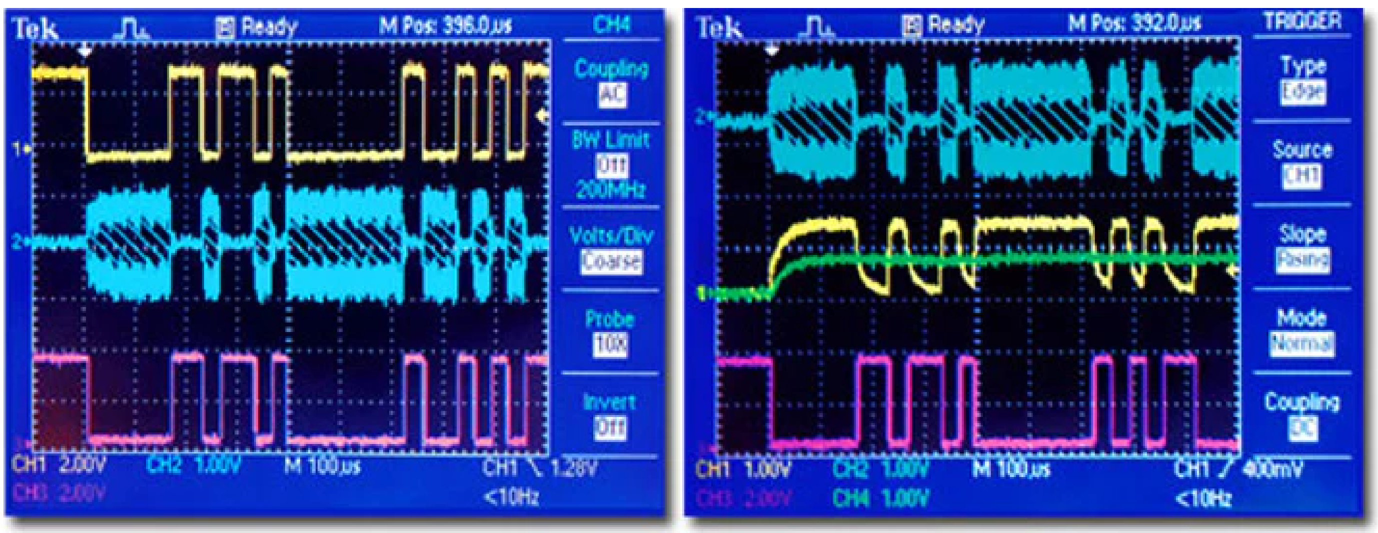


TECHNOLOGIES > COMMUNICATIONS

Simple Circuit Communicates Over Low-Voltage Power Lines

This circuit solves the problem of sending data over a cable with no free conductors. The data is OOK (on-off keying) modulated and superimposed on a high-frequency carrier so it can be sent over a low-voltage power supply line.

Julia Truchsess

APR 15, 2013

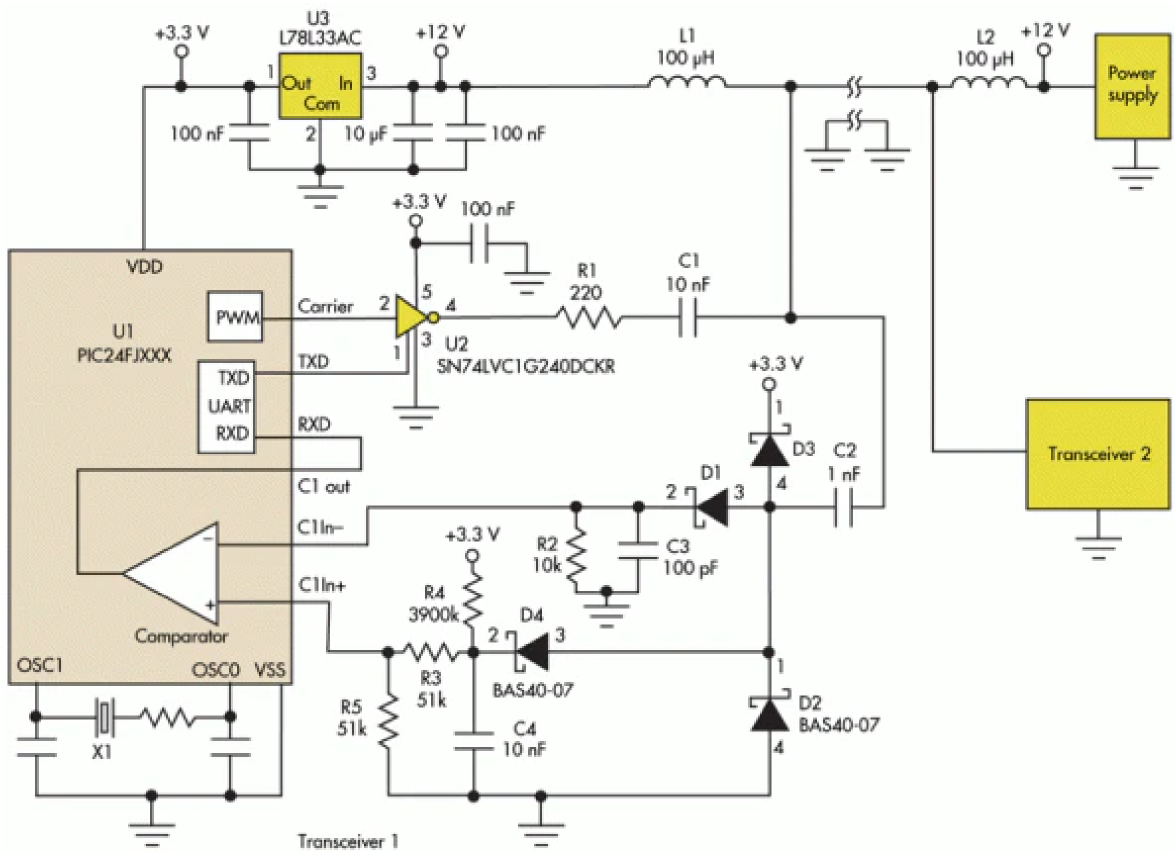
Sometimes a circuit requires a data link over an existing cable that doesn't have any free conductors for a dedicated comm link. A common solution is to superimpose a high-frequency carrier modulated by the data onto a power-supply line, particularly over high-voltage household wiring.

However, a Web search reveals that although many designers face this problem, no simple, inexpensive, and reliable solution for low-voltage systems has been widely publicized. This idea describes such a low-voltage solution. (Note that the circuit is not suitable for high-voltage applications unless specific measures are taken to ensure safe operation.)

The circuit, which requires only a handful of discrete components and two ICs, can reliably transfer data at rates up to at least 32 kbits/s with a 2.6-MHz carrier and probably well beyond that if a higher carrier frequency is used and component values are adjusted accordingly. The link can tolerate cable capacitance of up to 10 nF and has low radiated emissions. The circuit transmits data in standard (UART-compatible) asynchronous serial format, but designers can use Manchester encoding or other protocols.

For simplicity's sake, the modulation scheme is on-off keying (OOK), and the circuit provides no inherent noise rejection (other than a good signal-to-noise ratio). Designers can implement error detection/correction in software if desired.

U1 is a PIC microcontroller that includes several peripherals ideally suited for this application, in particular a pulse-width modulation (PWM) module or programmable time base for generating a square-wave carrier and a high-speed analog comparator whose input common-



1. A relatively simple circuit allows users to communicate data over a low-voltage power line in applications that do not have any free conductors in an existing cable.

The circuit is a two-transceiver system. Transceiver 1, on the left, is a “remote” node getting its power from the “base” unit, Transceiver 2, on the right. Inductors L1 and L2 isolate the high-frequency carrier from the low impedances on the power sides of the bus.

Multi-drop configurations are possible as long as each node includes an inductor to maintain the high impedance of the data-carrying portion of the power line. The inductors can be small surface-mount devices, as long as their current ratings, with a generous margin, are sufficient for the load(s).

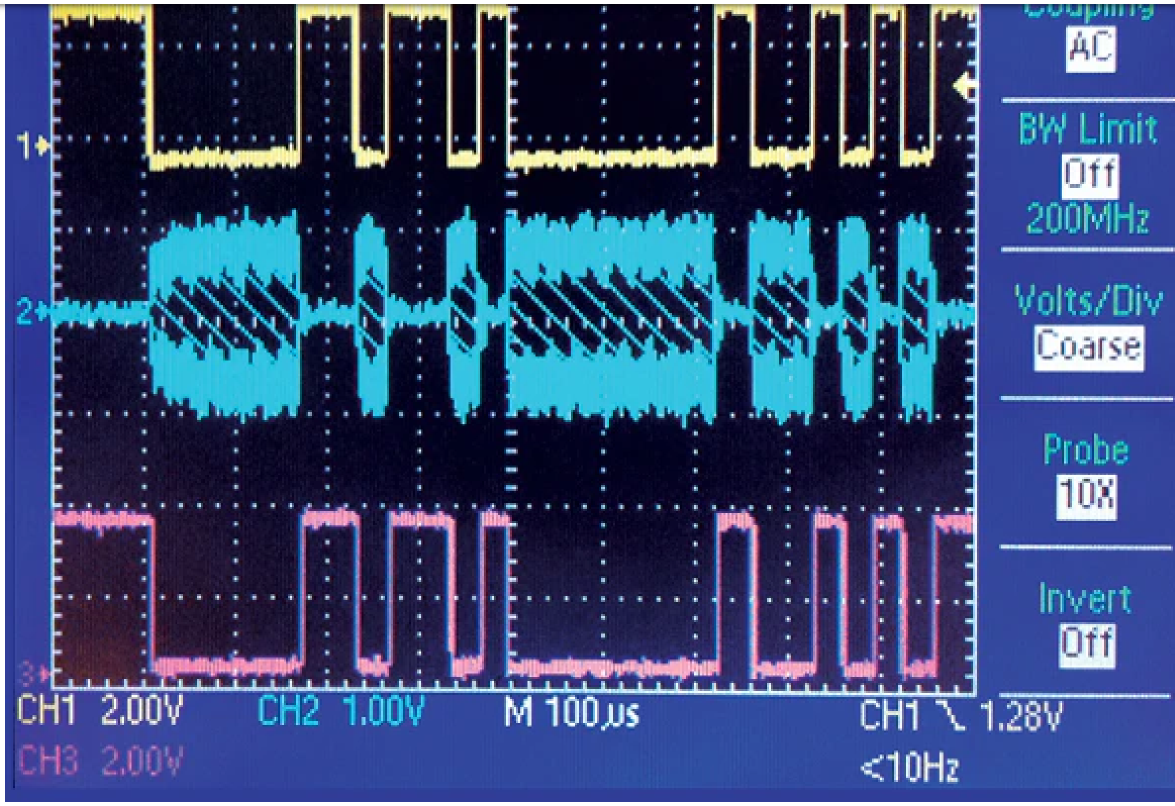
The transmitter portion of the transceiver comprises a TinyLogic tri-state line driver, U2, whose output is coupled to the bus by R1 and C1. R1 provides a bit of filtering to minimize electromagnetic interference (EMI) from the sharp edges of the square-wave carrier.

The receiver comprises a clamp formed by C2, D2, and D3, followed by two peak detectors. The first, with a time constant of approximately one-third of the data bit time, demodulates the carrier to recover the data timing. The other, with a time constant of about 50 times the bit time, adaptively follows the carrier level. R3 and R5 divide this level to approximately two-thirds of the carrier amplitude.

The demodulator and reference level outputs are applied to the inputs of the MCU's internal analog comparator to square up the final data, which is then routed externally to the MCU's UART. Resistor R4 biases the positive input of the comparator slightly positive to ensure a predictable logic-high idle state.

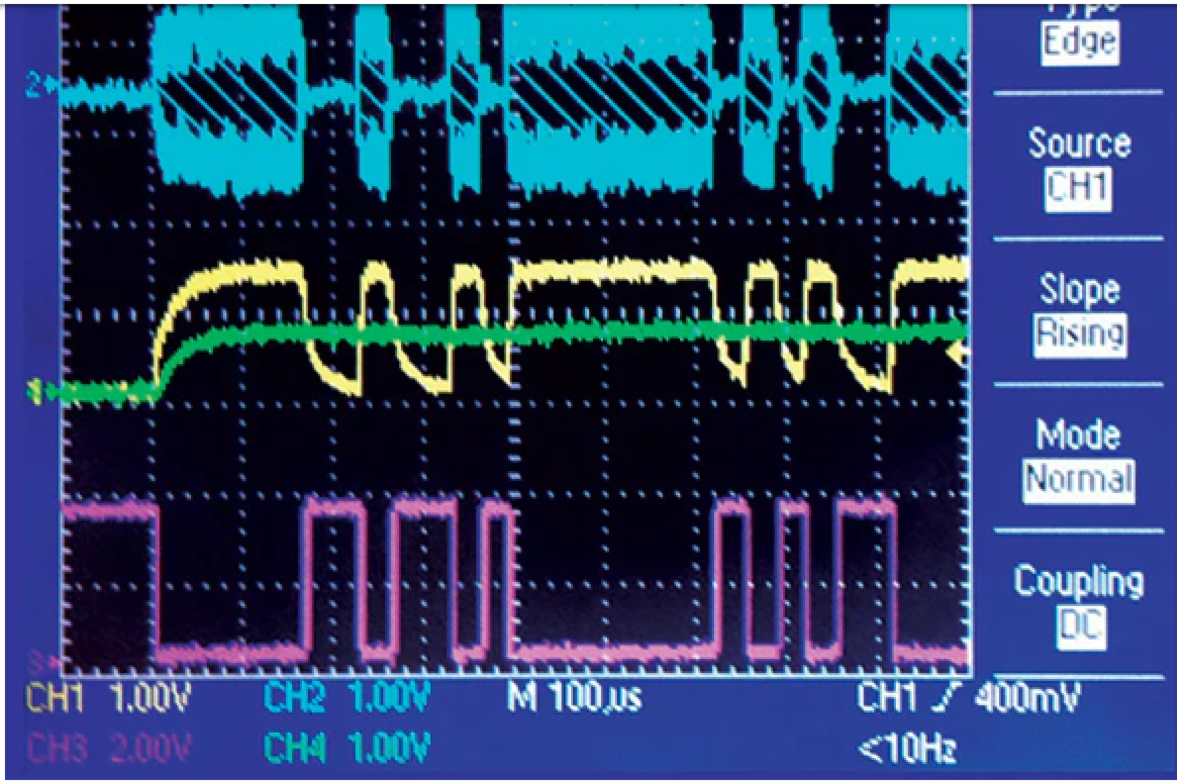
It should be noted that since the transceiver's input and output are always connected, the software must ignore reception of its own transmissions.

In Figure 2, trace one (yellow) is the original digital data sent from a remote transceiver's UART TX port. Trace 2 (blue) is the resulting modulated carrier present on the power line. Trace 3 (pink) is the demodulated and reconstructed data presented by the receiver's comparator to its UART RXD port.\



2. The original data (yellow) is transmitted over the power line on a modulated carrier (blue) and faithfully recovered at the comparatorâ□□s output (pink).

Figure 3 depicts the demodulation and reconstruction process. Trace 2 (blue) is the incoming OOK-modulated carrier, and the comparator inverting and non-inverting inputs are shown on traces 1 (yellow) and 4 (green), respectively. The comparator's output, which is the reconstructed data presented to the UART's RXD, is shown on trace 3 (pink).



3. This screen shows the demodulation and reconstruction process with the modulated signal (blue), the negative comparator input (yellow) and the positive comparator input (green), and the reconstructed data (pink).

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Posted by dungsoi1994 Apr 7th, 2018 11:47pm

Can you give me the project code? thank you

Posted by elecdes Apr 7th, 2018 7:23am

Hi Julia!I'm trying to adapt this for a project that required DC power and limited comms over 500' of 18AWG cable. Of course 2.6Mhz is way too high for such long cable, so I'm shooting for more like 80Khz and 2400 baud. Do you believe this is pratical to achieve and/or do you have any suggestions?

Posted by julia Jan 16th, 2017 2:12am

When I originally submitted the article, the carrier frequency was 1MHz and C3 was 1NF, giving a 10us time constant, ≈1/3 of the bit time as mentioned in the article. After further testing I found that a 30:1 carrier-data ratio was cutting it too close and I was getting errors under certain conditions; increasing the carrier frequency and dropping the time constant to 1us solved the problem. I passed the changes on to Electronic Design, but unfortunately I overlooked the mention of the time constants in the text, so they don't jibe.

R5 was at one time 100K, which would make that peak detector's time constant 1.5ms, or 50x the bit time, as mentioned in the article. The change of R5 from 100K to 51K was done to lower the comparator threshold to better center it within the demodulated carrier's voltage swing, and there was no need to readjust the time constant, as the time constant on this peak detector is very non-critical.

I settled on 27 Ohms for R1 instead of the 220 Ohms mentioned in the article. This value should be tailored empirically to the characteristics of your transmission line. 220Ω was working fine for a two-node system over 4-12 feet of cable, but I found that in order to drive a six-node system with 30-50 feet of cable I needed a bit more oomph from the transmitter. The circuit is performing well in production.

A lot of time passed between my originally writing the article (relatively early in the development cycle) and its acceptance and publication, which explains the discrepancies, I apologize.

Posted by carolchristensen123 Mar 2nd, 2016 4:33pm

Posted by cely.frey Oct 13th, 2014 11:18pm

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requirements of more than 300 Watts. Also referred to as Peltier coolers, these relatively small devices are designed with size, efficiency, low power requirement, cost and reliability in mind. Thermoelectric coolers enable OEMs to meet thermal design challenges including spot cooling, refrigeration or temperature stabilization.

Offering an alternative to conventional fan trays and compressor-based cooling systems, thermoelectric cooler assemblies combine Peltier cooling technology and heat transfer mechanisms in a compact unit to stabilize the temperature of sensitive electronic components or to cool devices, chambers, and enclosures below ambient temperatures. With thermoelectric coolers at their core, these eco-friendly, cooling assemblies are designed to absorb and dissipate heat of up to 400 Watts through convection, conduction or liquid means. With the ability to heat or cool in the same device, thermoelectric cooling assemblies, when combined with temperature controllers, can deliver precise temperature control for a wide variety of medical, analytical, telecom and industrial applications.

In this webinar, editor Bill Wong and Laird Thermal Systems' Vice President Sales & Marketing Christoph Bauckhage, and Product Director Andrew Dereka will discuss integration scenarios for these applications and how thermoelectric cooling can offer high reliability for years of service with little or no degradation in performance, reducing the total cost-of-ownership of the cooling solution.

Applications for Thermoelectric Cooling include:

- Industrial Lasers & Optics
- Projection Lasers
- Enclosure Cooling
- Refrigerated Centrifuges
- Incubator Chambers
- Reagent Storage
- Liquid Chromatography

People who should attend include:

- Design engineers, hardware engineers, mechanical engineers, engineering management
- Purchasing/procurement professionals

Speakers

Christoph Bauckhage, Vice President Sales & Marketing, Laird Thermal Systems

Christoph Bauckhage is Vice President of Sales & Marketing at Laird Thermal Systems. He has a diverse background in sales, research & development, project management and business development, with experience in building highly engineered components and turnkey thermal management systems for various markets. During the past 15 years, he has been successful in fueling growth and creating a global brand image for multiple companies. Christoph holds a master’s degree in Business Administration, Corporate Finance and Marketing from European Business School Oestrich-Winkel and a Bachelor of Science from James Madison University, VA, USA.

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Andrew Dereka is the product director for the thermoelectric cooler and thermoelectric cooler assemblies product lines at Laird Thermal Systems. Andrew has 20 years of thermal management experience working with leading OEM's from around the globe learning about their thermal problems and helping to solve them. He has applications expertise in refrigeration for medical and analytical instrumentation, spot cooling for imaging and laser systems and ambient cooling for telecommunications cabinets. He has successfully launched more than 12 new thermal products into the market driving mass adoption. Andrew holds an MBA degree from Rutgers University and BSME from University of North Carolina in Charlotte.

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