The VITA46 VPX standard defines a chassis that can accommodate all manner of cards with a common form factor (Reference 1). The cards plug into a common backplane. This design employs the VITA46.4 standard for PCIe to move data between peripheral cards and the host controller in a VPX system. It uses PCIe Revision 1, which runs at 2.5 Gbps. All VPX-compliant cards must use their own independent clocking, differing from other PCIe-compliant systems, such as PCs. VPX-peripheral cards must also create their own clock for PCIe transactions, meaning that the clock is not phase-coherent with the host single-board computer. Thus, the peripheral clock is asynchronous. The PCIe standard allows for this situation and imposes a tight jitter tolerance on all asynchronous PCIe clocks.

The peripheral card in this Design Idea uses an FPGA as the main digital-processing device. FPGA-vendor evaluation boards often feature PCIe interfaces but do not use asynchronous clocking on the board. To implement asynchronous clocking, you use a clock chip that you carefully match to a particular model of oscillator crystal (Figure 1). The clock-chip IC has requirements.

**Figure 1** This circuit feeds a clock generator into an FPGA to make an asynchronous VPX clock.
for the crystal for jitter, aging, and impedance. The crystal should maintain these requirements over a $-40$ to $+85^\circ C$ temperature swing. You must calculate the crystal’s loading-capacitor values using the formula in the CY24293’s data sheet. Feed the clock from the CY24293 directly into the FPGA’s high-speed-transceiver clock pins, yielding reliable PCIe packet transmission between the peripheral cards and the single-board computer. The CY24293 also has other component and layout requirements, as well. Specifically, it uses a PCIe-device-routing configuration, necessitating controlled impedance traces of specific length and series resistors of specific values.

**Use a photoelectric-FET optocoupler as a linear voltage-controlled potentiometer**

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**Figure 1** The output resistance of a photoelectric FET is nonlinear with respect to the input-LED current.

**Figure 2** This circuit feeds back the response of an identical photoelectric FET to linearize the response.
Place 50-kΩ resistors at the FET outputs to mimic the response of a potentiometer. The circuit amplifies the difference between the set input voltage, which you adjust using potentiometer R7, and the feedback from photoelectric FET 1. The resulting output controls the current in the photoelectric-FET LEDs until the feedback voltage equals the input voltage. The output voltage follows linearly with the input voltage (Figure 3). You might think that photoelectric FETs bearing the same part number are identical, but small manufacturing discrepancies can be present. Five H11F3M parts have offsets within 3%. 

Wireless temperature monitor has data-logging capabilities

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You can use a local temperature sensor and an ASK (amplitude-shift-keying) transmitter/receiver pair to design a simple wireless temperature-monitoring system with data-logging capabilities. A microcontroller processes and displays the temperature reading to the user. The microcontroller’s onboard UART (universal asynchronous receiver/transmitter) also allows for data-logging applications.

Local-temperature sensor IC1 detects the ambient temperature at the device (Figure 1). The output of IC1 is a square wave with a frequency of 9.84375 MHz.
proportional to temperature in kelvins. ASK transmitter IC₂ modulates the signal onto the carrier frequency of 315 MHz. You measure the output signal's frequency with a frequency counter. The configured scalar multiplier is 1K/Hz when the TS1 pin connects to ground and the TS0 pin connects to V_DD. This scalar multiplier is configurable with pins TS1 and TS0. ASK receiver IC₃ demodulates the signal at the corresponding carrier frequency (Figure 2).

Comparator IC₄ connects to IC₃’s RSSI (received-signal-strength indicator) with an internal peak detector. The external RC follows the peak power of the received signal and compares it with a predetermined, resistor-voltage-divider-generated voltage level. Lab experiments show that a threshold of approximately 1.57V generates a valid output on the data-out pin without receiving false readings. Adjust this threshold to the proper level for optimal performance. The comparator’s output is low when the received signal is weak or invalid and high when the received signal is adequate.

Microcontroller IC₅ then measures and displays the value of the signal frequency using its integrated timer/counters and LCD-driver peripherals. A counter tracks the number of rising-edge transitions on the input temperature signal, and a timer tracks the elapsed time. After the timer’s 1-sec period elapses, an interrupt occurs. At that moment, the circuit reads the counter value, converts it to Celsius, and displays it on the LCD. The counter then resets to zero to restart the process. The timer automatically reloads once the timer interrupt occurs. UART0 also outputs the resulting temperature. A handheld frequency counter verifies the temperature reading.

The microcontroller monitors the signal power through P6.0, a general-purpose input pin. When the input is logic low, the LCD and UART output “no RF” to alert users of possible transmitter issues when the transmitter and receiver are too far apart from each other. The LCD connection follows the design in the IC’s evaluation kit. Using a look-up table in the data segment of the assembly code enables you to preserve the internal mapping of the display’s A through G segments. This preservation ensures that the display enables the correct segments. Using an RS-232 level converter, the UART output sends data to a data-logging device, such as a computer.

Use the MAX-IDE assembler software to program the device during assembly. The MAXQJTAG board operates with the MAX-IDE to load the code onto the device. You can download the project files at www.edn.com/120119dia. This design provides for a 1-sec temperature-refresh rate in 1°C increments, which is within the accuracy of IC₁.

Figure 2 An ASK receiver with a microcontroller processes and displays temperature data.
Using the system shown in Fig 1, you can quickly test a cable containing twisted-wire pairs and detect open or reversed pairs, shorted pairs, and shorts between unrelated pairs. The tester consists of an active test set that plugs into one end of the cable, and a passive terminator that plugs into the other end. (An RS-449 cable is used as an example.)

A battery or a dc supply delivers 15 to 24V to the test set. The voltage regulator (IC$_1$) is connected as a current regulator to supply a nominal 25 mA to the LED strings at each end of the cable. The cable in this example contains eight twisted pairs, and for a good cable, all eight LEDs in the test set (D$_8$ through D$_1$, which are series-connected segments of a bar-graph display) and all eight LEDs in the terminator (D$_1$ through D$_8$) will light. If a twisted pair is open or reversed, the corresponding LED on the terminator will be extinguished; if a pair is shorted, corresponding LEDs at both ends will be extinguished; and if any two unrelated wires of different pairs are shorted, all intervening LEDs in the strings at both ends will be extinguished. For example, if pins 4 and 6 are shorted, LEDs D$_A$, D$_B$, D$_1$, and D$_2$ will not light.

You can add a heat sink to the IC$_1$ regulator as a safety precaution, but normal tester operation is well within the regulator’s power-dissipation limits. Even with many shorted pairs, a dissipation of 700 mW would cause no more than 60°C junction temperature, and the IC is guaranteed to turn itself off at 160°C. The complete tester costs less than $50 to build.

**Figure 1** By driving two LED strings from a common current source, you can quickly check a cable of twisted-pair wires for short circuits, open circuits, and pair-to-pair shorts.