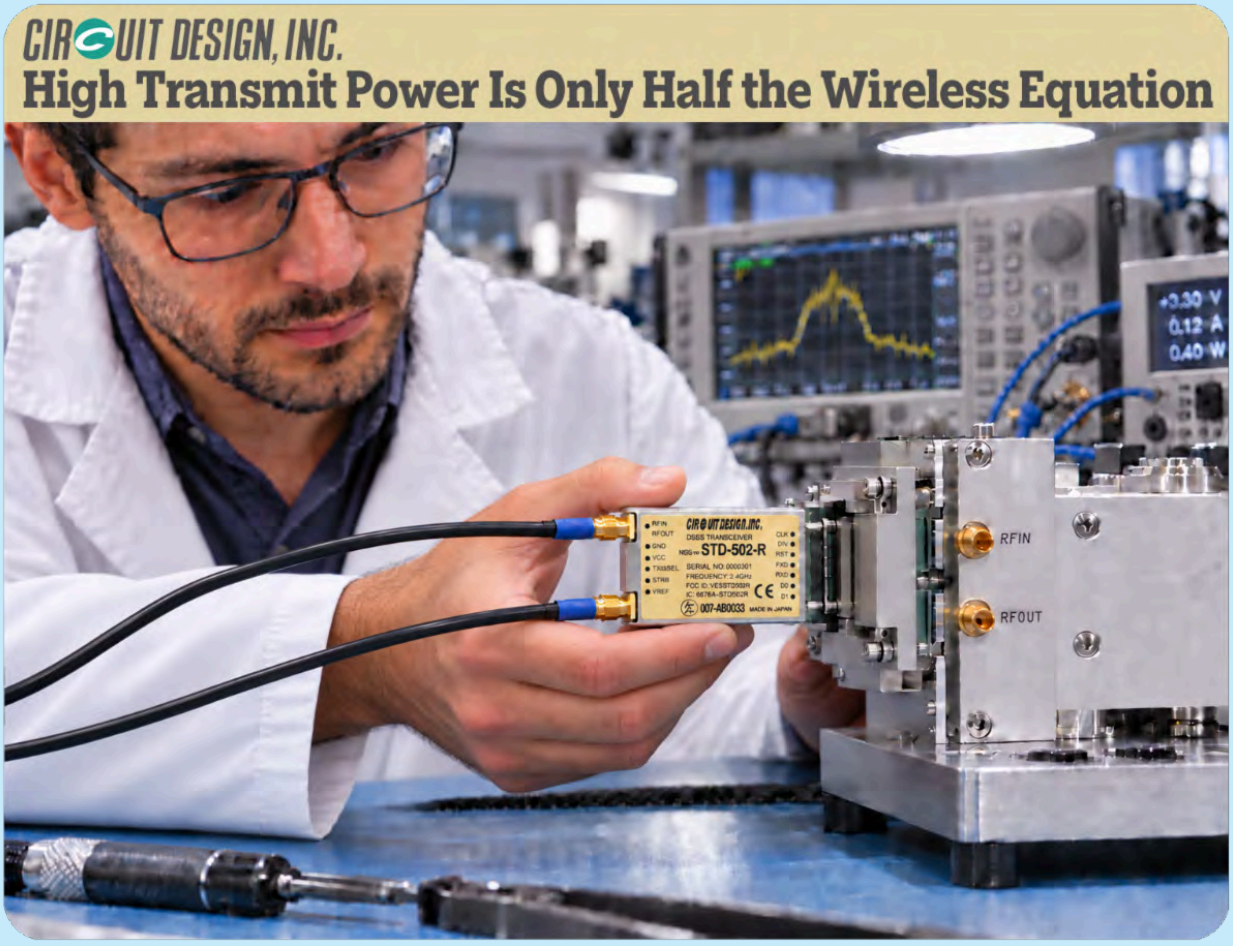
Saelig unique electronics

news & updates September 2026 | Issue 38

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CEO's Corner

When engineers need greater wireless range, increasing transmit power may seem like the obvious solution. But a powerful transmitter cannot compensate for a receiver that is unable to detect a weak return signal or reject interference. Reliable wireless communication depends on the performance of the entire radio link—not simply how loudly one device transmits.

Circuit Design, Inc. believes effective industrial wireless systems must balance transmit power with receiver sensitivity, selectivity, blocking performance, antenna efficiency, operating frequency, and the

surrounding RF environment. This system-level approach creates dependable two-way communication without relying unnecessarily on higher power.

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Why High Transmit Power Is Only Half the Wireless Equation

Wireless Communication Requires Both Talking and Listening

A wireless link is often evaluated by looking first at transmitter output power. A higher-power signal can overcome more propagation loss and arrive at the receiving antenna at a stronger level. That can improve range—but only in the direction in which the high-power transmitter is operating.

Most industrial applications require two-way communication. A remote sensor may need to acknowledge a command, a controller may need confirmation that an instruction was received, or a machine may have to return operating data to a central system. If one device transmits at high power but the other uses a lower-power radio, the forward link may work while the return link fails.

In other words, communication range is determined by the weaker direction of the link.

A transmitter that can be heard over a long distance is useful only if it can also hear the reply.

The Link-Budget Perspective

Engineers use a link budget to account for the gains and losses between a transmitter and receiver. In simplified form:

Received Power = Transmit Power + Transmit Antenna Gain + Receive Antenna Gain − Path Loss − System Losses

The received signal must then remain above the receiver's sensitivity threshold, with enough additional margin to accommodate fading, interference, antenna orientation, obstacles, component tolerances, and environmental changes.

This makes receiver sensitivity just as important as transmitter power. For example, improving receiver sensitivity by several decibels can provide a link-budget benefit comparable to increasing transmitter output by the same amount—without increasing transmitted RF energy.

Circuit Design's RF guidance emphasizes that achievable communication range depends on propagation conditions as well as antenna characteristics, receiver sensitivity, and modulation technique—not transmit power alone.

Sensitivity is influenced by several factors:

- Receiver noise figure
- Channel bandwidth
- Modulation method
- Data rate
- Required signal-to-noise ratio
- Filtering and demodulation performance
- Acceptable bit-error or packet-error rate



Sensitivity figures should therefore be compared only under equivalent test conditions. A sensitivity specification measured at a low data rate or relaxed error threshold may not represent performance at the intended operating rate and reliability level.

Sensitivity Is Not Enough in a Crowded RF Environment

Excellent sensitivity tells engineers how well a receiver performs when the desired signal is weak and interference is controlled. Industrial installations rarely provide such ideal conditions.
A receiver may also encounter:

- High-power transmitters operating nearby
- Signals on adjacent channels
- Multiple radios sharing the same frequency band
- Broadband noise from motors, drives, power converters, and digital electronics
- Intermodulation products
- Harmonics and spurious emissions
- Strong signals far outside the desired channel

Under these conditions, a receiver must do more than detect a weak signal. It must distinguish that signal from everything around it.

Selectivity and Blocking Performance

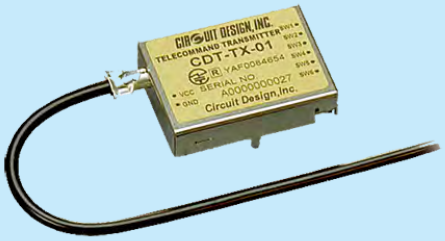
Selectivity is the receiver's ability to accept the desired channel while rejecting signals on nearby channels. Good selectivity is especially valuable when multiple wireless systems operate within a limited frequency band.

Blocking performance describes the receiver's ability to continue receiving a weak wanted signal when a much stronger unwanted signal is present elsewhere in the spectrum. A receiver with inadequate blocking performance may become desensitized or overloaded, even when the interfering transmission is not operating on the selected channel.

This is one reason Circuit Design emphasizes narrowband technology for demanding industrial applications. The company notes that narrowband receivers with strong blocking characteristics can provide reliable communication in environments containing competing RF signals.

In practice, receiver selectivity and blocking performance may contribute more to dependable operation than a simple increase in transmitter power.

More Power Can Create More Problems



Increasing transmit power is not always a free improvement. It can introduce several design and operational penalties.

Higher energy consumption

Greater RF output normally requires more current. This can shorten battery life, increase power-supply requirements, and make low-power or energy-harvesting applications more difficult to implement.

Additional heat

Higher-power amplifier stages dissipate more energy. This may require additional thermal management and can affect reliability in sealed or compact equipment.

More interference

A stronger transmission can interfere with nearby receivers or other users of the same spectrum. It may also aggravate the near-far problem, in which a strong nearby transmitter prevents a receiver from detecting a weaker, more distant device.

Regulatory limitations

Permitted output power, effective radiated power, channel occupancy, duty cycle, and access methods vary by country and frequency band. Simply increasing transmitter output may not be legally available as a solution.

Greater emissions-control challenges

Higher output can make harmonic, spurious-emission, shielding, filtering, and PCB-layout requirements more demanding.

Asymmetric communication

If only one end of the system receives a power increase, the link may remain unbalanced. The distant device might receive the powerful transmission but still be unable to send a usable response.

Antenna Performance Affects Both Directions

Improving an antenna system is often more effective than increasing transmitter output because antenna gain and efficiency benefit both transmission and reception.
Important considerations include:

- Antenna gain and radiation pattern
- Impedance matching
- Antenna orientation and polarization
- Mounting height
- Cable and connector losses
- Ground-plane dimensions
- Nearby metal, wiring, enclosures, and people
- Separation from noise-generating electronics
- Obstructions within the propagation path

An antenna mounted inside a metal enclosure or close to a large conductive object may lose much of its effectiveness. Similarly, polarization mismatch between transmitting and receiving antennas can substantially

weaken the link.

A well-designed antenna system allows more transmitted energy to reach the environment and more received energy to reach the receiver input.

Frequency and Propagation Matter

Wireless range is also affected by operating frequency and the physical environment. Lower-frequency signals can offer advantages in some long-range or obstructed applications, while higher frequencies may support smaller antennas and wider bandwidths but can behave differently around walls, terrain, foliage, machinery, and other obstacles.

Line of sight alone does not guarantee ideal propagation. Adequate clearance of the Fresnel zone can also be important. Circuit Design explains that obstructions within this region can introduce meaningful transmission loss, even when the two antennas remain visually unobstructed.

Designers must consider:

- Distance
- Frequency
- Terrain and building materials
- Antenna height
- Fresnel-zone clearance
- Reflections and multipath propagation
- Moving equipment or vehicles
- Seasonal changes in foliage
- Indoor machinery and structural steel

A system that performs well during an outdoor demonstration may behave very differently after installation inside a factory or warehouse.

Narrowband Technology for Reliable Industrial Links

Industrial telemetry, telecontrol, alarm, and remote-control systems often prioritize dependable communication over extremely high data throughput. Narrowband radio can be particularly effective in these applications.
A narrower receiver bandwidth generally admits less noise than a wider bandwidth. Combined with appropriate filtering, receiver architecture, modulation, and protocol design, this can support reliable reception of weak signals while helping the radio distinguish the wanted channel from nearby activity.

Circuit Design specializes in low-power, narrowband radio modules for short-range industrial applications where reliability is essential, including telecommand, telecontrol, telemetry, and alarm systems.

Data Rate and Modulation Must Match the Application

Maximum data rate and maximum range are frequently competing objectives. A higher data rate normally requires more bandwidth and may require a stronger signal-to-noise ratio at the receiver. Where the application sends only short commands, status messages, or sensor readings, a lower data rate may improve reception and link robustness.

The modulation method also affects:

- Receiver sensitivity
- Noise immunity
- Occupied bandwidth
- Resistance to interference
- Power consumption
- Spectral efficiency
- Implementation complexity

The best radio is therefore not automatically the one with the highest output power or fastest advertised data rate. It is the one whose complete performance profile matches the application.

Protocol Design Strengthens the Physical Radio Link

Reliable hardware should be supported by a well-designed communications protocol. Depending on the application, useful features may include:

- Packet validation
- Checksums or cyclic redundancy checks
- Acknowledgments
- Automatic retries
- Sequence numbering
- Addressing
- Duplicate-packet rejection
- Listen-before-talk operation
- Channel selection
- Store-and-forward or repeater functions
- Link-quality monitoring

These features cannot replace adequate RF performance, but they help a system manage temporary interference, collisions, fading, and lost packets.

Engineering for Link Margin



A wireless system should not be designed merely to work under ideal conditions. It should provide sufficient link margin for foreseeable variations in the installation.

A signal that is only slightly above the receiver threshold may work during initial testing and fail later because of:

- Rain, snow, or foliage
- A vehicle parked in the propagation path
- Antenna movement
- Component aging
- Battery-voltage reduction
- New machinery or wireless equipment
- Changes to the building or installation
- Additional cable or connector losses

Link margin gives the system room to absorb these changes. It should be established through realistic calculations and confirmed through testing in the intended operating environment.

A Better Approach to Extending Wireless Range

Before increasing transmitter power, engineers should evaluate the entire communications path:

1. Confirm that both directions of the wireless link have adequate budget.
2. Compare receiver sensitivity under the intended data-rate and error-rate conditions.
3. Evaluate selectivity, blocking, and adjacent-channel performance.
4. Measure environmental noise and identify likely interferers.
5. Optimize antenna type, placement, orientation, matching, and height.
6. Minimize cable, connector, enclosure, and PCB losses.
7. Select a suitable frequency, bandwidth, modulation method, and data rate.
8. Account for regulatory output-power and duty-cycle restrictions.
9. Incorporate acknowledgments, retries, and error detection where appropriate.
10. Test the completed system under realistic worst-case conditions.

The Circuit Design Philosophy

Circuit Design's position is straightforward: transmit power is only one element of wireless performance. A dependable radio link requires a transmitter that delivers an appropriate, compliant signal and a receiver capable of detecting that signal in the presence of noise and interference.

By combining suitable output power with high receiver sensitivity, narrowband selectivity, strong blocking performance, an efficient antenna system, adequate link margin, and a robust communications protocol, designers

can achieve reliable industrial wireless operation without treating higher transmit power as the only answer.

Conclusion

High transmit power can make a wireless device louder, but it does not automatically make the device a better listener. Nor can it correct poor antenna placement, inadequate receiver selectivity, severe interference, an obstructed propagation path, or an unbalanced return link.

For industrial telemetry, remote control, monitoring, and alarm applications, reliable communication comes from engineering both sides of the connection. That is why Circuit Design considers high transmit power only half of the wireless equation: the complete solution must transmit effectively, receive intelligently, and remain dependable in the real world.

Saelig Company, Inc., Circuit Design's sole U.S. distributor, can answer any questions you may have about Circuit Design products and help you identify the right wireless solution for your application.

Contact Saelig at **585-385-1750** or email **info@saelig.com** for product information, technical assistance, pricing, and availability.

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