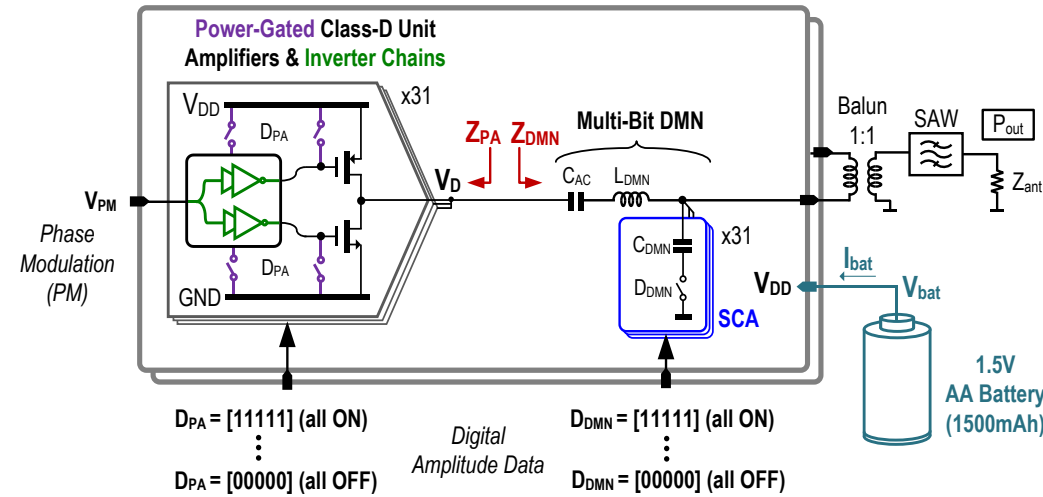


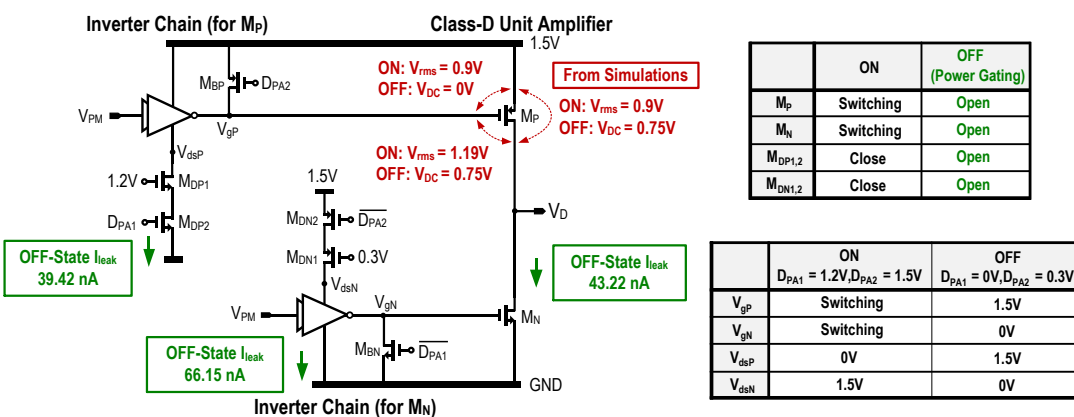
System Diagram



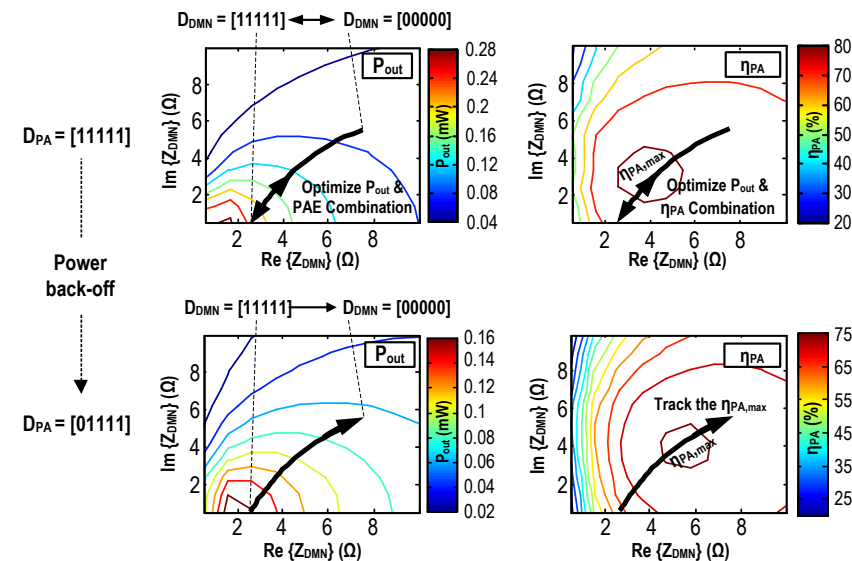
System Highlights:

- **Dynamic Matching Network(DMN)** biases optimum load for Class-D PA at **each AM input code**
- **Class-D PA Power-Gating (PAPG)** minimizes **leakage current** during off-state of each PA unit cell
- DMN improves **MN power efficiency** by reducing its transform ratio
- Class-D PAPG guarantees the **reliability during off-state** and enabled 1.5V operation without cascode devices

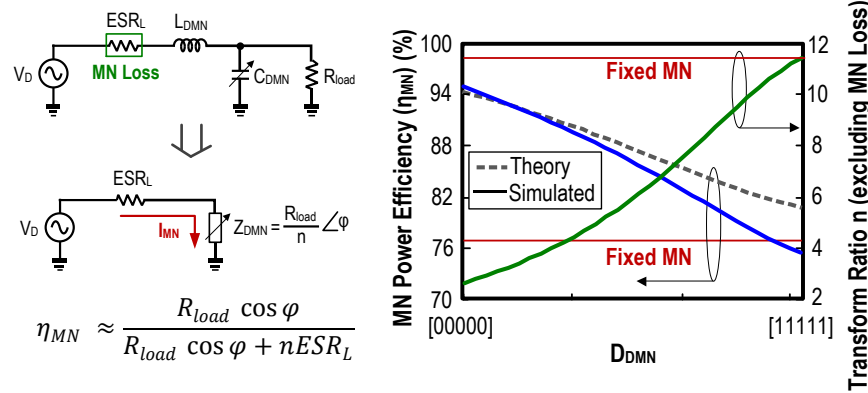
Class-D PAPG Technique



DMN Optimum Load Biasing



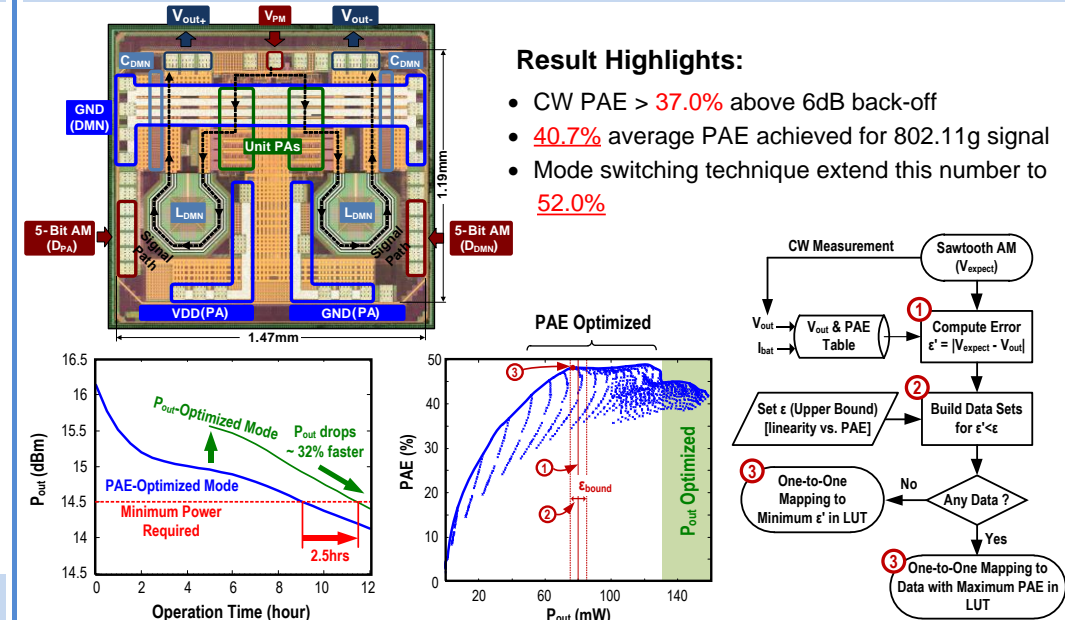
DMN MN Power Efficiency Improvement



Techniques Summary (simulation based):

- PAPG reduced leakage current by **8.0x** comparing to typical unit-cell switching PAs
- PAPG increased the reliable supply voltage of PA unit cell by **25.0%**
- DMN optimum load bias improved DE by **21.2% @ 5.7dB back-off**
- DMN improves MN power efficiency is improved by **26.0%** from n = 11.4 to 2.6

Measurement Setup & Result



Comparison with State-of-the-Art

	This Work		R. Hezar et al. JSSC'15 [10]	Y. Yin et al. TMTT'15 [15]	L. Ye et al. ISSCC'13 [11]	P. Madoglio et al. ISSCC'12 [9]	Y. Yoon et al. TMTT'12 [16]
	P _{out} -Opt. Mode	PAE-Opt. Mode					
Frequency	2.4 GHz		2.4 GHz	2.4GHz	2.4 GHz	2.4 GHz	2.4GHz
Key Techniques	Power-Gated Class-D PA + Multi-Bit DMN + Mode Switching		PWM + Sigma-Delta	Bias Mode Switching	Inverse Class-D PA + Single-Bit DLM	Delay Line + Class-D PA + Out-Phasing	Mode Switching + Single-Bit DLM
Technology	Standard 65nm CMOS		Standard 45nm CMOS	0.18-μm CMOS	Standard 65nm CMOS	32nm CMOS + Ultra-Thick Metal	0.18-μm CMOS
Supply Volt. (V)	1.5 ^a		1.7/1.2	5.6	1.2	1/2.05	3.3
Peak P _{out} (dBm)	22.0		23	27	23.3	25.9	23.1
Peak PAE (%)	48.7		47	26.1	38	N/A	42
P _{out,ave} (dBm) ^b	16.9 (15.54)		16.3	14.8	22 ^c	16.8	20.0
PAE _{ave} (%) ^b	34.8 (31.7) ^c		40.7 ^c	23	21.3 ^d	21.8	22
EVM (dB) ^b	-25.2 (-30)		-25	-29	-26.9	-28	-25
Leakage Current (μA)	20 (TX + ESD pads)		N/A	N/A	N/A	N/A	N/A
Antenna Impedance Correctability	VSWR 2.5 : 1 @ 180° P _{out,ave} = 11.47–11.86 dBm PAE _{ave} = 15.49–15.91%		No	No	No	No	No

a : For direct 1.5-V AA battery powering, and P_{out} is >14 dBm over 12-hour of continuous operation.

b : For a 20-MHz 64-QAM OFDM signal, the EVM target is -25 dB for 802.11g [9].

c : PAE_{ave} = 52% by mode-switching from P_{out}-optimized to PAE-optimized modes under the AA battery test.

d : Measured with 40-MHz 64-QAM OFDM signal, PAPR is similar, and therefore comparable.