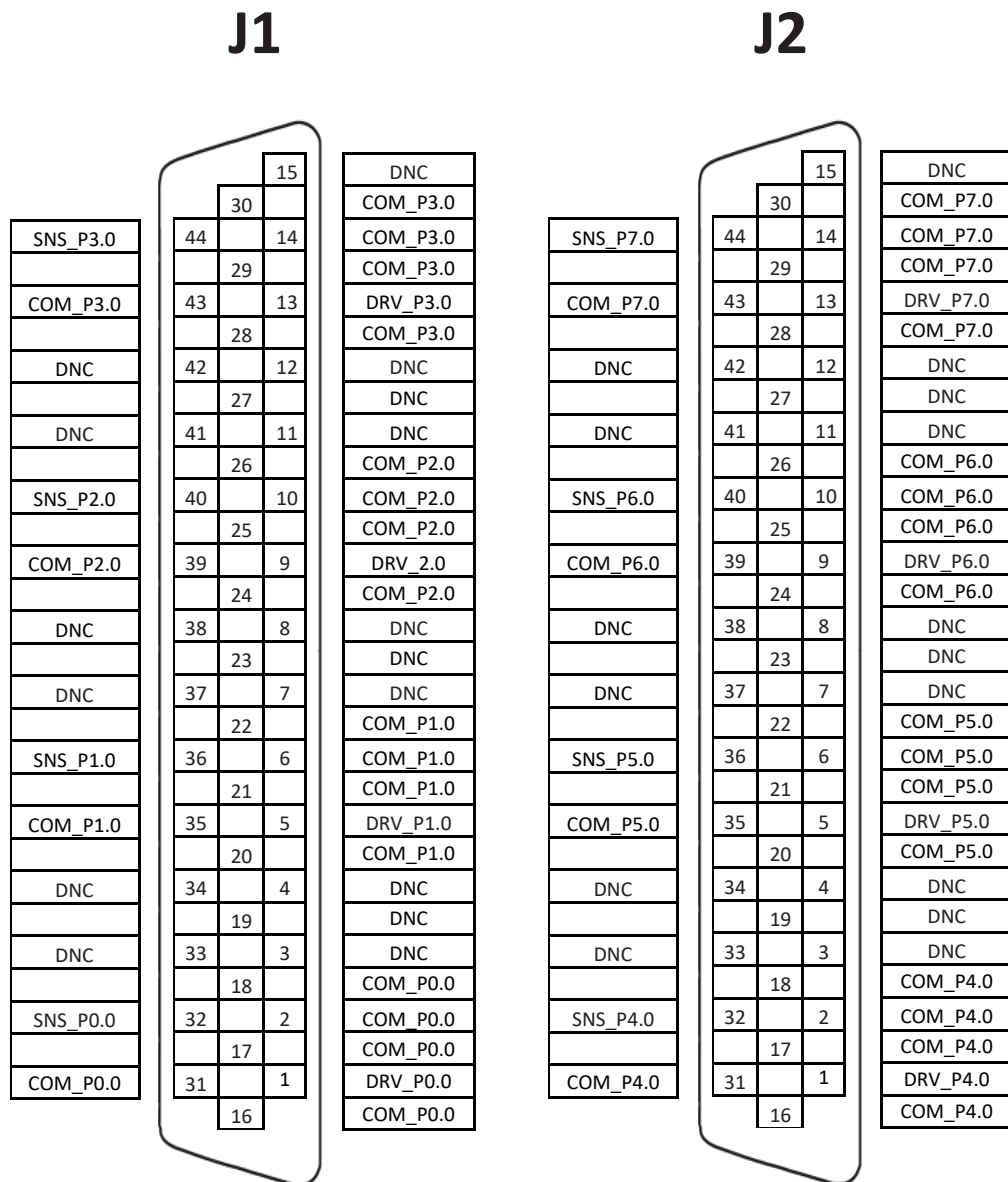
Since the sense output of the SET-1220 card act as a current source, the output must be connected to DUT ground or a virtual ground reference to DUT ground as shown in Figure 2. This connection should either be a direct connection (to virtual ground) or a connection via a shunt resistor. The current source has a compliance voltage of over 10 V, allowing shunt resistors up to 1 k $\Omega$  to be used.



**Note** The DUT sense input impedance (to COM\_Px or a virtual ground reference to COM\_Px) should not exceed 1  $\Omega$ .

In order to provide a return path for the sense current, the DUT ground must be connected to the COM\_Px connection of the SET-1220 card. This must be a low impedance connection to avoid measurement errors.

# J1, J2 Pinout (Front)



Signal	Description
DRV_Px.y	Excitation Input Channel x
SNS_Px.y	Current Output Channel x
COM_Px.y	Ground Return Channel x
GND	Ground connection
DNC	Do Not Connect

J1, J2 Connector Pin Assignments

# LED Behavior

LED Name	LED Behavior	Definition of Behavior
Power	Off	No power present on the board
	Solid green	Power good state
RDY	Off	Card is unpowered
	Solid green	Card is recognized by the chassis and ready to communicate
	Solid amber	Card is booting
	Blinking amber	Chassis is communicating with the card

# Error Handling

LED Name	LED Behavior	Actions
Power	Off	<ul style="list-style-type: none"> <li>- Check the power supply of the chassis.</li> <li>- Check the external power supply if used.</li> </ul>
RDY	Off	<ul style="list-style-type: none"> <li>- Check the power supply of the chassis.</li> <li>- Check the external power supply if used.</li> <li>- Check if 24V fuse on the SET-1220 board is blown.</li> </ul>
	Solid amber	<ul style="list-style-type: none"> <li>- Wait until boot process is finished.</li> </ul>
	Blinking amber	<ul style="list-style-type: none"> <li>- Wait until communication is finished.</li> <li>- If communication does not finish, shut down all operations and reboot chassis.</li> </ul>

# Hardware Specifications

General Specifications			
Property	Condition	Value	Comment
Max. Voltage	Any Input/Output, relative to DGND	$\pm 60$ V	
Max. Drive Input AC Voltage	Measured between DRV_Px and COM_Px	$\pm 15$ V <sub>peak</sub>	AC content above 400Hz
Max. Drive Input DC Offset	Measured between DRV_Px and COM_Px	$\pm 25$ V <sub>DC</sub>	
Typ. Drive Input Impedance		1 nF + 1.5 k $\Omega$	$\pm 1\%$
Max. Sense Output Current		$\pm 1.02$ mA <sub>peak</sub>	

Emulation Specifications			
Property	Condition	Value	Comment
Emulated Capacitance Range		10 pF to 800 pF	
Accuracy of Emulated Capacitance / Current		TBD	
Operational Drive Input Voltage Range	Measured between DRV_Px and COM_Px	5 V <sub>pk</sub> to 15 V <sub>pk</sub>	
Drive Input Frequency Range		2 kHz to 13.5 kHz	
Typical Sense Output Phase Error		TBD	
Typical Sense Output Noise		TBD	
Max. DUT output resistance		1 kΩ	
Output Settling Time		< 50 μs	

Physical Characteristics			
Property	Condition	Value	Comment
Module dimensions	Excluding ejector	144.32 mm x 30.48 mm x 302 mm (H x W x D)	Standard SLSC card size
Front Panel Connector		2x female DB -44 high-density D-Sub with 4-40 UNC screw lock	For mating connectors and cables, see below
RTI Connector		2 mm hard metric per IEC 61076-101	Any RTI marked

Environmental Specifications			
Property	Condition	Value	Comment
Operating humidity	Relative, non-condensing	10%-90%	
Storage humidity	Relative, non-condensing	5%-95%	
Operating temperature	Forced-air cooling from chassis	0°C-85°C	
Storage temperature		-40°C-100°C	
Maximum altitude		2000m	