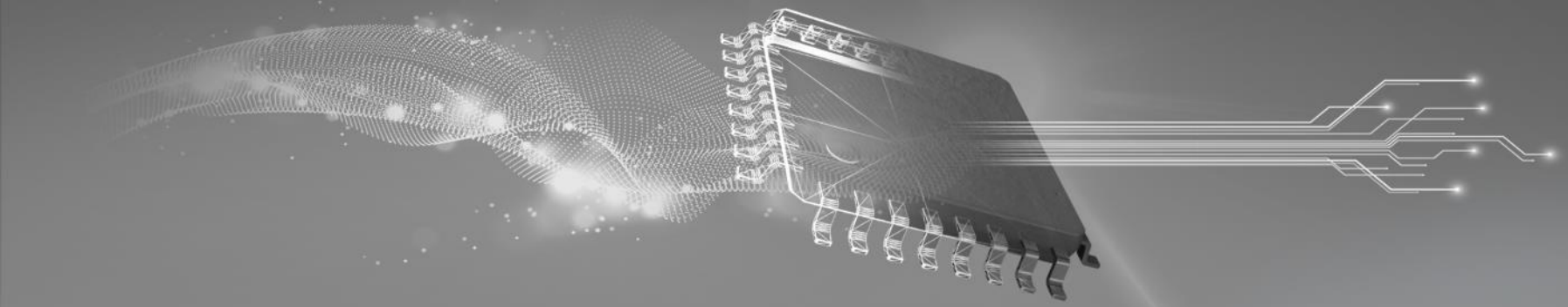
TI TECH DAYS



Say goodbye to 4-wire cables.

Learn how to transmit your RS-485 communication over a power bus, eliminating wires and optimizing system cost

Hao Liu

ASC/INT/TRX

Texas Instruments

Agenda

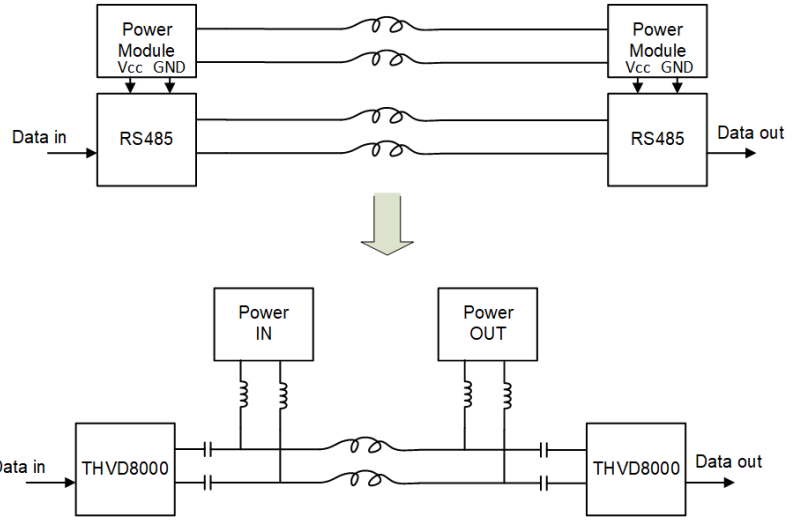
- 4-wire application becomes 2-wire!
  - Comparison with existing PLC technology
- Introduction to THVD8000
  - Driver
  - Receiver
- Implementation concerns and common questions
  - Carrier frequency, termination, L/C selection, grounding
- Special application circuits
  - Single-ended communication
  - Operate with line driver

When a 4-wire application only needs 2-wires

Traditionally the power line and data line are carried separately.

If data could be transmitted over power lines, the total wires would be reduced from 4 to 2.

- **Result: Up to 50% cost savings**



Key applications include HVAC, E-meters, elevator, lighting, E-bike, etc.

When a 4-wire application only needs 2-wires

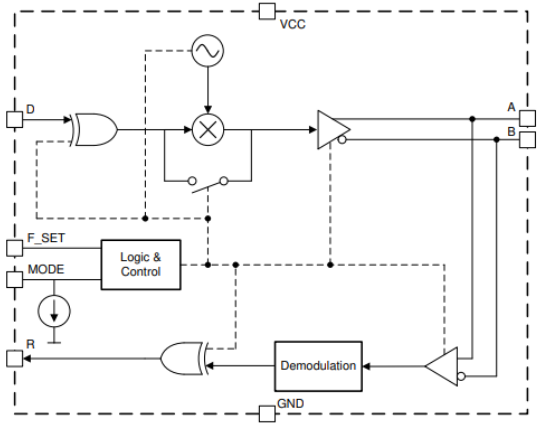
Data over power line technology

- Making power and data transmitting on the same wires
- Combine and separate power (low speed) and data (high speed) signals
- Existing solutions
  - PoE (Power over Ethernet)
  - Power line communications (PLC)
  - Powerline communication analog front-end (AFE)

THVD8000 applies OOK modulation to couple data to the power line for simple, flexible, and effective communication.

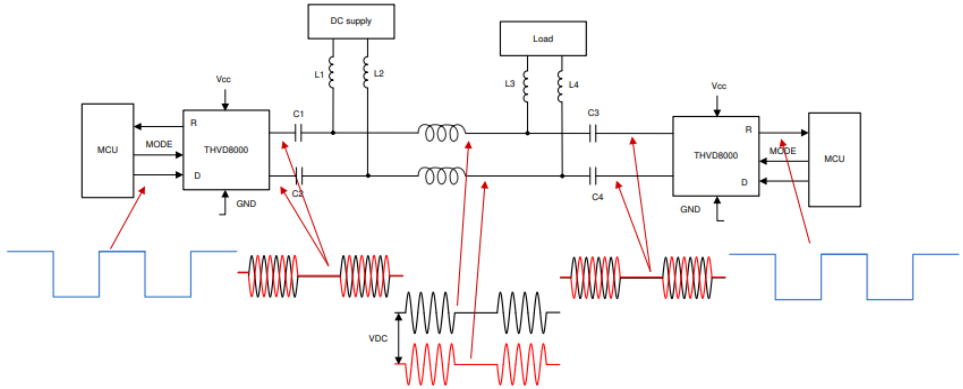
THVD8000 blocks

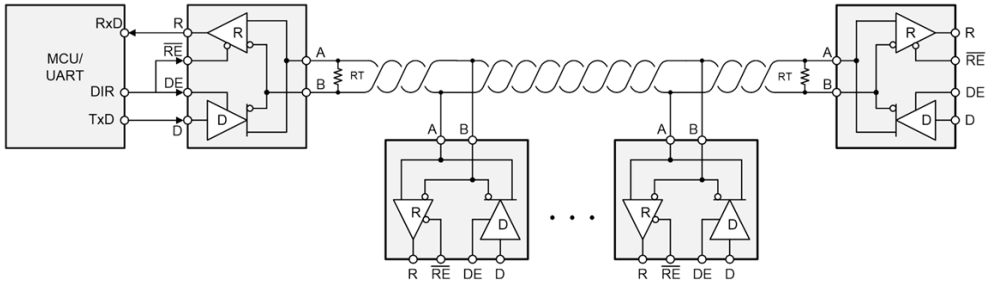
- Driver – Same as RS-485 transceiver structure
- Internal clock to OOK modulate data
- Integrated bandpass filter for demodulation and envelop detection
- Variable data rate setting by external resistor at the F_SET pin



THVD8000 system

- Leverage RS-485 signaling
- OOK modulated data
- PHY level replacement
- Flexible data rate
- Polarity free operation
- Multiple node network
- Long distance



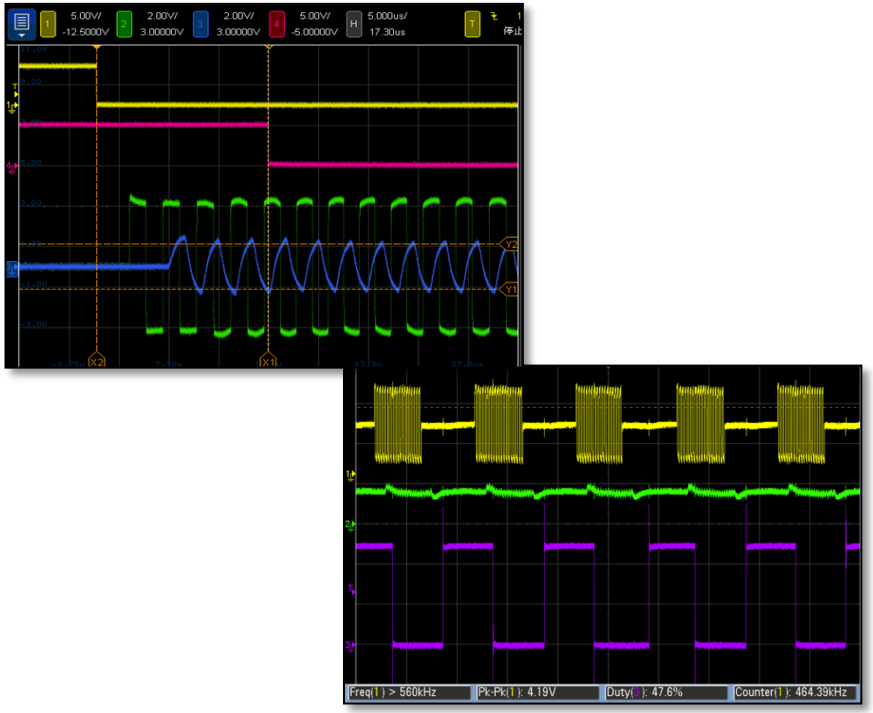


THVD8000 benefits

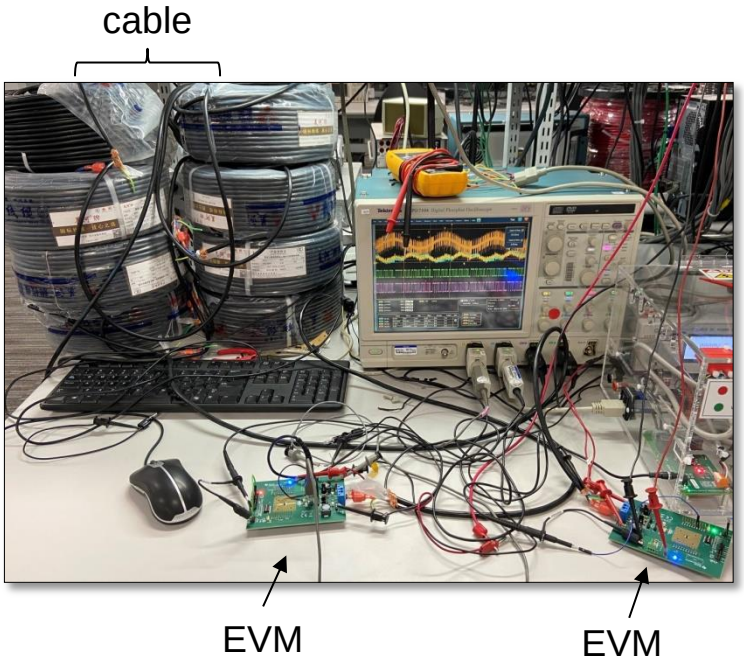
- OOK modulation handled inside the RS-485 transceiver
  - Wide data rate operation
  - No data DC balancing needed
  - Electrical signaling parameters conforms to TIA/EIA-485A standard
- No controller/software updates needed (good for drop-in)
- All the benefits of RS-485
  - Physical layer definition only → Flexibility in implementation
  - Robust operation in noisy environments → Excellent EMC/EMI performance
  - Cost effective

THVD8000 setup and waveforms

Communication waveforms



Lab bench setup example



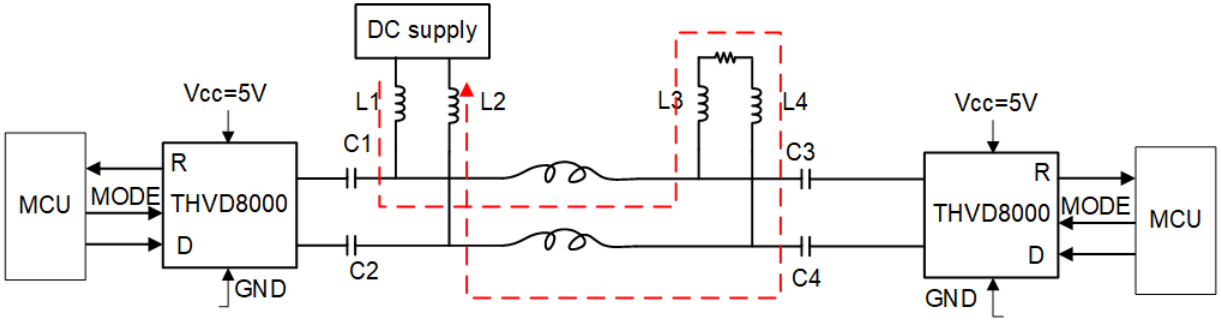
Design tips – Data rate and carrier frequency

- It is recommended to use a carrier frequency that is 10x higher than the data rate.
  - For example, for 9600 baud rate, 100kHz or higher carrier frequency can be chosen.
  - The OOK f_0 is not sensitive to the external resistor variation (+/- 2%).

R_{F_SET} (kΩ)	OOK f_0 (kHz)
77	125
50	187.5
19	500
12.5	750
9.3	1000
4.4	2000
1.5	5000

Design tips – Power delivery

- THVD8000 sits behind the AC coupled capacitor so the THVD8000 pins don't interface DC or AC power directly (ref 2).
- The capacitor needs to have high enough voltage rating
  - 24 VDC or 24 VAC are common applications
- The energy that can be transmitted depends on the inductor current rating and DC resistance, and the cable.



Design tips – Data rate vs. distance

- In applications, maximum distance that can be achieved at a given rate is mostly a function of the cable used.
- Transmitter output amplitude (drive strength) can be useful in low-speed/long-range applications that are limited by the DC resistance of the interconnect cable (ref 1.).
- At higher frequencies, the most critical factor is the insertion loss of the transmission line

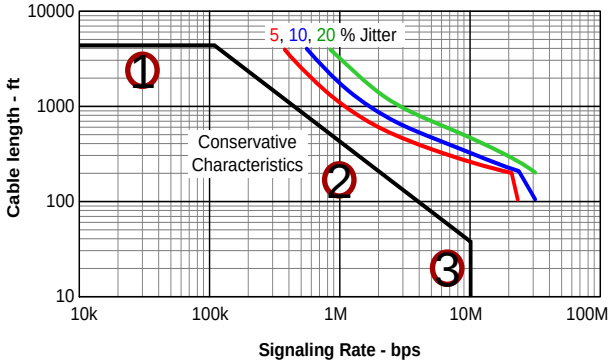
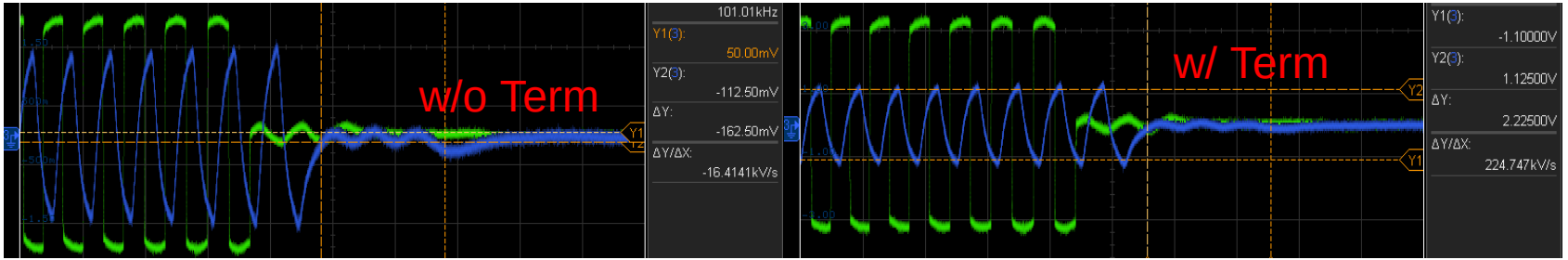


Table 2. Cable Length Versus Carrier Frequency

		fo (kHz) (data rate = 1/10 fo)				
		125	300	500	750	1000
Cable Length (Meter)	300	y	y	y	y	y
	600	y	y	y	y	y
	900	y	y	y	y	n
	1200	y	y	y	n	n
	1500	y	y	n	n	n

Design tips – Termination

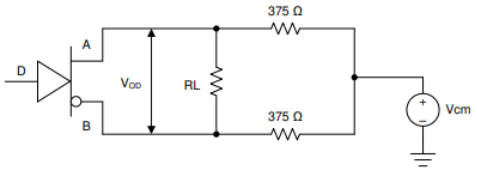
- Termination: Terminate the two furthest points of the bus with resistors equal to the characteristic impedance, Z_0, of the bus, which improves the signal integrity (ref 5).
- THVD8000 works without termination, meaning topologies other than daisy-chain can be used.

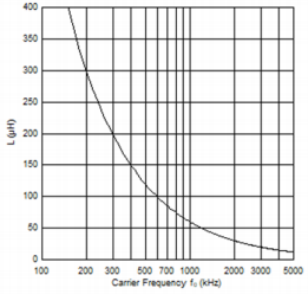


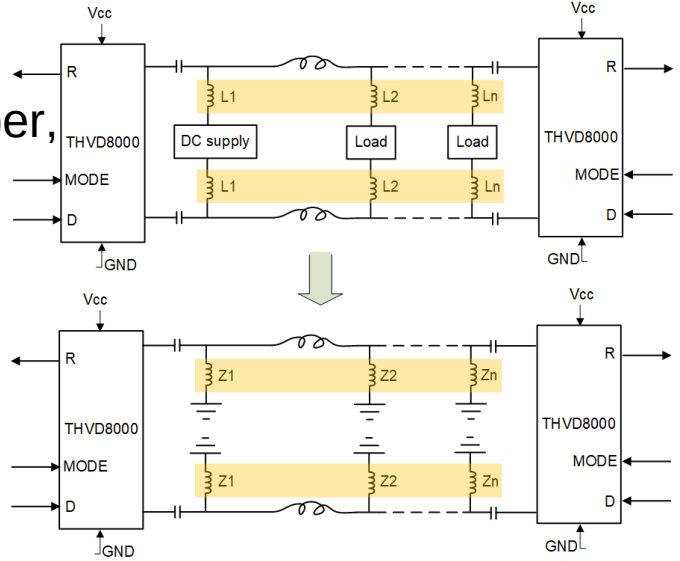
- In designs, the signal should have enough time to settle in one bit time.

Design tips – Inductor selection

- Inductor value is based on the impedance at the carrier frequency.
- 375 Ohm is the maximum load of the bus, which guarantees 1.5 V Vod.
- All active inductors need to be taken into account.
- More accurate result expressed as complex number, including R and C.
- Cable impedance also plays a role in evaluation.

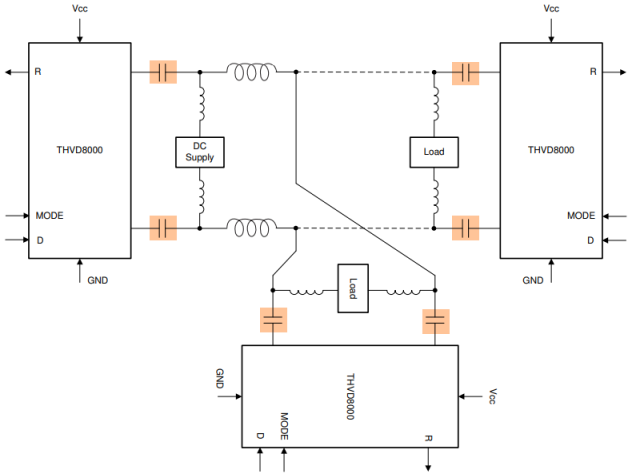


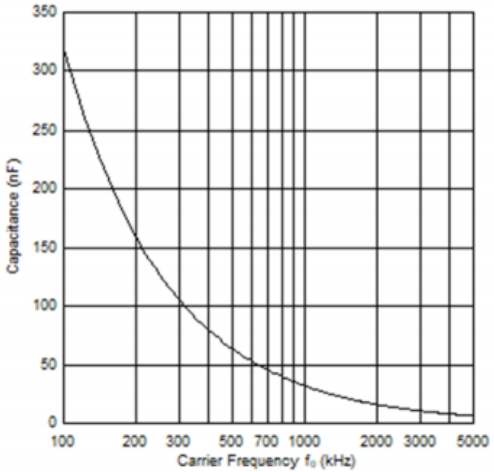




Design tips – Capacitor selection

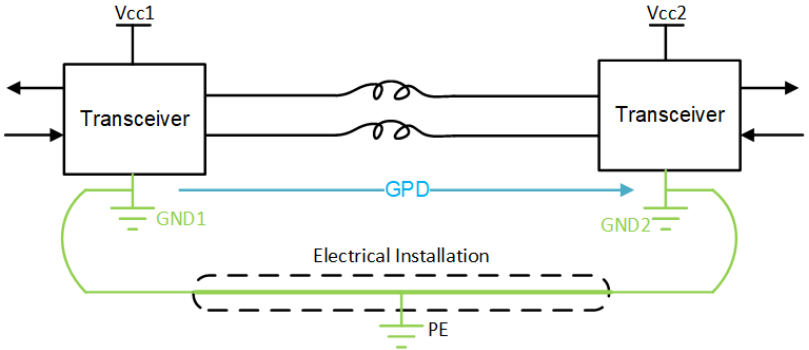
- The impedance at the carrier frequency should be small (< 5 Ω) to prevent attenuating the signal (ref 4).
- Each capacitor is evaluated individually.





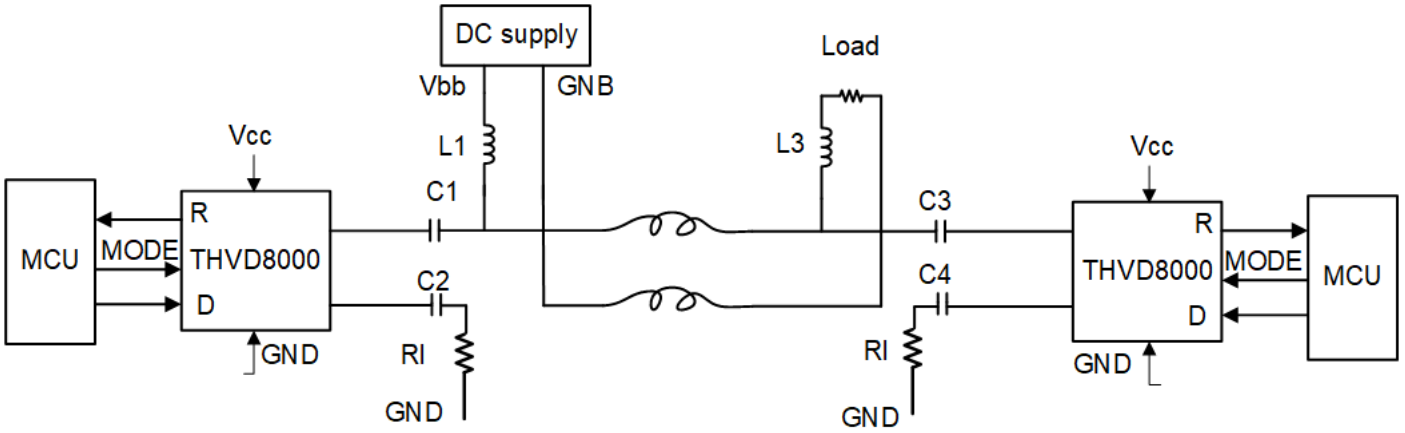
Design tips – Grounding and noise

- Noise sources:
  - High frequency (running compressor, etc)
  - Low frequency (adaptive DC-DC of load, 50/60Hz AC, etc)
- Common mode noise can become differential (power cables are usually not twisted pair)
- Floating grounding can pick up lots of noise in high impedance current return path (ref 3.)



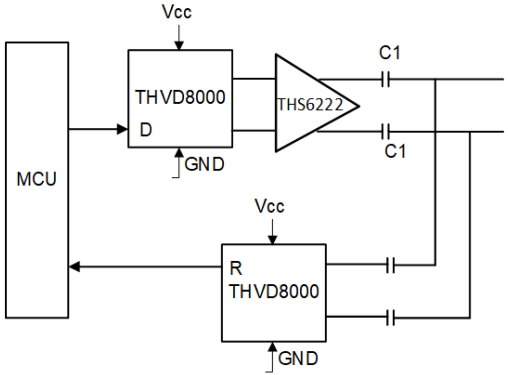
Special applications – Single-ended setup

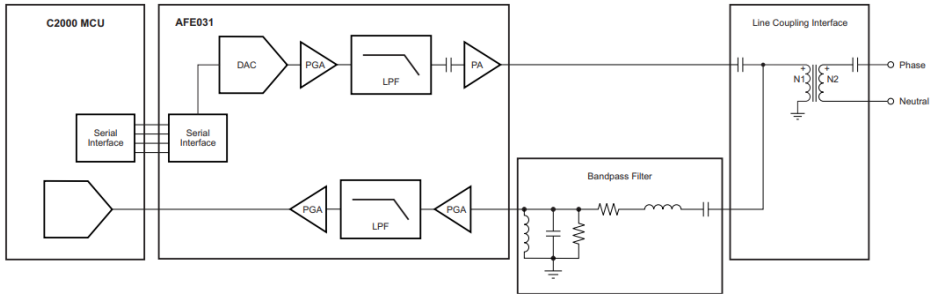
- THVD8000 works with single-ended setup, although it generates differential signal.
- This setup further reduces the inductor number by half.



Special applications – Working with a line driver

- THVD8000 can work with a high-speed line driver to drive a low impedance AC line.
- This implementation is similar to the AFE application.
- Instead of FSK or OFDM, THVD8000 takes care of OOK modulation/demodulation (ref 6).





Summary

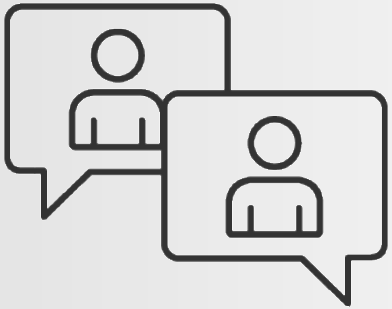
- THVD8000 is an RS-485 transceiver with on-off keying (OOK) modulation and demodulation built in for power line communication.
- Does THVD8000 fit your application?
  - What are the data rate requirements?
  - DC/AC power (and voltage) requirements?
  - Any restrictions on capacitor and inductor selections?
  - Emissions requirements?
  - Package preference?

Reference

1. RS-485 design guide
2. THVD8000 design guide
3. Ground noise
4. Power over data bench simulation
5. Signal integrity and reflection
6. MCU interface with AFE

Q & A

Visit our TI E2E™ support forums to receive direct support from our engineers throughout every step of your design.



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