# Alarm Circuits Explained

## A Guide to Inputs and Outputs Used in Video Security

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# Content

## Introduction

Video security devices often provide input and/or output terminals which are designed for connecting to external devices. These input and output terminals are often referred to respectively as "alarm inputs" and "alarm outputs," owing to their typical use in alarm-related functions. However, since there are many uses of inputs and outputs that have nothing to do with alarm functions, this paper recommends using the general terms "Digital Input" and "Digital Output" to refer device inputs and outputs, respectively.

DVRs/NVRs, cameras and camera systems, illuminators, motion detectors, light sensors, and door/window contacts are examples of video security devices that typically include event input and/or status output circuits. By appropriately connecting the input and output terminals of security devices, it is possible to enhance or augment the performance of the security system. For example, a day/night camera's status output (which signals when the camera is in night mode) could be wired to a VIS IR illuminator's enable input, thus causing the VIS illuminator to turn on whenever the camera is in night mode.

## Useful Terminology

The following list contains terminology used in describing Digital Input and Output circuits.

**Isolated Contact** – The pair of terminal pins that is electrically isolated from powered circuits. The isolation between the contacts and the powered circuits can range from 100's to 1000's of volts. Usually there is some type of switch between the contact pins. This type of contact is sometimes referred to as a "dry contact".

**Non-isolated Contact** – The pair of terminal pins that is not electrically isolated from powered circuits. Typically, the "Common" or "Ground" terminal pin is connected to the device's circuit ground and the other pin may or may not have some voltage present on it (usually it is a very low voltage, perhaps 12V or less). This type of contact is sometimes referred to as a "wet contact".

**Relay** – An electro-mechanical switch that is used where it is desired to control a high power circuit with a low power signal. The low power signal is used to energize a magnetic coil to cause the mechanical switch to open or close. Relay switch outputs are virtually always configured as isolated contact outputs.

**Transistor** – An electronic device that acts as a switch but contains no mechanically moving parts. The three main types of transistors used in Digital I/O circuits are: bipolar junction transistor (BJT), field effect transistor (FET), and photo-transistor (use in opto-isolators).

**Opto-isolator** – An electronic device designed to transmit electrical signals, using light waves to provide coupling while also enabling electrical isolation between the input and the output. An opto-isolator is composed of an LED on the input side and a photo-transistor on the output side, with the entire assembly sealed to protect the photo-transistor from external light. Electrical input signals are converted to light by the LED, which illuminate the photo-transistor and turn it on.

**Opto-relay** – This is a special type of opto-isolator which functions like an electro-mechanical relay but without any mechanical parts. It is often called a solid-state relay.

**Ohm's Law** (**I = V / R**) – A fundamental electrical relationship stating that the current (**I**, measured in *amperes* or *amps*) through two points in a circuit is directly proportional to voltage (**V**, measured in *volts*) across those two

points, with the constant of proportionality being the resistance (**R**, measure in *ohms*) between the two points. When dealing with AC circuits, resistance is sometimes referred to as impedance (**Z**).

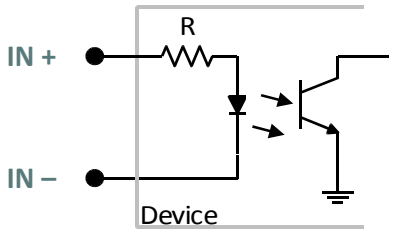
## Digital Input Circuits

The purpose of a digital input is to notify the device that some activity has occurred outside of the device. The device may then act upon this information directly, it may forward the information to a different connected device, or it may do both. A digital input will have two different states, which will be referred to from this point forward as "asserted" and "de-asserted," with asserted typically meaning "on," "tripped," "closed," "detected," etc., and de-asserted typically meaning "off," "idle," "open," "quiescent," etc. Typically, devices provide the means for configuring which input condition signifies asserted ("on" or "off"), with the opposite condition signifying de-asserted.

There are a number of different types of digital inputs encountered in the video security business. The following section lists the most common ones along with a schematic representation and description of each.

### Opto-isolator Input

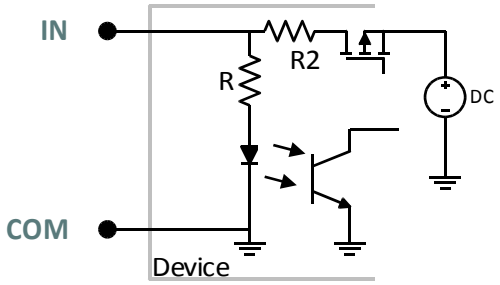
This is an isolated contact input that requires a minimum current level flowing between **IN+** and **IN–** in order to assert the input. The minimum current required to do this is usually in the range of 1 to 10 milliamperes (1/1000 of an amp, mA for short). The simplest way to assert this input is to apply the proper voltage between **IN+** and **IN–**, with the positive voltage terminal connected to **IN+** and the negative voltage terminal connected to **IN–**. The device manual should specify what the proper voltage range is to assert the input.




Some opto-isolators contain two anti-parallel LEDs connected across the input, which enables either polarity voltage to be applied to the input terminals. If the device has an opto-isolator input and doesn't specify a polarity for the external connections, then it probably utilizes the anti-parallel LED style input.

### Switch Drive or Voltage Drive Input

This configurable input enables two different output types to assert this input. The Switch Drive mode should be configured when the connected output is one of the multiple output types that function as a switch (i.e., Relay, Transistor, Opto-isolator). In this configuration, the upper transistor is turned on and DC current flows through **R2**, **R**, and the opto-isolator's LED, which has the effect of asserting the opto-isolator. When a switch type output is connected between **IN** and **COM** and that switch is closed circuit, current no longer flows through R and the LED, which has the effect of de-asserting the opto-isolator.

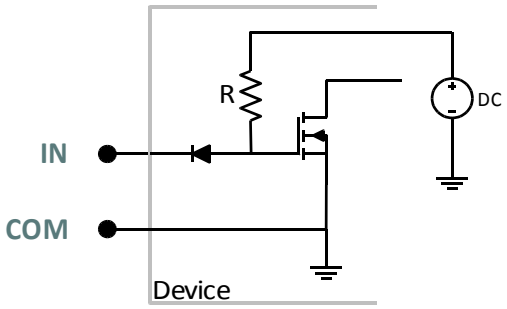



The Voltage Drive mode should be configured when the output is a Switched Voltage type. In this configuration, the upper transistor is turned off, which causes this circuit to look and operate like the Opto-isolator input type. Refer to the Opto-isolator input for details on how to drive this input in the Voltage Drive mode. This input

requires the positive voltage terminal be connected to **IN** and the negative voltage terminal be connected to **COM**. This input is a non-isolated contact input in either configuration.

### TTL / Logic Input

This non-isolated contact input requires one of the multiple output types that function as a switch (i.e., Relay, Transistor, Opto-isolator). When a switch type output is connected between **IN** and **COM** and that switch is closed circuit, the input voltage is low and this digital input is asserted. When the connected output is open-circuit, the input voltage is high because of the pull-up **R** and this digital input is de-asserted.



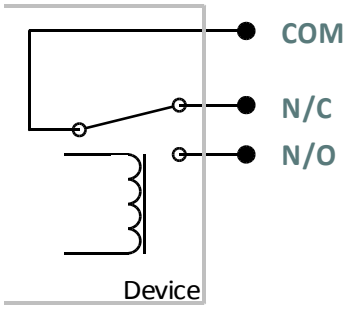

The external connection must be made with the positive voltage terminal connected to **IN** and the negative voltage terminal connected to **COM**. This type of input is found on all VIS illuminators.

## Digital Output Circuits

There are a number of different types of status outputs encountered in the video security business. These can be used to drive other device inputs as well as external loads, for example an alarm horn (an electrical speaker that emits a loud, alerting noise) may be powered through a digital output (provided the output is capable of driving the required current and voltage of the horn).

### Relay Output

The Relay is an isolated contact output that functions as a switch and usually provides three terminals: **N/O** (Normally Open), **N/C** (Normally Closed), and **COM** (Common). When a Relay is de-asserted, **N/C** is connected to **COM** and **N/O** open-circuit. When it is asserted, **COM** is disconnected from **N/C** and is connected to **N/O**. Typically, an external connection is made between **COM** and either **N/O** or **N/C** and there is no voltage polarity requirement for how the external connection is made.

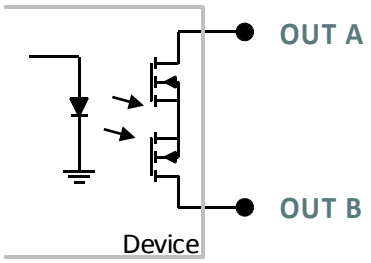



The Relay output is often used to drive external loads, as it is designed to handle a relatively high voltage and/or a large amount of power. Typically, it is rated to carry current ranging from hundreds of milliamps to multiple amps, and switch hundreds of volts. As well, it is often capable of switching DC or AC loads. Be sure to consult the device's manual regarding the maximum power and voltage the Relay is capable of switching before connecting high voltage or high power devices to it.

### Opto-isolator / Opto-relay Output

The Opto-isolator is an isolated contact output that functions as a two terminal switch. These terminals are often labeled **OUT+** and **OUT–**, indicating that the connected device must have its positive voltage connected to **OUT+** and its negative voltage connected to **OUT–**. When it is asserted, **OUT+** is connected to **OUT–** and when it is de-

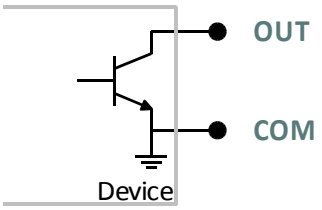
asserted, **OUT+** is disconnected from **OUT–**. Sometimes, an Opto-isolator output is implemented with an Opto-relay device, as shown in the diagram to the right. This device operates the same as an Opto-isolator except that the externally connected device does not have a voltage polarity requirement.




The Opto-isolator and Opto-relay outputs are almost always less capable than the Relay in terms of carrying large currents or driving high voltages. Typically, it is rated to carry current ranging from tens of milliamps to hundreds of milliamps and switch up to about 60 volts. The Opto-relay is often capable of switching DC or AC loads, while the Opto-isolator can only switch DC loads. Be sure to consult the device's manual for maximum voltage and power specifications for this output.

## Transistor Output

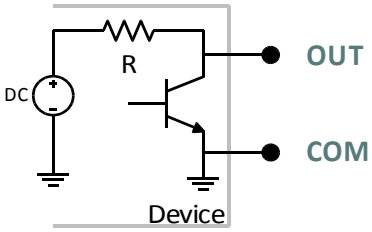
Just as the Opto-isolator does, the Transistor output functions as a two terminal switch. However, a key difference is that it is a non-isolated contact output, and as such, the **OUT** and the **COM** terminals are referenced to the device's powered circuits. The connected device should have its positive voltage connected to **OUT+** and its negative voltage connected to **OUT–**. When it is asserted, **OUT+** is connected to **OUT–** and when it is de-asserted, **OUT+** is disconnected from **OUT–**.




The Transistor output is typically rated to carry tens of milliamps of current and switch voltages less than 50 volts. The external connection must be made with the positive voltage terminal connected to **OUT** and the negative voltage terminal connected to **COM**.

## Transistor with Pull-up Output

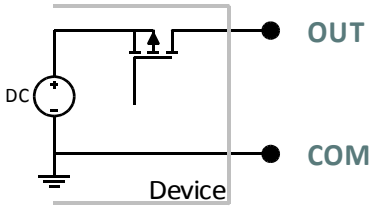
The Transistor with Pull-up output is very similar to the Transistor output except that it has a resistor **R** internally connected between **OUT** and an internal voltage. This pull-up **R** provides a voltage on **OUT** when the output is de-asserted, which can be useful for driving Opto-isolator inputs.




The Transistor with Pull-up output is typically rated to carry tens of milliamps of current and switch voltages less than 50 volts. The external connection must be made with the positive voltage terminal connected to **OUT** and the negative voltage terminal connected to **COM**. This type of output is found on all VIS illuminators.

## Switched Voltage Output

The Switched Voltage output is somewhat different from most of the previous output types, as they function as a two terminal switch. When this output is de-asserted, it presents an open-circuit between **OUT** and **COM**, much like the other output types (with the exception of the Transistor with Pull-up). However, when this output is asserted, a voltage is presented between **OUT** and **COM** instead of a short-circuit.

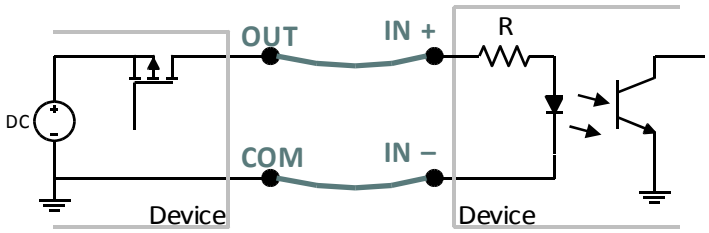


# Direct Connection Options between Digital Inputs and Outputs

This section outlines how digital inputs can be asserted/de-asserted by directly connecting the appropriate digital output. For each digital input, all digital outputs that can assert and de-assert the input are shown, and the connection between the two is illustrated.

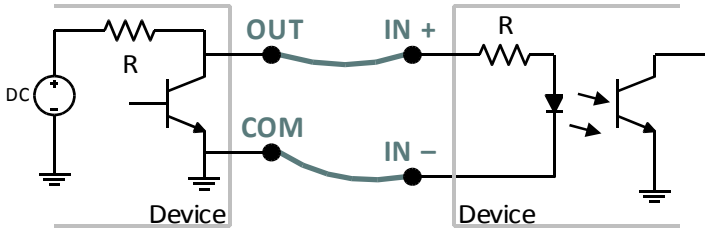
## Opto-isolator Inputs

The Opto-isolator input requires a voltage to be applied in order to assert it. The Switched Voltage output is capable of doing this, and the connections are shown in the first diagram below.




The diagram below illustrates the use of the Transistor with Pullup output. This output may be capable of asserting the opto-isolator input, however proper functioning depends on a few factors. When the output is de-asserted, DC current flows through the output's **R**, the input's **R**, and finally through the input's LED. Depending on the values of the two **R** s and the **DC** voltage present, there may or may not be sufficient current flowing through the LED to enable the opto-isolator. Determining this requires knowing the values of the two Rs and the output DC voltage. Ohm's Law can be used to determine the current flowing in the opto-isolator's LED as follows:

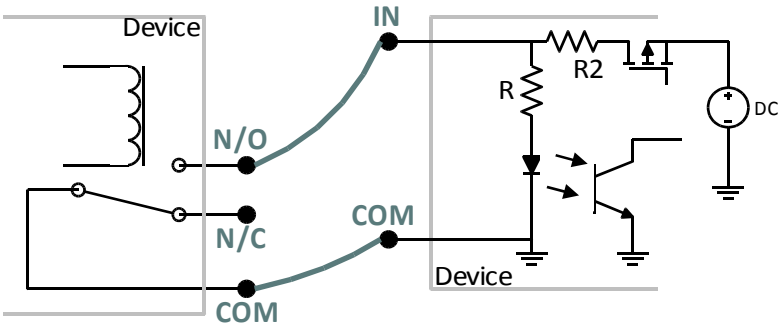
$$I_{LED} = (V_{DC} - 1.3V) / (R_{output} + R_{input})$$



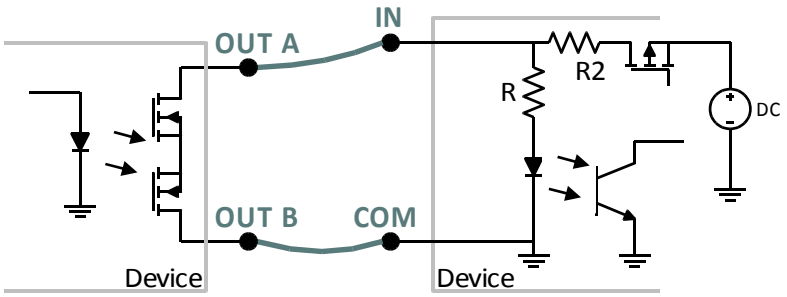

## Switch Drive or Voltage Drive Inputs

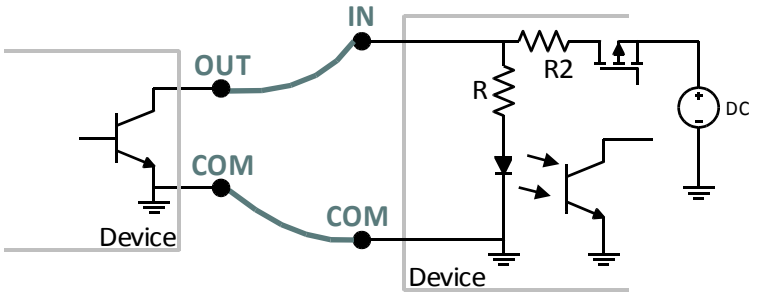
The following are output to input connections that work for Switch/Voltage Drive inputs when configured in Switch mode. Note that when this input is configured as a Voltage Drive, it acts just like an Opto-isolator input, so refer to the above diagrams for that mode.

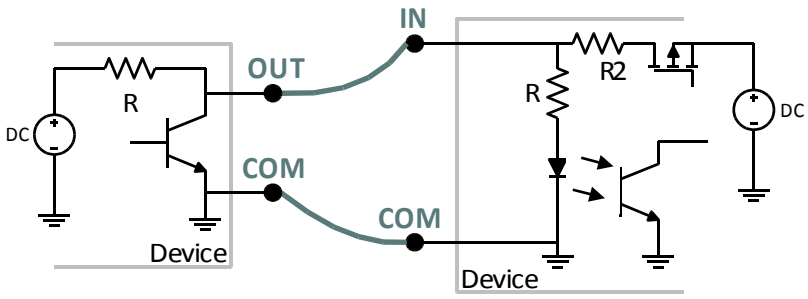
The Relay output acts like a switch so it can simply be connected as shown below. Either **N/O** or **N/C** can be used as the second terminal of the switch, depending on which polarity is desired for assertion.




The Opto-isolator/relay, Transistor, and Transistor with Pull-up outputs all act like a switch, so they can be directly connected to the Switch Drive input as illustrated below:

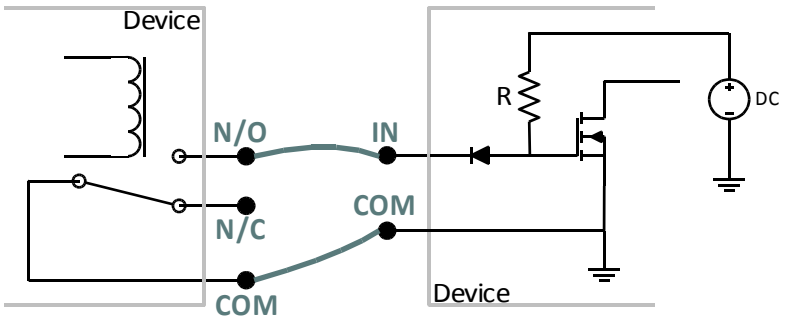


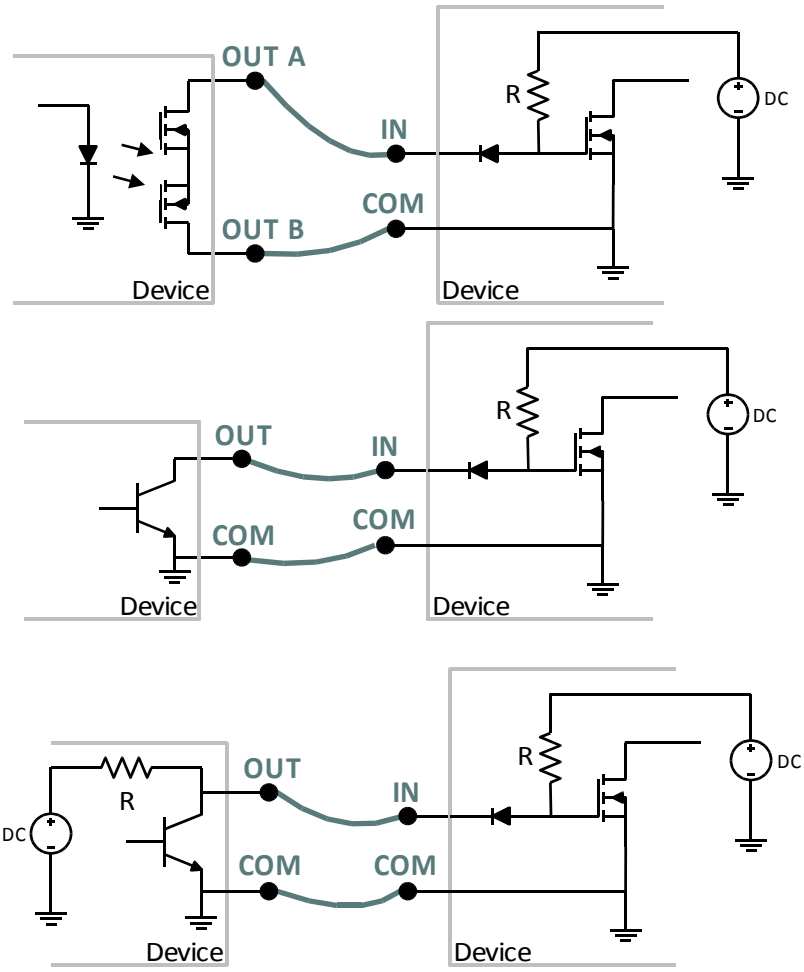



## TTL / Logic Inputs

The following are output to input connections that can be made for TTL/Logic inputs. As stated before, the Relay output acts like a switch so it can simply be connected as shown below. Either **N/O** or **N/C** can be used as the second terminal of the switch, depending on which polarity is desired for assertion.




The Opto-isolator/relay, Transistor, and Transistor with Pull-up outputs all act like a switch, so they can be directly connected to the TTL/Logic input as illustrated below:

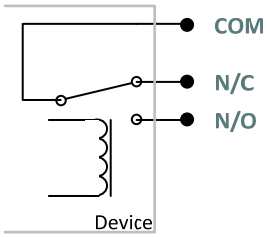


# Summary Diagram of Digital Inputs and Outputs

## Digital Output Types

### 1 Electro-mechanical Relay

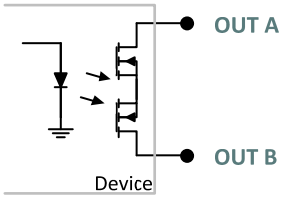
*voltage free*
*dry contact /*
*fully isolated*




Direct connects to: 2 (switch mode), 3
Used by: DVR I/O cards, ACTi (type 4)

### 2 Opto-relay

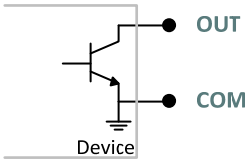
*voltage free*
*dry contact /*
*fully isolated*




Direct connects to: 2 (switch mode), 3
Used by: Pelco, UDP, Raytec, Illuminar, Arecont

### 3 Open Collector

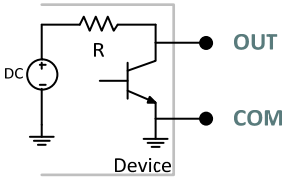
*voltage free*
*wet contact /*
*non-isolated*




Direct connects to: 2 (switch mode), 3
Used by: Axis, Panasonic, ACTi (type 3)

### 4 Open Collector with pull-up

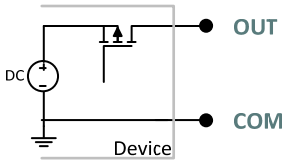
*wet contact /*
*non-isolated*




Direct connects to: 1, 2 (switch mode), 3
Used by: NuOptic

### 5 Switched Voltage Source

*wet contact /*
*non-isolated*

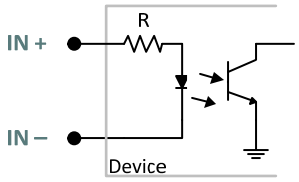



Direct connects to: 1, 2 (volt mode)
Used by: ACTi (type 1)

## Digital Input Types

### Opto-isolator 1

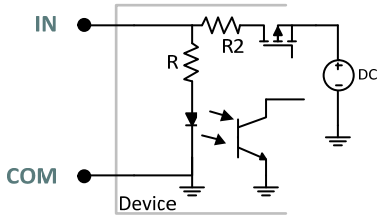
*dry contact /*
*fully isolated*
*Requires external voltage*




Direct connects to: 4, 5
Used by: DVR I/O cards, ACTi (type 1, 4), Arecont?

### Switch or Voltage Drive 2

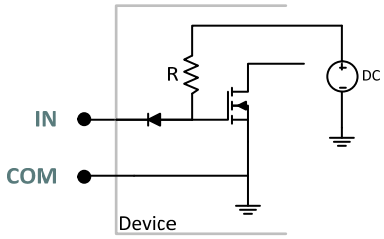
*wet contact /*
*non-isolated*
*Requires external voltage*
*(volt mode)*




Direct connects to: 1, 2, 3, 4 (switch mode); 4, 5 (volt mode)
Used by: UDP

### TTL / Digital 3

*wet contact /*
*non-isolated*




Direct connects to: 1, 2, 3, 4
Used by: NuOptic, Raytec, Illuminar, Panasonic, Pelcom, ACTi (2,3)

## References

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Wikipedia contributors, "Relay,"*Wikipedia, The Free Encyclopedia*, http://en.wikipedia.org/wiki/Relay (accessed January 26, 2013).

Wikipedia contributors, "Opto-isolator,"*Wikipedia, The Free Encyclopedia*, http://en.wikipedia.org/wiki/Opto-isolator (accessed January 26, 2013).