SECOND GENERATION RF LINEARIZER TARGETS 4G SMALL CELL DEPLOYMENTS

Cellular service providers are struggling to keep up with the surging demand for data services. As this demand continues to outstrip the available infrastructure capacity, operators are recognizing the need for heterogeneous network deployments. This trend, from voice-centric macro base stations to lower power, wider bandwidth small cell, distributed antenna, and MIMO architectures increases the requirement for more linearity out of power amplifiers at lower output power levels.

Deployment of these heterogeneous network base stations with smaller coverage areas and low power transmit architectures will significantly increase the volume of transmitters as well as necessitate lowered equipment and deployment costs. Furthermore, the worldwide trend to reduce carbon emissions is also driving operators to seek solutions that are highly energy efficient. Prior to Scintera, no commercially available solution existed that could cost-effectively linearize PAs from 50 W down to 250 mW (average output power at the antenna) while also meeting operator's and OEM's stringent performance and system requirements.

Scintera's SC1889 is a second generation RF PA linearizer (RFPAL) and, as can be seen in ***Figure 1***, features a compact footprint and low external BOM. The SC1889 consumes minimal power while providing excellent correction performance across static signals including CDMA and W-CDMA, and dynamic signals including WiMAX and LTE. The SC1889 represents one of the key enabling technologies for the successful deployment of small cells for heterogeneous networks. The SC1889 can increase system efficiency of lower power base station PAs (10 W average power at antenna and lower) by up to 2×, if linearizing Class A/B amplifiers, and up to 4× by enabling the use of more efficient Doherty amplifiers. In either configuration, Scintera's SC1889 will cut capital and operation/energy costs by an amount proportional to the efficiency improvement.

ACTIVE AND PASSIVE LINEARIZATION

The two legacy linearization solutions deployed include digital predistortion (DPD) and operating the PA in backoff. While DPD is an active linearization solution, the most popular linearization method by far is passive linearization that requires reducing (backing off) the PA output power until achieving the desired linearity. This method typically requires doubling the size of the RF power devices compared to active linearization.

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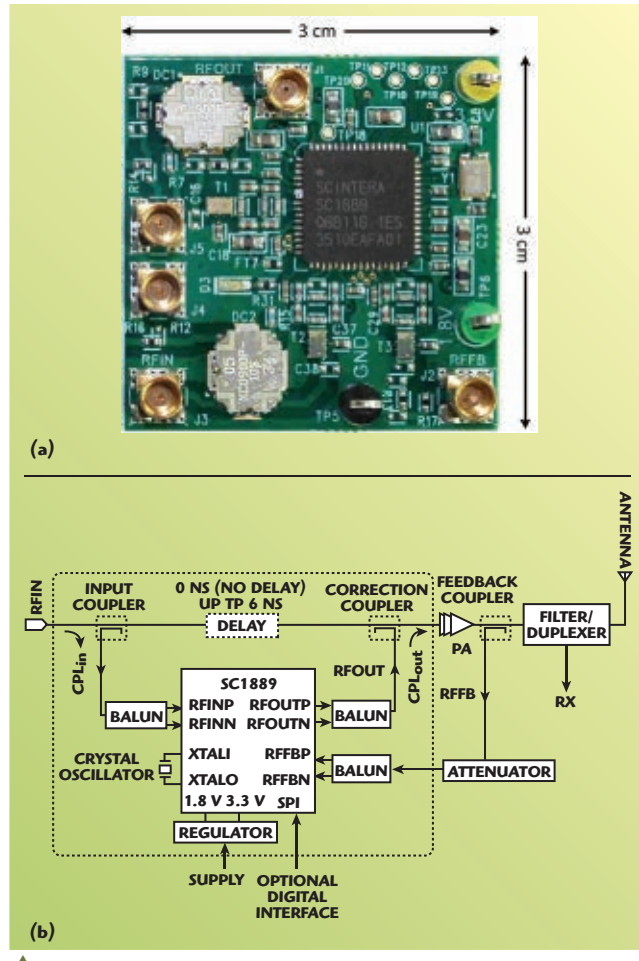
Due to cost, complexity and system power consumption considerations, RFPAL is one of the best linearization solutions to effectively displace passive linearization in small cell applications with average output power levels (at the antenna) of 5 W down to 500 mW. It is important to note that with advanced communication protocols with wide signal bandwidth requirements like LTE, or in wideband multicarrier/multiprotocol systems, backing off the PA output power may not be an option as the PA may never reach the desired linearity at any power level. In these systems, Scintera's RFPAL represents a practical linearization solution for small cell network deployments.



▲ *Fig. 1 Scintera's complete standalone linearization solution in a 3 × 3 cm footprint on a PCB (a) and block diagram (b).*

RF PREDISTORTION VS DIGITAL PREDISTORTION

Scintera's RF predistortion technology shares similarities with DPD in that both compensate for AM-AM and AM-PM distortion, intermodulations and PA memory effects and utilizes adaptive feedback. The similarities end with their circuit and system implementations.

Scintera takes a new approach to RF power amplifier linearization by repartitioning portions of the predistortion algorithm from the digital to the analog/RF domain. Additionally, the entire adaptive feedback path including the analog to digital converters (ADC) is integrated within the RFPAL. The result is an elegant, single chip and highly integrated solution that maintains the flexibility of digital approaches while offering the simplicity and power consumption of analog approaches.

BENEFITS

Many factors determine the system performance of any linearization solution. Comparing RFPAL against solutions operating in backoff, customers can realize the greatest performance benefits. As highlighted in ***Table 1***, for a given average output power level at the antenna, by "spending" 0.8 W on active linearization, customers can realize up to a 4× improvement in efficiency, thus enabling proportional decreases in the system power consumption. Additionally, linearization enables operation of the PA closer to its PSAT operation point and typically can cut the power transistor size and cost in half. A direct benefit of the improved power consumption is a reduced yearly operating cost (electricity) which, at higher antenna power levels, can offset the initial cost of the RFPAL system in a relatively short time. The system power consumption and system efficiency can be seen in ***Figure 2***.

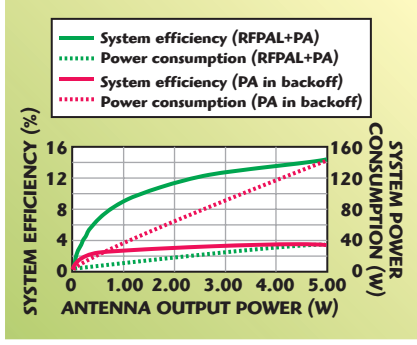
An often overlooked benefit is the

TABLE I

CALCULATION FOR SYSTEM POWER CONSUMPTION, SYSTEM EFFICIENCY AND YEARLY OPERATING COST

Parameter	RFPAL (Doherty Amplifier)	Back Off (Class A/B amplifier)	Unit
Desired max antenna Pout (avg)	37	37	dBm
Component IL between PA and antenna	3.5	3.5	dB
PA output power (max antenna power - IL)	40.5	40.5	dBm
PA efficiency at 40.5 dBm (avg)	35.0%	8.0%	
Linearization power consumption	0.8	0	W
Pre-amp + driver power consumption	2	2	W
Total power consumption (w/o final stage PA)	2.8	2	W
System efficiency at max antenna Pout = 37 dBm	14.4%	3.5%	
System power consumption at max antenna Pout = 37 dBm	34.9	142.3	W
Cost of energy (cost per kWhour)	$0.05	$0.05	
Yearly cost of operation per system	$15.28	$62.35	
Added yearly cost of operation compared to RFPAL		$47.07	

INDICATES ENTERED VALUES



▲ *Fig. 2 Graph of system power consumption and system efficiency against antenna output power.*

dramatic reduction in size/volume and cost associated with the power supplies and cooling elements (heat-sinks, fans, etc.). The power supply savings can be proportionally higher than the improvement in efficiency due to power supply cost increasing faster than supply capacity. At the same time, the RFPAL will deliver similar or better ACLR (distortion) performance than when the PA was operated in backoff (a simplified version of the calculator is available online at www.scintera.com/RF-PA-linearization-predistortion-efficiency-calculator).

Finally, Scintera's RFPAL lends itself to fast system design times and requires no expertise in predistortion algorithms. The RFPAL offers standalone operation that is very nearly "plug and play," thus accelerating time to market and enabling any company, large or small, to enjoy the benefits of active linearization. Typically, linearization results are achieved within a half day of opening the evaluation kit.

RELIABILITY

Replacing a system operating in backoff with RFPAL provides an improvement in device and system reliability. By improving the efficiency of the device and thus lowering its operational case temperature leads to a decrease in the failures in time (FIT) rate. With more than 50,000 systems based on Scintera's first generation RFPAL, the SC1887, deployed in the field with no failures or returns, Scintera's RFPAL clearly demonstrates the robustness and ruggedness required to meet even the most stringent operator requirements.

Based on field-proven technology, Scintera's SC1889 represents a new alternative to existing linearizing solutions. It is an elegant and compact solution that reduces development costs and speeds time to market. Applicable across a broad range of signals, including 2G, 3G, 4G wireless and other modulation types. The SC1889 solves some of the key challenges faced by operators trying to deploy data services and will continue to play a key role in the transition to 4G and beyond.

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