Optimizing mobile handset performance

By Greg Mendolia

Mobile phones are being used in many ways, but electronics in phones are optimized and frozen without the ability to be re-optimized for each mode of operation. Real-life conditions yield compromised performance vs. "perfect" lab conditions, sometimes by as much as 100 times. How users hold their phones and the increased use of hands-free accessories can contribute to dropped or missed calls, poorer area coverage, shorter battery life, and increased "network busy" conditions due to increased interference and lost network capacity.

Making RF radios in mobile devices "tunable" is not a new development. But, tunable RF technology is seen as too lossy (erasing the benefit of tunability), too large, too expensive or having poor linearity. Without the underlying tunable RF technology, tunable radios simply cannot be realized. An adaptive impedance-matching module (AIMM) solves the issue of mobile device tunability, irrespective of how the phone is used and variances in operating functions and environmental conditions. AIMM is based on Paratek's RF tuning material called ParaScan, which is used to construct high-Q RF tunable capacitors with integrated resistors, on a single miniature IC.

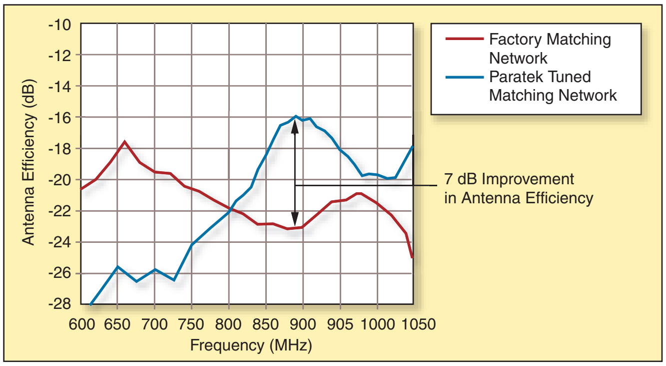
AIMM provides a closed-loop tuning function that optimizes phone performance by maximizing radiated power (minimizing wasted power reflected back into the mobile phone) under all conditions. It instantly eliminates impedance mismatches between antenna and power amplifier in RF transmission and reception networks. Plus, it functions regardless of protocol, frequency of operation, power level setting (determined by distance from the cellular tower/base station), temperature, how the phone is held, or any other environmental condition causing performance degradation. The quality of mobile phone service is improved and common user problems disappear.

AIMM theory and benefits

Since AIMM is an intelligent, closed-loop impedance-matching network, it is an automatic tuner. Internal sensors monitor forward and reverse power and correct for all mismatch losses, regardless of cause. Mismatches can occur for several reasons:

- change in antenna environment; i.e., how phones are held or used with respect to the body;
- unit-to-unit variation in volume production;
- voltage changes due to battery drainage that also changes impedances;
- temperature changes;
- frequency band-edge coverage, especially for multifrequency coverage that includes UMTS;
- varying power levels;
- multiprotocol operation; and
- open vs. closed phone flip configurations.

AIMM can be inserted at different points within the mobile phone radio. Completely self-contained, it has a 3 V dc input pin, a Tx enable pin, an RF input pin, a band select pin, and an RF output pin. For clarity, we have referred to AIMM when placed in the transmitter path as Tx-AIMM and AIMM when put at the antenna as Tx/Rx-AIMM (or full-band AIMM, where transmit and receive signals are present at the antenna input port). Thus, it enables mobile communication devices to transmit a full, clear power signal with less interruption or distortion. Placing the module in the transmit signal path maximizes the power transferred from the power amplifier (PA) to the antenna and the total radiated power to the cellular tower. In traditional radio line-ups, output power, current drain, and linearity degrade dramatically under varying antenna conditions. AIMM adapts and corrects for the impedance mismatch, allowing performance to stay largely constant and optimized.



Antenna efficiency improvement of 7 dB (or 4x) for de-tuned environment.

Mismatch loss occurs at any point within the radio where a component RF input port or RF output port impedance is not at 50 Ω. Components are typically connected in a series cascade configuration from the transceiver to the antenna, and all are designed to function optimally at 50 Ω. A component not at 50 Ω can cause the series to degrade. If the main transmit amplifier sees impedance other than 50 Ω, it begins to consume more dc power to make up for the impedance mismatch. Not only does efficiency worsen, but amplifier linearity severely degrades. AIMM corrects the mismatch, allowing the amplifier to operate optimally (by consuming less power), which saves battery life.

When the antenna does not see 50 Ω, performance also suffers. 'Detuned' antennas cause tremendous degradation to in-band performance. Objects near the antenna—the user's ear or items on a table or briefcase, for example—can detune antenna resonance and pull frequency response (frequencies at which an antenna radiates efficiently) downward. The figure shows the low-band response (824 MHz to 915 MHz) of a typical detuned mobile phone antenna, so that it operates best at 660 MHz (red curve, original OEM hardware). With AIMM added, the antenna (detuned in the presence of the user) can be re-tuned to operate optimally in the intended band. This is represented by the blue curve, centered back at 900 MHz. Antenna efficiency improves by 7 dB or four times.

Integrating the radio and antenna into a mobile phone is a special challenge, especially for phones using embedded internal antennas vs. external ones. This effort is often empirical and iterative, consuming significant development time and engineering resources. Designers can reach "close enough" impedance values and then let AIMM do the rest. Development time and cost shrink, which is critical as product life cycles shorten to less than six months.

The automated tuning capability of AIMM can also increase factory yields. Each phone coming off an assembly line will have a "custom-tuned radio," since AIMM electronically tunes and optimizes the match. This reduces variability and tightens all key electrical tolerances, thus increasing yield at high volumes, reducing overall cost and allowing the production of more consistent wireless products.

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