What is the Difference Between a Line Driver, Open Collector, and Push-Pull Quadrature Encoders and Which One Should I Use?

**Hardware:** Multifunction DAQ (MIO)>>M Series

**Problem:**
I want to use a quadrature encoder with my M Series DAQ card. What is the difference between line driver, open collector, and push-pull and which one should I use?

**Solution:**

**Line Driver**
A line driver is a sourcing output. When in the on state, a line driver will supply Vcc. In the off state, a line driver will float. Because of this, a sinking input is required for proper operation. Please refer to the table below for a simple example of a line driver.

**Open Collector**
An open collector is a sinking output. In the off state, an open collector will supply a path to ground. When in the on state, an open collector will float. For proper operation, a sourcing input is required. Please refer to the table below for a simple example of an open collector.

**Push-Pull**
A push-pull output is a combination of a line driver and an open collector. In the off state it will supply a path to ground and in the on state it will supply Vcc. Please refer to the table below for a simple example of a push-pull output.

<table>
<thead>
<tr>
<th>Line Driver</th>
<th>Open Collector</th>
<th>Push-Pull</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1.png" alt="Line Driver Diagram" /></td>
<td><img src="image2.png" alt="Open Collector Diagram" /></td>
<td><img src="image3.png" alt="Push-Pull Diagram" /></td>
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**Open Collector / Open Drain**

Open-collector/open-drain is a circuit technique which allows multiple devices to communicate bi-directionally on a single wire.

Open-collector/open-drain devices sink (flow) current in their low voltage active (logic 0) state, or are high impedance (no current flows) in their high voltage non-active (logic 1) state. These devices usually operate with an external pull-up resistor that holds the signal line high until a device on the wire sinks enough current to pull the line low. Many devices can be attached to the signal wire. If all devices attached to the wire are in their non-active state, the pull-up will hold the wire at a high voltage. If one or more devices are in the active state, the signal wire voltage will be low.

An open-collector/open-drain signal wire can also be bi-directional. Bi-directional means that a device can both output and input a signal on the wire at the same time. In addition to controlling the state of its pin that is connected to the signal wire (active, or non-active), a device can also sense the voltage level of the signal wire. Although the output of an open-collector/open-drain device may be in the non-active (high) state, the wire attached to the device may be in the active (low) state, due to activity of another device attached to the wire.

The bi-directional nature of an open-collector/open-drain device is what makes this circuit so important in interconnecting many devices on a common line. The I2C Bus and SMBus uses this technique for connecting up to 127 devices.

Open-drain refers to the drain terminal of a MOS FET transistor. Open-collector is the same concept on a bipolar device.
Open Collector ("OC") outputs are low powered, solid state switches. Although the term “Open Collector” stipulates the use of bipolar transistors (NPN-type or PNP-type) as a switch, nowadays Field Effect Transistors (FET or MOSFET) are used. Unlike electro-mechanical switches (e.g. pushbuttons or dry contact relays) these OC switches are very fast, use little power, are inexpensive, do not bounce and do not wear. However, OC’s are also more limited in terms of voltage and current rating as well as being polarized (i.e. they have a “plus” and “minus” terminal and thus DC only switching capability). They are less tolerant to overload abuse than electromechanical devices. Usually these switches have higher resistance and voltage drop.

Totem pole outputs

Transistor acts like a switch
Output is a voltage divider

Upper transistor OFF
Lower transistor ON

Upper transistor ON
Lower transistor OFF

Only one on at one time

output low

output high
Remember that gates are made from transistors only. Hence we are looking at both views.

Figure 4. Using a Pull-up Resistor with an Open-Collector Output

Figure 7. Wired-OR Connection
Wiring an **NPN** Style Output to a PLC

- Pull Up Resistor
- Input
- Gnd

Wiring a **PNP** Style Output to a PLC

- Pull Down Resistor
- Input
- Gnd

*Figure 1-7: Operation of a bipolar PNP transistor.*
Figure 1-8: Operation of a bipolar NPN transistor.

Figure 1-10: The transistor inverter; input = 1 and transistor ON. The transistor ON configuration is at left and the equivalent circuit is at right.

Figure 1-11: The transistor inverter; input = 0 and transistor OFF. The transistor OFF configuration is at left and the equivalent circuit is at right.
**FET**

Figure 1-12: Field effect transistor (FET) schematic diagram.

Figure 1-14: NMOS inverter circuit.

Figure 1-15: CMOS inverter circuit and equivalent output.

Figure 1-16: Logic output voltage is current dependent.
Figure 1-18: Logic symbols, symbolic notation, and truth tables.

Figure 1-19: Active and passive states of a tri-state buffer.
Figure 3-11: TTL outputs, totem pole and open collector.

Figure 8-1: Simplified I/O port circuit.

Figure 8-2: Quasi-bi-directional pin.
Figure 8-3: Driving a LED directly from a port pin.

Figure 8-4: NPN transistor for greater load current.

Figure 8-5: PNP transistor output driver.

Figure 8-6: I/O pin voltage limits.

Figure 8-7: Simple switch used as input.