LTC2874
8-Port IO-Link Master Reference Design

DESCRIPTION

Demonstration circuit 2228A is a complete 8-port IO-Link® Master that uses two LTC®2874 IC's to implement its IO-Link v1.1 physical interface (PHY). DC2228A operates either with an external supply V_{DD} or a Power over Ethernet (PoE) system. The IO-Link stack protocol runs on an NXP microcontroller. A software Control Tool operates the DC2228A.

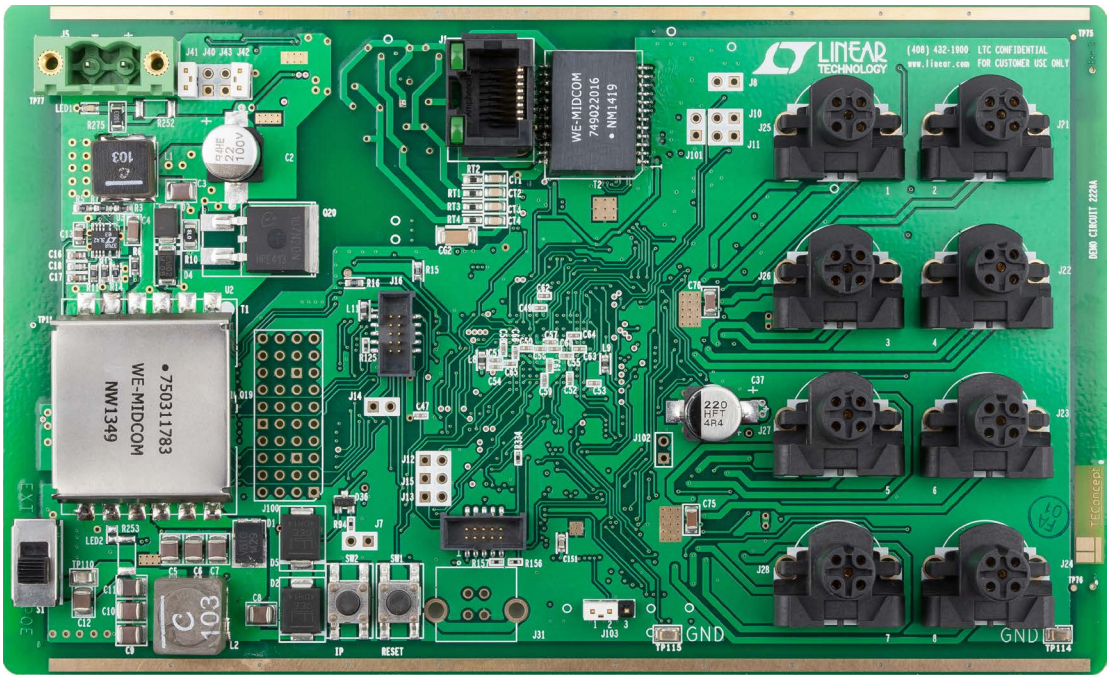
Design files for this circuit board are available at http://www.linear.com/demo/DC2228A

PERFORMANCE SUMMARY

Specifications are at T_A = 25°C

SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
V_{DD}	Input Supply Range	J5; S1 in EXT Position	20		30	V
----	PoE Supply Range	J1; S1 in PoE Position; LTPoE++ 90W	41		57	V
VS_M	Supply Voltage for Devices		20		30	V
IS_M	Supply Current for Devices		200			mA
$ISIR_M$	Current Pulse Capability for Devices	V(L+) > 18V		500		mA

BOARD PHOTO



QUICK START PROCEDURE

The following hardware and software are required:

- PC running WinXP or later with Ethernet or USB-to-Ethernet adapter
- TEConcept Control Tool software. See Step 1.
- 24V power supply or PoE power sourcing equipment (PoE injector or PoE switch).
- One or more IO-Link devices, such as Linear Technology's DC2227A.

This procedure assumes a 24V power supply and a dynamic IP address assigned via DHCP. Operation using PoE or a fixed IP address is described elsewhere in this manual.

1. Download and install the DC2228A Control Tool software from: www.linear.com/demo/DC2228A.
2. Hook-up (Figure 1):
   a. Set the power source selector (S1) to the EXT position.
   b. Keeping its output disabled, connect a 24V input power supply to J5.

      NOTE: Ensure that the input voltage does not exceed 30V.
   c. Connect an Ethernet cable between J1 and the network to which the PC is connected.
   d. Connect one or more IO-Link devices using the M12 connectors (J21–J28) and cables up to 20m in length. Refer to Table 1.
3. Turn on the 24V Power.
4. Operate the DC2228A using the Control Tool software. **Refer to the *DC2228A Control Tool* section for details.** Briefly, the steps are:
   a. Start the Control Tool.
   b. Find the IP address assigned to the DC2228A by DHCP.
   c. Configure port devices using I/O Description (IODD) files.
   d. Enter the DC2228A IP address (from Step a), then click the "Connect" button to connect the Control Tool software to the DC2228A (Figure 8).
   e. Click "Power ON" button to turn on device power.
   f. Click "IO-Link" button to begin communication.
5. Alternate configurations:
   a. For operation using a direct Ethernet connection not involving a LAN, refer to the *Alternate Configuration for Fixed IP Address* section and Figure 2.
   b. For Power over Ethernet (PoE) operation, refer to the *Power over Ethernet* section and Figures 3 and 4.
6. Reference material:
   a. Refer to the DC2227A Demo Manual for information and operating details if using this IO-Link device.
7. When finished, disable all ports (using the "Inactive" and "Power OFF" buttons) and disconnect the Control Tool (using the "Disconnect" button). Then, turn off the power supply or PoE source.

QUICK START PROCEDURE

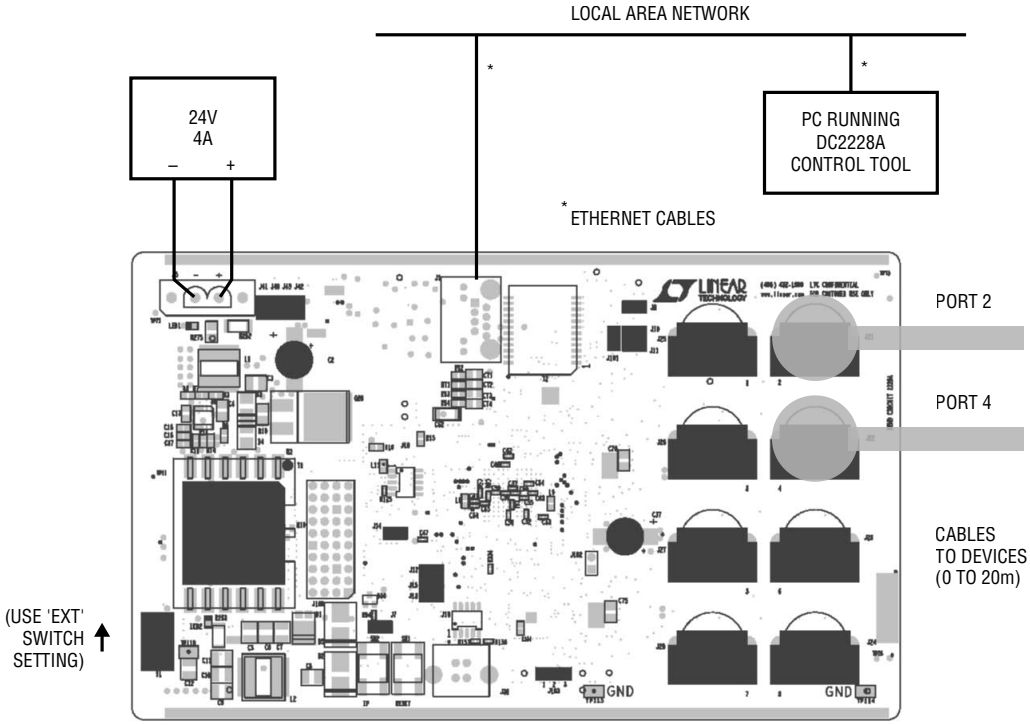


Figure 1. Set-Up Using Power Supply and DHCP

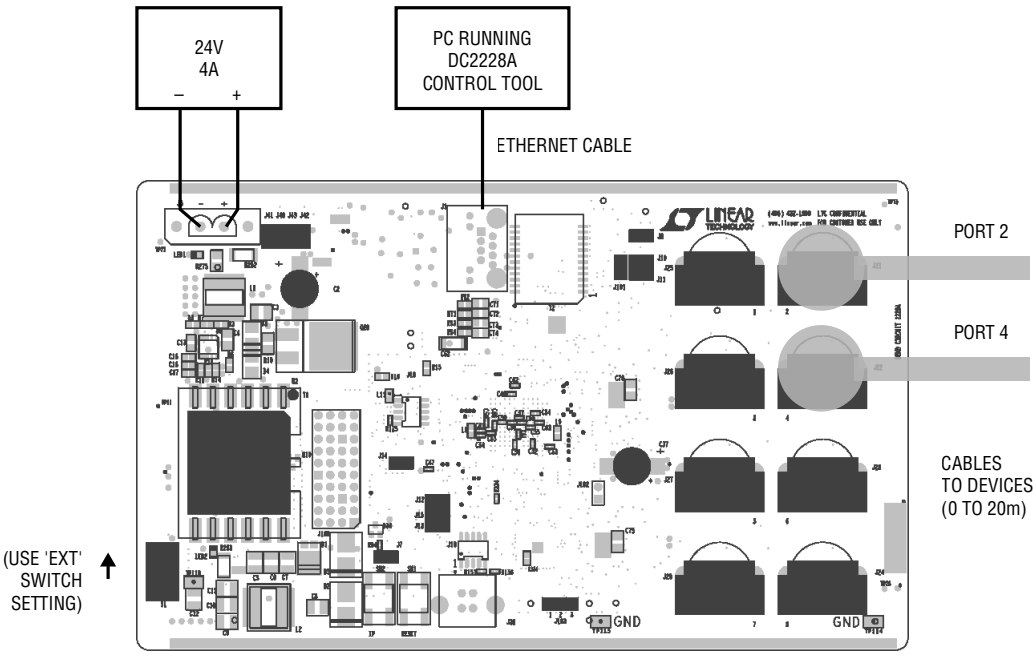


Figure 2. Alternate Set-Up Using Power Supply and Direct Ethernet Connection

OPERATING INFORMATION

Overview

The DC2228A implements a complete IO-Link Master for eight ports. Two LTC2874 quad-master IC's provide power and signaling for the physical interface (PHY). The IO-Link stack protocol runs on one core of a dual-core NXP LPC43 microcontroller. The other core runs an Ethernet port for connecting to a PC running a control program.

A 90W LTPoE++™ Power over Ethernet system supports alternative power from sourcing equipment such as a PoE injector or PoE switch. The LTPoE++ circuits use an LT4321 ideal diode bridge and an LT4275 PD controller, and feed into an isolated flyback converter controlled by an LT3748.

Four IO-Link ports connect directly to the LPC43's built-in UARTs, while the remaining four use a port expander application run by an Atmel SAM4N MCU.

Supporting functional blocks include a step-down switching regulator that uses an LT3682 to produce a regulated 3.3V supply for both microcontrollers, and a temperature sensor made with an LTC2997.

Compatibility

The DC2228A and Control Tool software will operate any device compliant with IEC 61131-9 Single-Drop Communication Interface (SDCI), commonly known as IO-Link.

Switch and Button Controls

S1: Power Source Selector. Selects between external 24V (switch up) and PoE (switch down) sources.

SW1 (RESET): Resets the NXP microcontroller and Ethernet connection.

SW2 (IP): Sets the current IP address as the default.

Connectors

J1: Ethernet jack

J5: External 24V power

J16: JTAG programming interface for NXP LPC43 microcontroller. Factory use only.

J18: JTAG programming interface for Atmel SAM4 microcontroller. Factory use only.

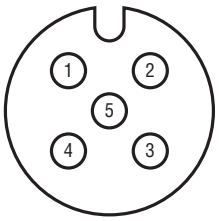
J21 to J28: M12 connectors for IO-Link cables. Although these are 5-pin connectors, the DC2228A PHY uses only 3 pins per port.

Table 1. Connector vs. Port

PORT	CONNECTOR
1	J25
2	J21
3	J26
4	J22
5	J27
6	J23
7	J28
8	J24

Table 2. M12 Connector Pins

PIN NUMBER	PIN NAME
1	L+
2	N/C
3	L– (GND)
4	C/Q
5	N/C



Jumpers

J41: PoE Classification resistor selector. Selects 49.9Ω RCLASS resistor. See Table 5. Default shunt.

J42: LTPoE++ Classification resistor selector. Selects 118Ω RCLASS++ resistor. See Table 5. Default shunt.

J103: JTAG source selector for SAM4N. Factory use only. Default position 2–3 (GND).

OPERATING INFORMATION

Status Indicators

Top LED

Table 3. LED0 (Ethernet Link/Active)

STATE	DESCRIPTION
Off	No link
Green	Link
Blinking Green	Activity

Bottom LED

Table 4. LED1 (Ethernet Link Speed)

STATE	DESCRIPTION
Off	10 Mbps
Green	100 Mbps

Power over Ethernet (PoE)

The DC2228A optionally operates using power supplied over an Ethernet connection, eliminating the need for a local power supply. To use this mode:

a. Set the power source selector (S1) to the PoE position.

b. Connect a PoE injector (Figure 3), PoE switch, or other Power Sourcing Equipment capable of 90W (for example, an LTPoE++ demo board, DC1814A-D) to its power adapter or supply.

c. Connect an Ethernet cable between J1 and the PoE injector/switch output.

d. Connect an Ethernet cable between the PoE injector/switch input and the PC running the Control Tool software.

Because the DC2228A is nominally classified as a 90W LTPoE++ PD (Powered Device), it requires a PSE rated at this power level for unrestricted operation.

Limited operation with a PSE rated for less power is possible, but the classification must be changed using Table 5. For example, to operate using a 13W PoE injector, remove the J42 shunt (keeping the J41 shunt in place) and restrict the total power consumption accordingly.

A PSE rating below 90W might easily be adequate, depending on the actual power consumed by devices connected to eight ports. This consideration must take into account whether the C/Q lines will drive DC loads (e.g., in SIO mode) or only connect with IO-Link devices.

For additional guidance regarding PoE classification settings, refer to the LT4275 data sheet.

Figure 3. 90W LTPoE++ Injector (Allnet ALL048900)

Table 5. Classification Resistor Programming

RCLASS		RCLASS++		CLASS	PD Type	NOMINAL ICLASS	PD POWER AVAILABLE	NOTE
J40 34.8Ω	J41 49.9Ω	J42 118Ω	J43 34.8Ω					
----	Open	Open	----	0	Type 1	0.4mA	13W	
----	Shunt	Open	----	3	Type 1	28mA	13W	
----	Open	Shunt	----	----	Invalid	----	----	
Shunt*	Open	Open	----	4	Type 2	40mA	25.5W	
----	Open	Open	Shunt*	4**	LTPoE++	40mA	38.7W	
----	Shunt	Shunt	----	4**	LTPoE++	40mA	90W	Default

*Jumper not provided. Requires addition of 2-pin header to PC board.
**LTPoE++ PD will be classified as Class 4 Type 2 by an IEEE 802.3 compliant PSE.

OPERATING INFORMATION

TVS Protection

The C/Q and L+ pins are protected by 36V TVS diodes. Do not connect to any voltage higher than 30V.

Thermal Protection

If the DC2228A board temperature reaches 80°C, the Control Tool software reports a “TEMP-FAULT” and disables operation. The thermal sensor Q19 is located underneath flyback transformer T1.

L+ Diode Isolation

If L+ isolation is desired, remove 0Ω resistors R158 to R165 which normally shunt Schottky diodes D28 to D35.

Demonstration Board Options

The DC2228A reference design demonstrates LTC2874 operating in an 8-port IO-Link master system. Its two LTC2874 IC’s operate under the control of the IO-Link v1.1 protocol stack coded in microcontroller firmware. Control Tool software provides access to a limited set of LTC2874 features but is oriented toward operating IO-Link devices that connect to the DC2228A ports.

The default internal register settings for the on-board LTC2874 IC’s are listed in Table 6.

Another demonstration board, DC1880A, provides access to all LTC2874 features and more direct access to its SPI register.

Table 6. DC2228A Default Settings for LTC2874 R/W Registers

Register Address	Register Name	Default Value	Register Address	Register Name	Default Value
0x1	IRQMASK	0x96	0x9	MODE2	0x04
0x2	EVENT1	0x00	0xA	NSF	0xFF
0x3	EVENT2	0x00	0xB	ILLM	0xFF
0x4	EVENT3	0x00	0xC	TMRCTRL	0xD2
0x5	EVENT4	0x00	0xD	CTRL1	0x00
0x8	MODE1	0x80	0xE	CTRL2	0x00

Companion IO-Link Device DC2227A

While the DC2228A and Control Tool software will operate any IO-Link sensor, the example screen shots given in this manual use the *DC2227A IO-Link Device with Multiple Sensors*. The DC2227A is a complete IO-Link Device incorporating the LT3669-2 along with a temperature sensor, light sensor, pushbutton, and an incandescent lamp.

IO-Link Firmware

The firmware contained in the NXP microcontroller is intellectual property owned by TEConcept GmbH in Germany. Any attempt to copy, transfer, or reverse engineer the firmware is forbidden. The source code or an object library for the IO-Link stack can be licensed from TEConcept.

OPERATING INFORMATION

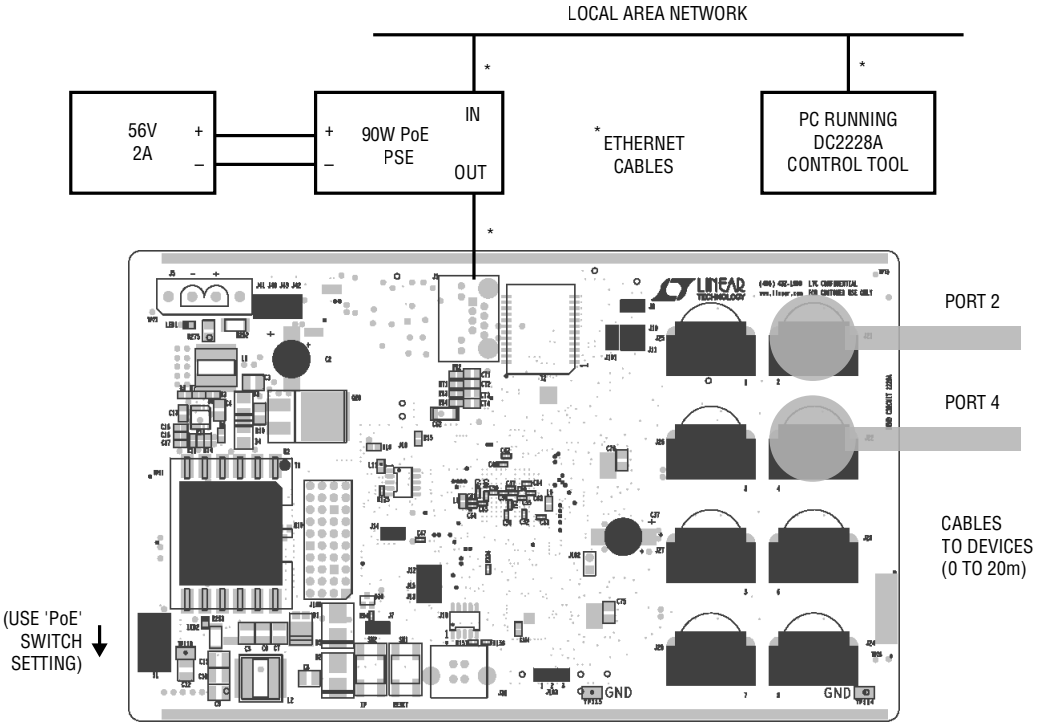


Figure 4. Set-Up Using PoE and DHCP

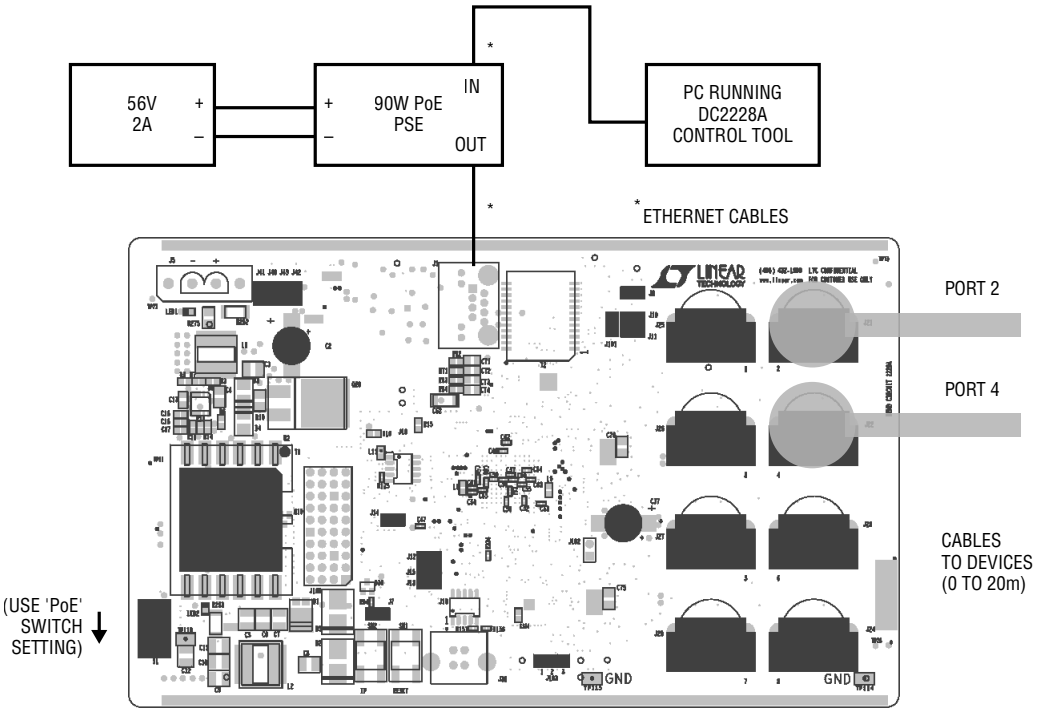


Figure 5. Alternate Set-Up Using PoE and Direct Ethernet Connection

DC2228A CONTROL TOOL

Overview

The DC2228A Control Tool configures and operates the 8-port IO-Link Master via an Ethernet connection. It controls and monitors the status of each port, while also providing access to the parametric register data within each connected IO-Link device.

The Control Tool supports DHCP for dynamic IP address assignments, or can operate using a fixed IP address.

Along with some navigation aids, the main window is shown in Figure 6.

Installation

Download the software from www.linear.com/demo/DC2228A and follow the on-screen instructions.

IO-Link Device Configuration

For any port that will operate an IO-Link device, load the device's IO Device Description, or IODD, file (Figure 7):

1. Click "Select device" button.
2. If IODD file isn't already listed, click "Import" button, select the {IODD}.xml file, and then click "Open."
3. Highlight the IODD file to be assigned and click the "Select device" button.

Normal Configuration for Network Connection using DHCP

Normally, the Control Tool connects with the DC2228A via Ethernet connections to a local area network (LAN), in which case network-assigned IP addresses are usually expected. To configure for dynamic IP address assignment by DHCP, both the PC and the DC2228A must each be configured for this mode. However, for the PC, this is usually already the case, and it's also the default mode for the DC2228A.

1. Connect Ethernet cables per Figure 1 (if using a power supply) or Figure 4 (if using PoE).
2. As needed, set the PC settings per the section *Configuring a PC to Operate with DHCP-Assigned IP Address*.
3. Apply power from either a 24V power supply or PoE power sourcing equipment.
4. Start the Control Tool software.
5. Find the IP address assigned to the DC2228A as follows:
   a. Open a Command Window.
   b. Get the PC IPv4 address returned by:
      `ipconfig`
   c. In the Control Tool, run *Master settings → Find*. Set the IP address range to span the subnet that includes the PC's IP address from Step 5b; then click the "Search" button.
   d. When the utility finishes running, note the IP address listed following "IO-Link Master connected on address:"
6. Enter the DC2228A communication settings (Figures 8a and 8b):

   IP address = {from step 5}
   Port = 7
7. Connect the Control Tool to the DC2228A using the green "Connect" button (Figure 8c and 8d).

   NOTE: to re-enable DHCP behavior after using the DC2228A with a fixed IP address, use the procedure given in the section *One-Time DC2228A configuration to Restore DHCP Behavior after using a Fixed IP Address*.

Alternate Configuration for Fixed IP Address

To use a fixed IP address, first configure both the PC and the DC2228A for this mode:

1. Connect Ethernet cables according to Figure 2 (if using a power supply) or Figure 5 (if using PoE).
2. Configure the PC to operate with a fixed IP address using the procedure given in the section *Configuring a PC to Operate with Fixed IP Addresses*.
3. Configure the DC2228A to operate with a fixed IP address using the procedure given in the section *One-Time DC2228A Configuration to Use a Fixed IP Address Instead of DHCP*.

DC2228A CONTROL TOOL

4. Apply power from either a 24V power supply or PoE power sourcing equipment.
5. Start the Control Tool software.
6. Enter the DC2228A communication settings (Figure 8a and 8b). Using the default address:

   IP address = 192.168.10.150
   Port = 7

   NOTE: The default IP address can be changed using the procedure given in the section *One Time DC2228A configuration to change the fixed IP address*.
7. Connect the Control Tool to the DC2228A using the green "Connect" button (Figure 8c and 8d).

IO-Link Operation

To operate a connected device that's been configured for IO-Link operation (Figure 9):

1. Click the "Power ON" button to supply power to the device.
2. Click the "IO-Link" button to begin communication.
3. Operate IO-Link device. For a typical sensor this involves monitoring process data and events.
4. Click the "Inactive" and "Power OFF" buttons when done.

Digital Input Operation

To operate in DI mode (Figure 10), for receiving data from a device connected to the C/Q line:

1. If an IODD file has been associated with the port, remove it using *Select device → Exit and not select*. When powered, the connected device will now run in Standard IO (SIO) mode.
2. Click the "Power ON" button to supply power to the device.
3. Click the "DI" button. The Raw Process Data In field will monitor the digital state at the C/Q pin.
4. In the case of a DC2227A device, the C/Q state can be changed by interacting with its light sensor.
5. Click the "Inactive" and "Power OFF" buttons when done.

Digital Output Operation

To operate in DO mode (Figure 11), for switching the C/Q line as a Standard IO (SIO) output:

1. If an IODD file has been associated with the port, remove it using *Select device → Exit and not select*. When powered, the connected device will now run in Standard IO (SIO) mode.
2. Consider whether the connected device will tolerate a C/Q driver conflict. If conflicts occur, master C/Q overcurrent events could be triggered (see *Fault Conditions* section). If connected to a DC2227A, be aware that the device output state in SIO mode is determined by its light sensor. The DC2228A and DC2227A won't damage each other. Other devices could be stronger or weaker than the DC2228A, and might not tolerate a conflict.
3. Click the "Power ON" button to supply power to the device.
4. Click the "DO" button and "OK" the confirmation message.
5. Click the "High" or "Low" radio buttons to switch the C/Q state.
6. Click the "Inactive" and "Power OFF" buttons when done.

Fault Conditions

If the Control Tool detects a fault on any port, it reports, in red, a Master PHY event at the bottom of the main window. The operator may query faults using the *Master settings → Check PHY events* pull-down menu. After fixing the underlying condition, the operator may clear faults using the same pull-down menu.

Software License and Renewal

The Control Tool license is valid for 10000 minutes of cumulative operation. Unlimited free renewals, as well as an unlimited license, are available. To renew the license:

1. Get the hardware ID using *Tools → License key manager* and clicking the "Export hardware ID" button.

DC2228A CONTROL TOOL

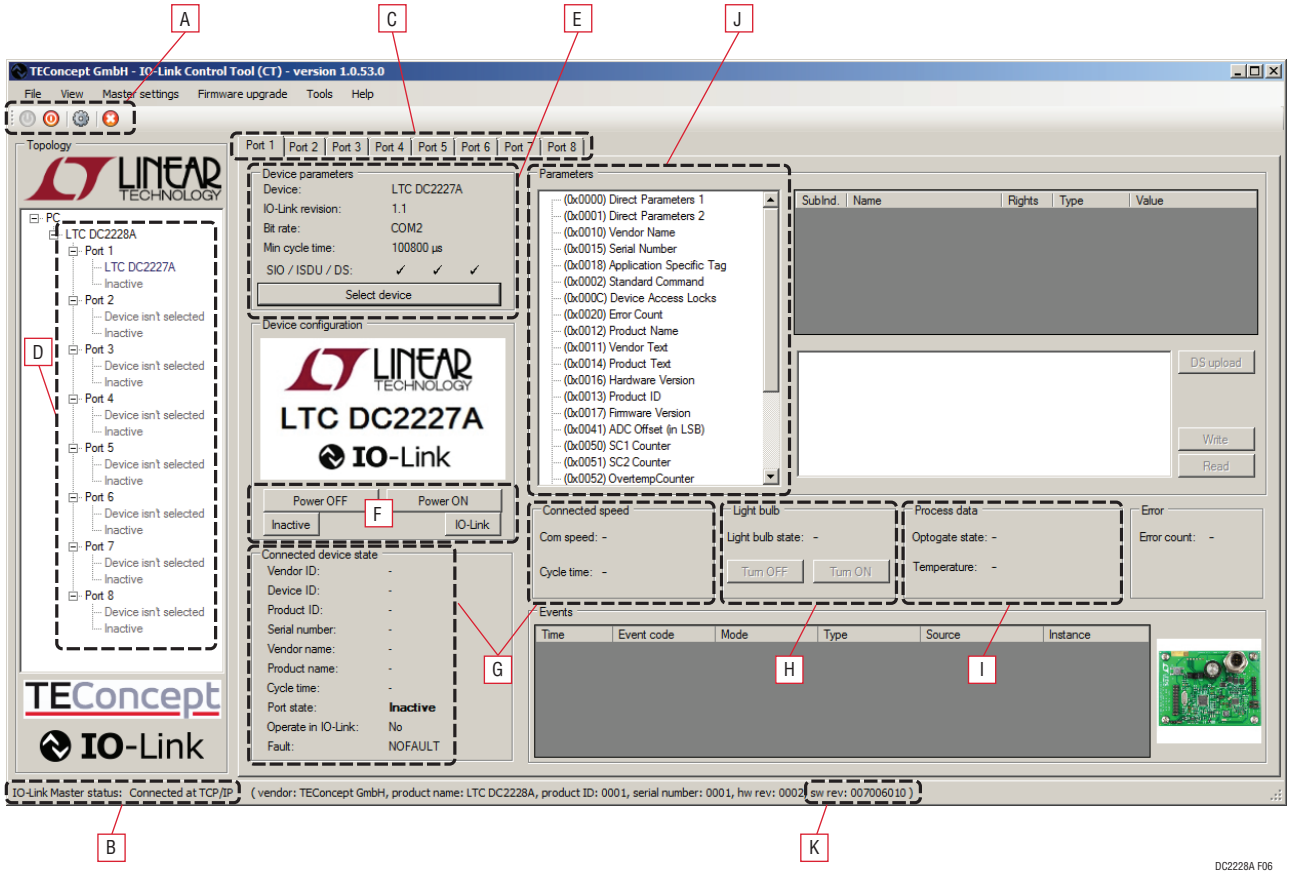
2. Send the hardware ID and request for free license renewal to TEConcept GmbH using this address and subject line:

   To: info@teconcept.de
   Subject: DC2228A license renewal request

3. Receive the new license key by email.

4. Again using *Tools* → *License key manager*, enter the new key. For Period, enter “10000”. Then click the “Send” button and close the window.

5. Re-open the license manager and check that the “Remaining time” has been reset.



(A) Control Tool connection controls
(B) Control Tool connection status
(C) Port selector
(D) Port status
(E) Device selector and device parameters
(F) Device configuration controls
(G) Connected device state and speed
(H) Light bulb controls and status
(I) Process data
(J) Device parameters
(K) Firmware version

Figure 6. Control Tool Main Window

DC2228A CONTROL TOOL

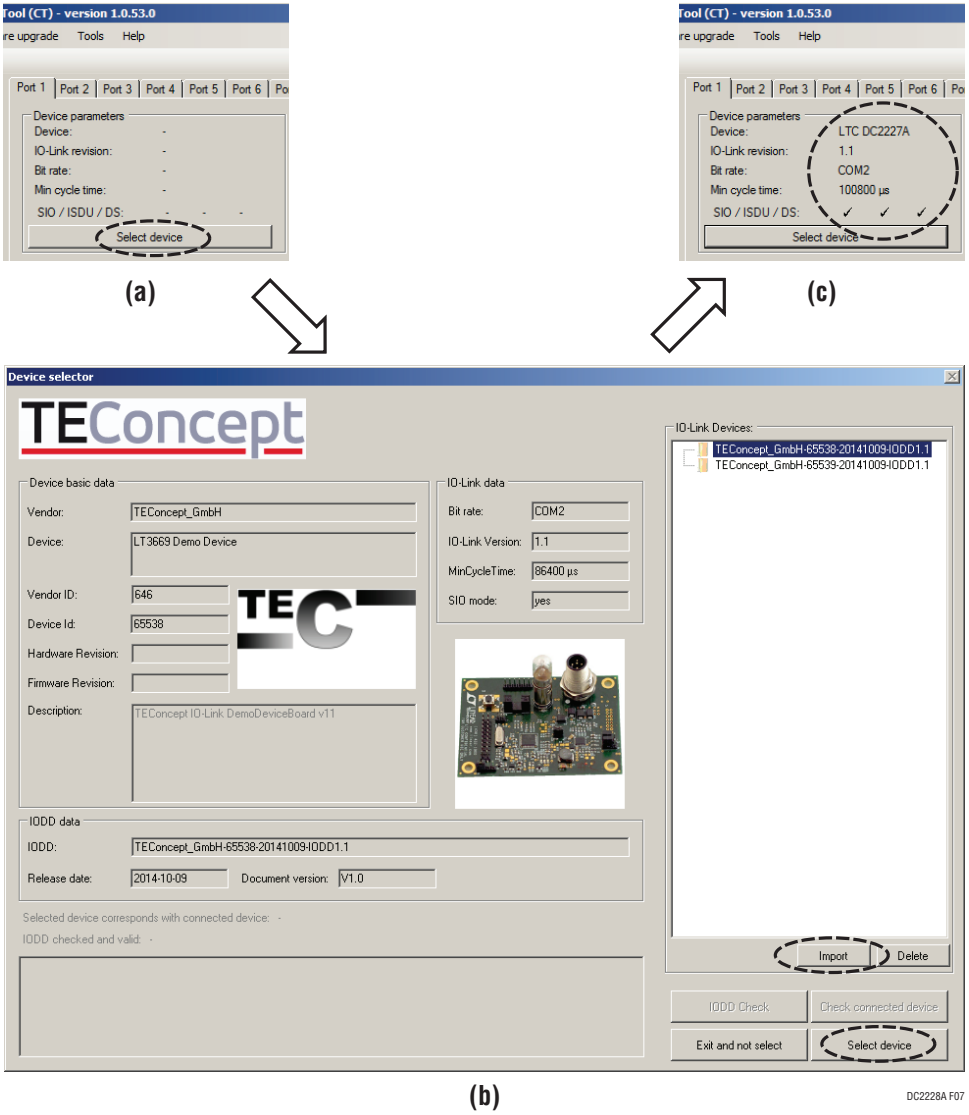


Figure 7. Selecting a Device IODD (IO Description Data) File

DC2228A CONTROL TOOL

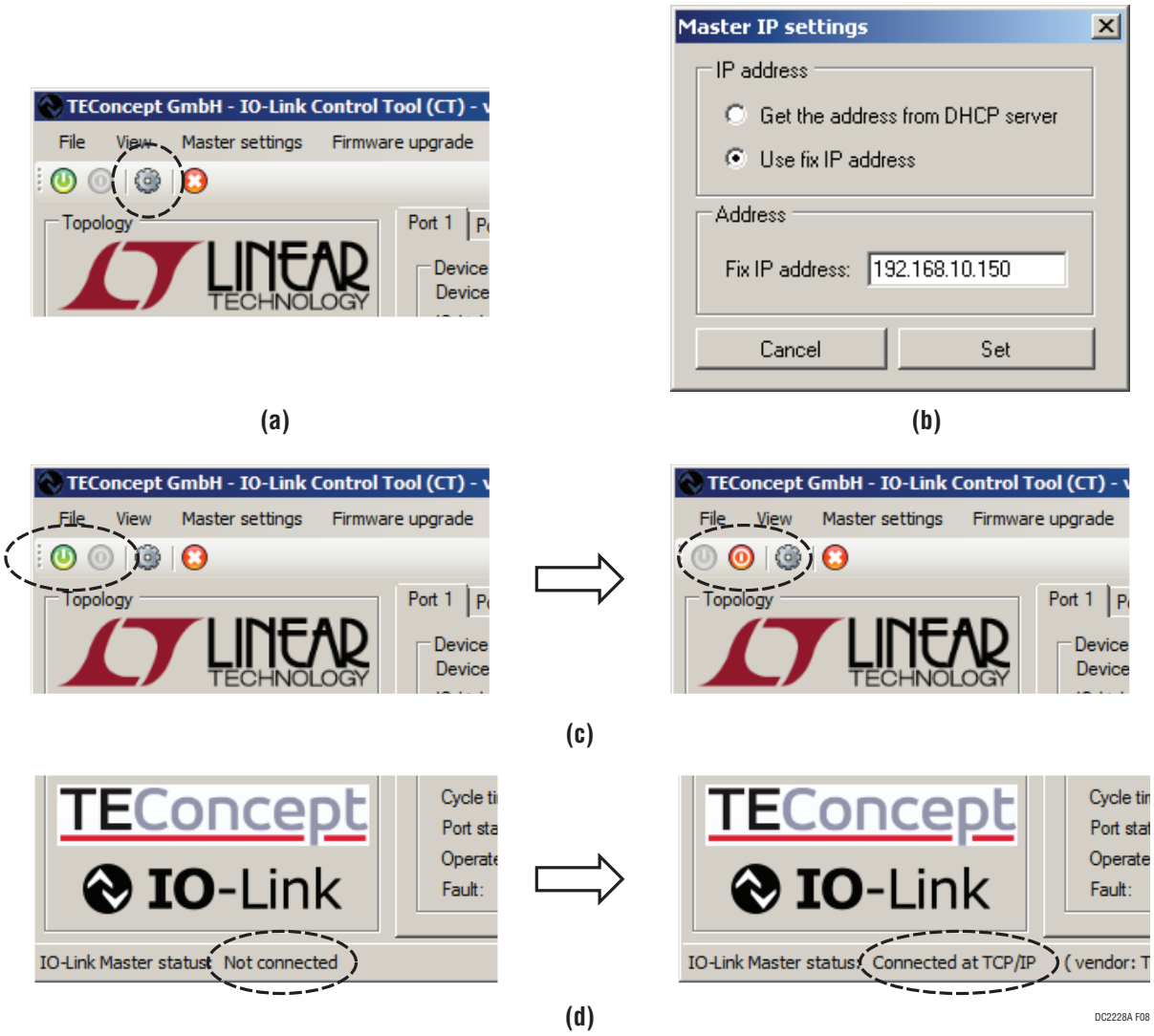
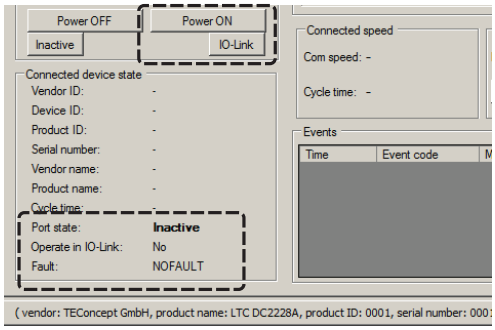
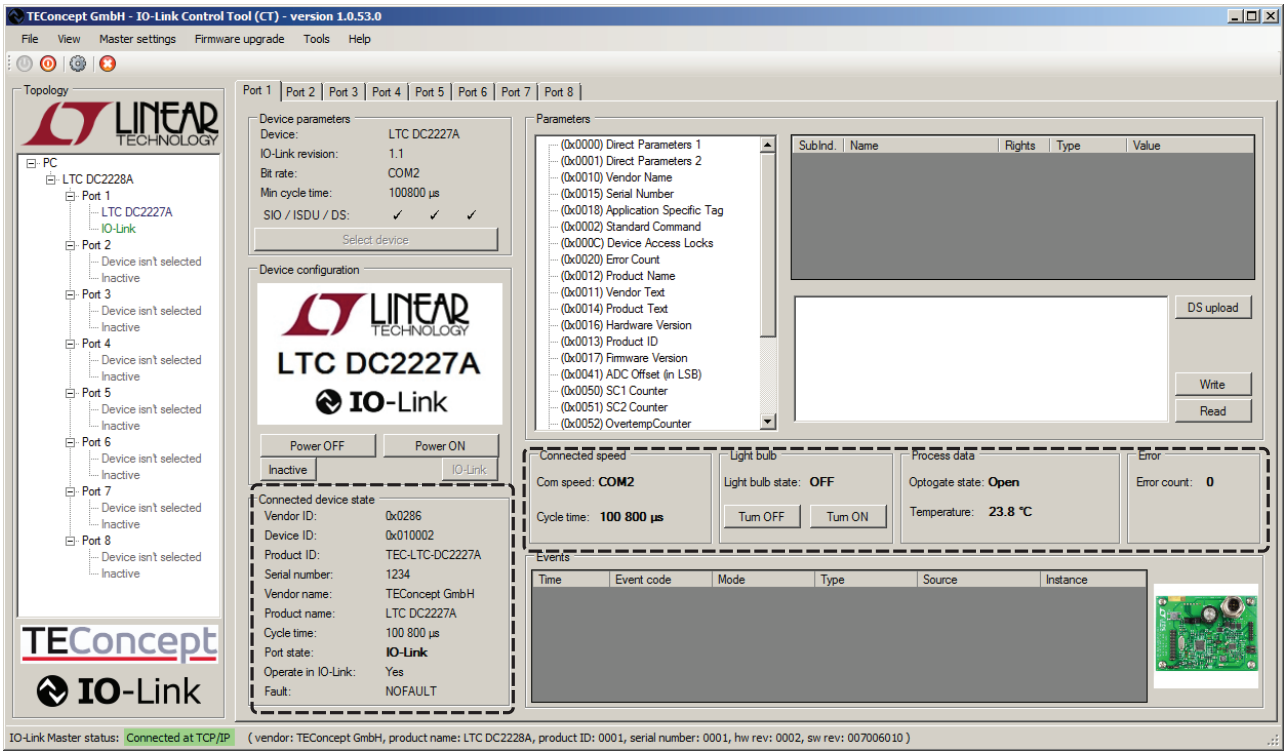


Figure 8. Connecting the Control Tool to DC2228A

DC2228A CONTROL TOOL



(a)

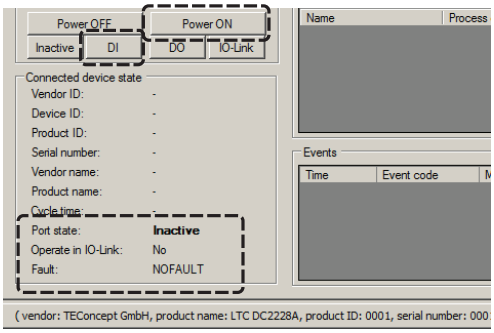


(b)

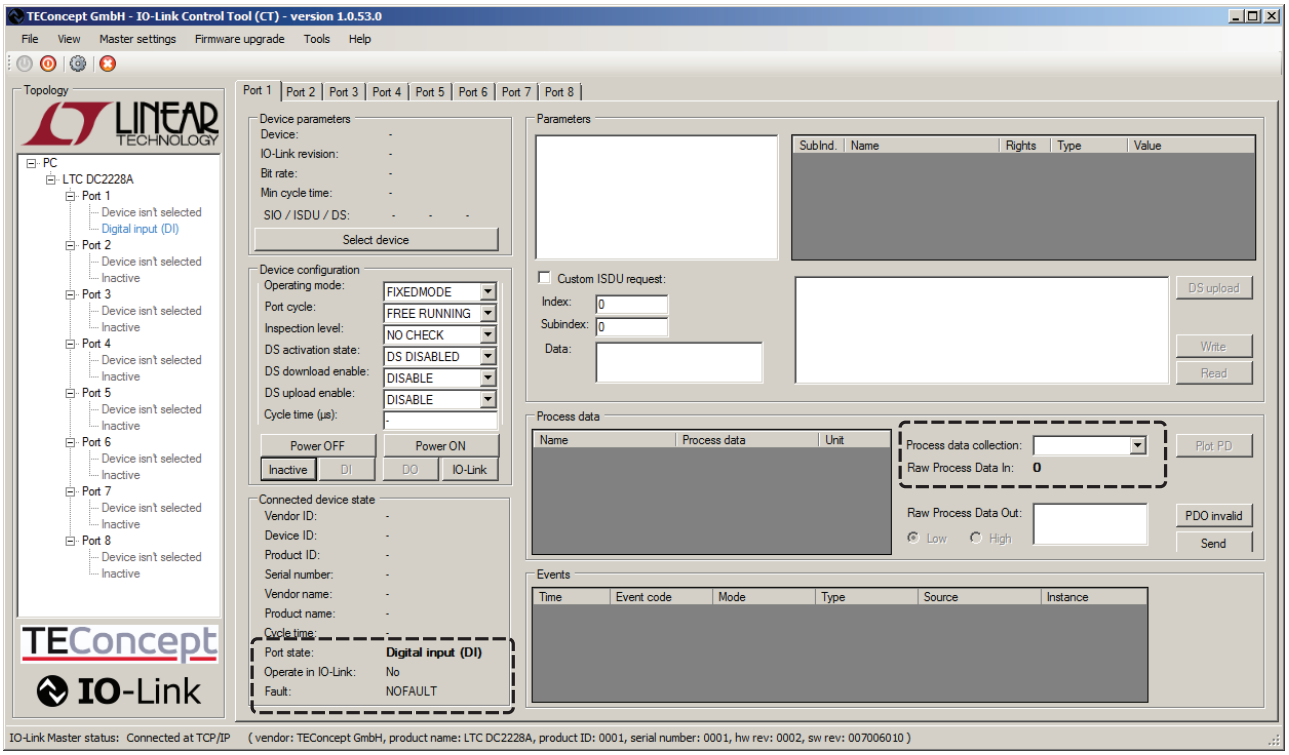
DC2228A F09

Figure 9. IO-Link Operation

DC2228A CONTROL TOOL



(a)

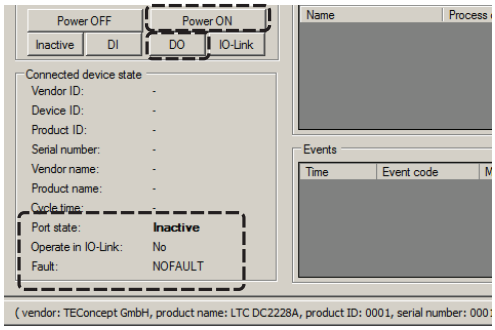


(b)

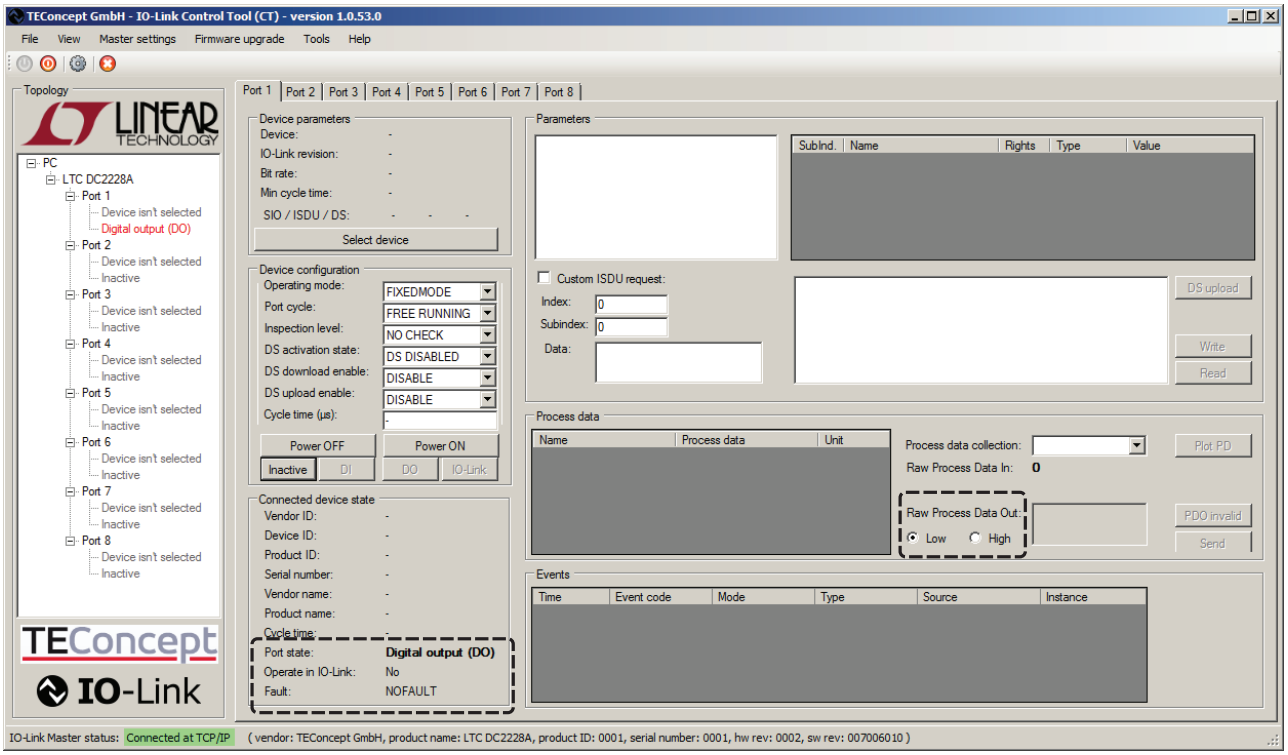
DC2228A F10

Figure 10. Digital Input (DI) Mode

DC2228A CONTROL TOOL



(a)



(b)

DC2228A F11

Figure 11. Digital Output (DO) Mode

ADDITIONAL INFORMATION

Configuring a PC to Operate with DHCP-Assigned IP Address

For a PC running Windows 7:

a. Open the adapter settings for the LAN adapter: *Control Panel → Network and Internet → Network and Sharing Center → Change adapter settings*

b. Right click the appropriate adapter and select "Properties."

c. Highlight "Internet Protocol Version 4 (TCP/IPv4)," then click the "Properties" button.

d. Select "Obtain an IP address automatically."

e. "OK" or "Close" all windows.

A PC connected to a LAN likely already uses DHCP.

Configuring a PC to Operate with Fixed IP Addresses

For a PC running Windows 7:

Steps a through c: same as above

d. Select "Use the following IP address" and configure as follows. For "X", use an integer such as 2 and don't use the address assigned to the DC2228A (default = 150).

IP address: 192.168.10.X
Subnet mask: 255.255.255.0
Default gateway: {leave blank}

e. "OK" or "Close" all windows.

One-Time DC2228A Configuration to Use a Fixed IP Address Instead of DHCP:

The DC2228A comes preconfigured for DHCP operation. To operate using a fixed IP address for the first time:

a. While powered up, press the SW1 (RESET) and SW2 (IP) buttons on DC2228A at the same time.

b. Release the RESET button first.

c. Release the IP button.

d. If the Control Tool is connected, click the "Disconnect" button. (Refer to "A" in Figure 6.)

e. Cycle the power or press the RESET button.

The DC2228A will now operate in fixed IP address mode using the default address 192.168.10.150.

One-Time DC2228A Configuration to Change the Fixed IP Address:

a. While powered up and connected to the Control Tool, select *Master settings → Set network address → Use fixed IP address*.

b. Enter the new address, then click the "Set"" button.

c. Cycle the power or press the SW1 (RESET) button.

The DC2228A will use this address when operating in fixed IP address mode.

One-Time DC2228A Configuration to Restore DHCP Behavior after Using a Fixed IP Address

a. While powered up and connected to the Control Tool, select *Master settings → Set network address → Get the address from DHCP server.*

b. Click the "Set" button.

c. Click the "Disconnect" button.

d. Cycle the power or press the SW1 (RESET) button.

The DC2228A will now operate in DHCP mode.

TROUBLESHOOTING GUIDE

PROBLEM	SOLUTION
No Ethernet connection (LED0 not blinking)	a. Check Ethernet cable connection. b. Check 24V power supply to green connector (if source selector S1 in up position). c. Check power adapter connection to PoE power sourcing equipment (if S1 in down position). d. If using PoE, check PD classification settings against PSE rating. Adjust J41/J42 settings as needed (see Table 5).
DHCP worked previously, but the Control Tool no longer connects in a subsequent session	A new IP address might have been assigned to the DC2228A by the DHCP server. In the Control Tool, run *Master settings → Find* to confirm the address. Refer to the *Normal Configuration for Network Connection using DHCP* section for details.
Error message "Can't connect to the IO-Link Master" or "Can't Open the port!"	a. If LED0 isn't blinking, refer to above issue. b. Check IP address settings for PC and DC2228A.
Missing power to connected device	a. Check device cable connection. b. Check that Control Tool port number matches actual port. c. Click "Power ON" button.
Missing DI or DO button	Remove the IODD file association via: *Select device → Exit and not select*
COMLOST fault when attempting IO-Link connection	a. Check device cable connection. b. Check that Control Tool port number matches actual port. c. Click "Power ON" button if device lacks power. d. Check that correct IODD has been loaded and Device Parameters entries are valid.
COMPFAULT	a. Remove IODD selection, then check whether "Inspection level" setting was inadvertently changed. Normally it should be set to NO CHECK. When done, reselect IODD. b. Check health of connected device.
TEMP-FAULT	Refer to *Thermal Protection* section. a. Investigate source of PC board overheating (overload or environmental). b. Allow PC board to cool. c. Return each port to operation, beginning with port's "Power ON" button.
Master PHY event	Refer to *Fault Conditions* section.
General misbehavior	Press SW1 (RESET) button on DC2228A. This will require communication between the Control Tool and DC2228A to be re-established.
Can't "Select Device" to change IODD	Select "Inactive" and "Power OFF" buttons first.
Can't find the IP addressed to the DC2228A	a. Run *Master settings → Find* to find the IP address. Refer to the *Normal Configuration for Network Connection using DHCP* section for details. b. Reset Winsock and TCP/IP stack. For a Windows 7 PC: • `netsh winsock reset catalog` • `netsh int ipv4 reset reset.log` • `netsh int ipv6 reset reset.log` • Restart computer.
DHCP mode doesn't work	a. Review Additional Information section. b. Press SW1 (RESET) button on DC2228A.
DHCP mode doesn't work on a particular Local Area Network	**Work-Around:** Use a direct Ethernet connection and a fixed IP address. To clear DHCP behavior, refer to *One-Time DC2228A Configuration to Use a Fixed IP Address Instead of DHCP*.
License key fault (LICENSEKEYFAULT)	a. Obtain free renewal of 10000 minute license. See *Software License and Renewal* section. b. Purchase unlimited license.

PARTS LIST

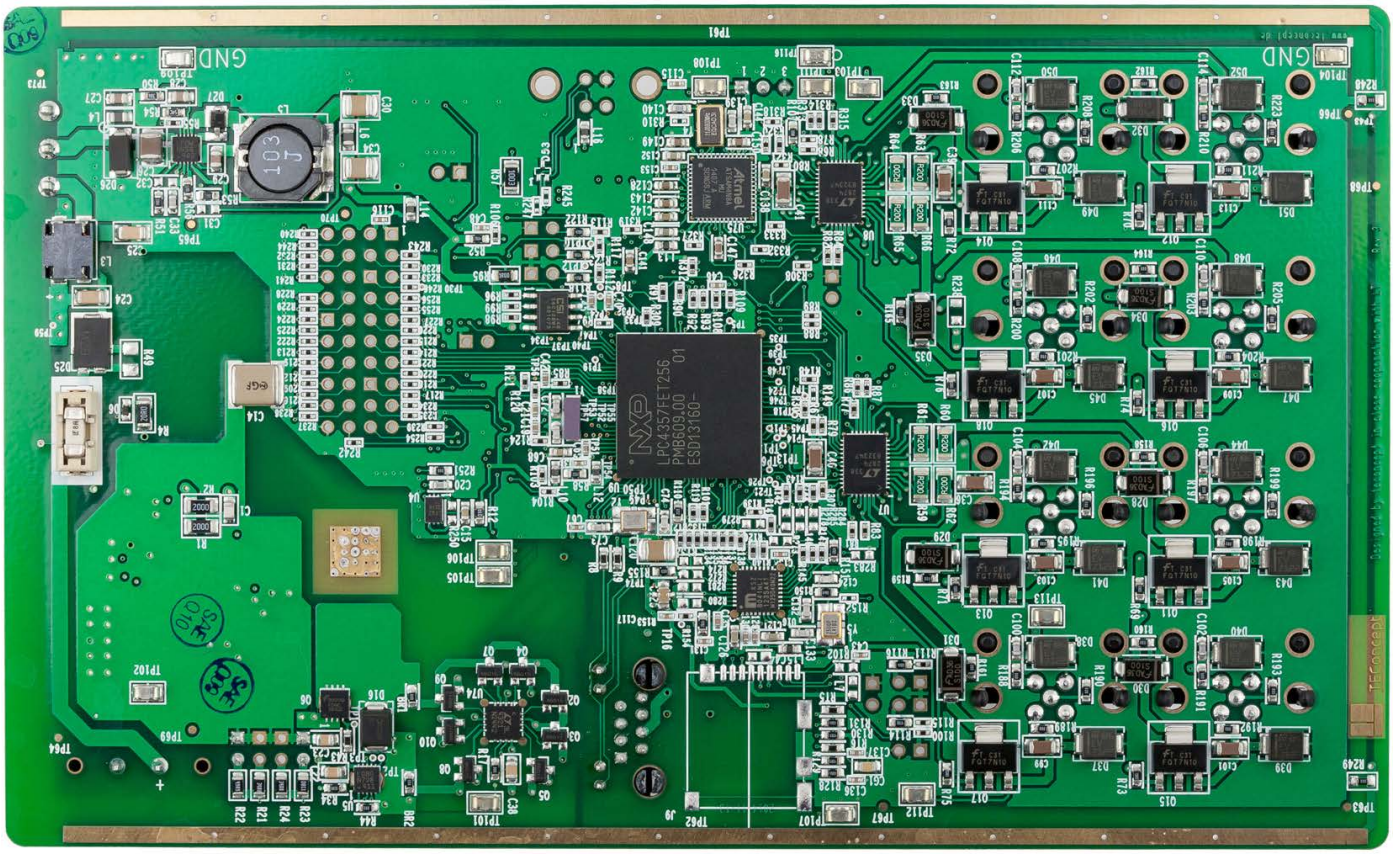
The table below lists components that comprise both the IO-Link physical interface and an optional enclosure. The complete parts list is found here: www.linear.com/demo/DC2228A

ITEM	QTY	REFERENCE	PART DESCRIPTION	MANUFACTURER/PART NUMBER
IO-Link Physical Interface Components				
20	14	C36, C39–41, C75–76, C99, C101, C103, C105, C107, C109, C111, C113	CAP, 1µF, 10%, 50V, X7R, 1206	TDK, C3216X7R1H105K160AB
21	1	C37	CAP, 220µF, 20%, 50V, 12H10 ELEC	PANASONIC, EEE-FT1H221AP
23	8	C100, C102, C104, C106, C108, C110, C112, C114	CAP, 560pF, 5%, 100V, C0G, 0603	TDK, C1608C0G2A561J080AA
41	8	D28–35	DIODE, SCHOTTKY, SMA_2C	FAIRCHILD, S100
43	16	D37–52	DIODE, TVS, 36V, SMB_2C	STM, SM6T36A
50	8	J21–28	CONNECTOR, M12, 5 PIN	PHOENIX, 1694237
64	8	Q11–18	XSTR, 100V N-CH MOSFET SOT-223	FAIRCHILD, FQT7N10LTF
95	8	R59–66	RES, 0.2Ω, 1%, 1206	SUSUMU, RL1632R-R200-F
96	2	R67–68	RES, 4.7k, 1%, 0402	VISHAY, CRCW04024K70FKED
97	8	R69–76	RES, 10Ω, 1%, 0603	VISHAY, CRCW060310R0FKEA
102	1	R107	RES, 1Ω, 1%, 0603	VISHAY, CRCW06031R00FKEA
123	2	U7–8	IC, QUAD IO-LINK MASTER	LINEAR TECH, LTC2874IUHF
Optional Enclosure				
134	0	----	HOUSING, BASE	DIGI-KEY, 2200939-ND
135	0	----	HOUSING, SIDE	DIGI-KEY, 2200952-ND
136	0	----	HOUSING, FRONT PLATE	DIGI-KEY, 2200947-ND
137	0	----	SHEET METAL SCREW, PAN PHILLIPS #6	

SCHEMATIC DIAGRAM

The schematic is found here: www.linear.com/demo/DC2228A

BOARD PHOTO



Reverse Side

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