CoreHW

# Load Insensitive Power Amplifier

## Targets & Benefits

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# Load Insensitive Power Amplifiers: Why

- **Improved System Reliability**
  - Load insensitive PAs prevent damage from impedance mismatches, enabling also CMOS PA implementations
- **Higher Efficiency Across Varying Loads**
  - Adaptive power management ensures optimal power delivery, minimizing energy waste and operational costs.
- **Consistent Performance in Dynamic Environments**
  - Essential for wireless communication, radar, and satellite systems where load conditions frequently change: especially on End-User's terminal and Antenna Arrays (Beamforming)
- **Better Signal Integrity & Linearity**
  - Less signal distortion and improves communication quality, crucial for 5G, IoT, and high-data-rate applications.
- **Enhanced/Simplified Digital Pre-Distortion**
  - load-insensitive PAs are better suited for digital pre-distortion (DPD) because they provide a more stable and predictable response, which improves the effectiveness of DPD algorithms / simplifies the design of optimum DPD algorithms
- **Supports Wideband & Multi-Standard Systems**
  - Enables robust performance across multiple frequency bands, making it ideal for modern RF and wireless applications.
- **Process: SOI CMOS Implementation…**

# Load Insensitive Power Amplifiers: Why Not

- **Increased Complexity**
  - Advanced designs (e.g., adaptive matching, feedback control, hybrid-based architectures) add circuit complexity, making design and implementation more challenging.
- **Higher Cost**
  - Additional components (e.g., tunable impedance networks, isolators, feedback loops) increase material and manufacturing costs.
- **Potential Efficiency Trade-offs**
  - Some techniques, such as negative feedback and hybrid couplers, introduce additional losses that can slightly reduce overall efficiency.
- **Larger Size & Weight**
  - Hybrid couplers, circulators, or adaptive tuning circuits may increase the PA's footprint, which can be problematic for compact or mobile applications.
- **Tuning and Calibration Requirements**
  - Some architectures require precise tuning and calibration, which adds complexity to deployment and maintenance.
- **Limited Bandwidth in Some Configurations**
  - While some solutions offer wideband performance, certain architectures are optimized for specific frequency bands and may not adapt well across broader ranges.

# Linear PA Architecture Comparison

| PA Type | Load Insensitivity | Efficiency | Linearity | Complexity |
|---|---|---|---|---|
| **Balanced PA** | High | High | High | Low |
| **Load-Modulated Balanced PA (LMBA)** | High | Very High | Moderate | Moderate |
| **Doherty PA** | Low | Very High | Moderate | High |
| **Hybrid Doherty-LMBA** | High | Very High | Moderate | Very High |
| **Envelope Tracking PA (ET-PA)** | Low | High | High | High |
| **Chireix Outphasing PA** | Low | Very High | Moderate | High |

# CoreHW PA Architecture

- **New solution for load insensitivity without size/cost penalty**
  - CoreHW solution enables load insensitivity practically without extra chip/pcb area and without extra loss
- **Features**
  - The concept suits for any frequency range from 100MHz to 100GHz and more.
  - Can be implemented as highly linear version that does not require DPD
  - Alternative implementation has high Doherty-like back-off efficiency and moderate linearity, but stable and predictable response, which improves the effectiveness of DPD algorithms / simplifies the design of optimum DPD algorithms.
  - Works for any process technology, but best suited for area/cost sensitive applications and lower power levels, e.g. <10W peak.

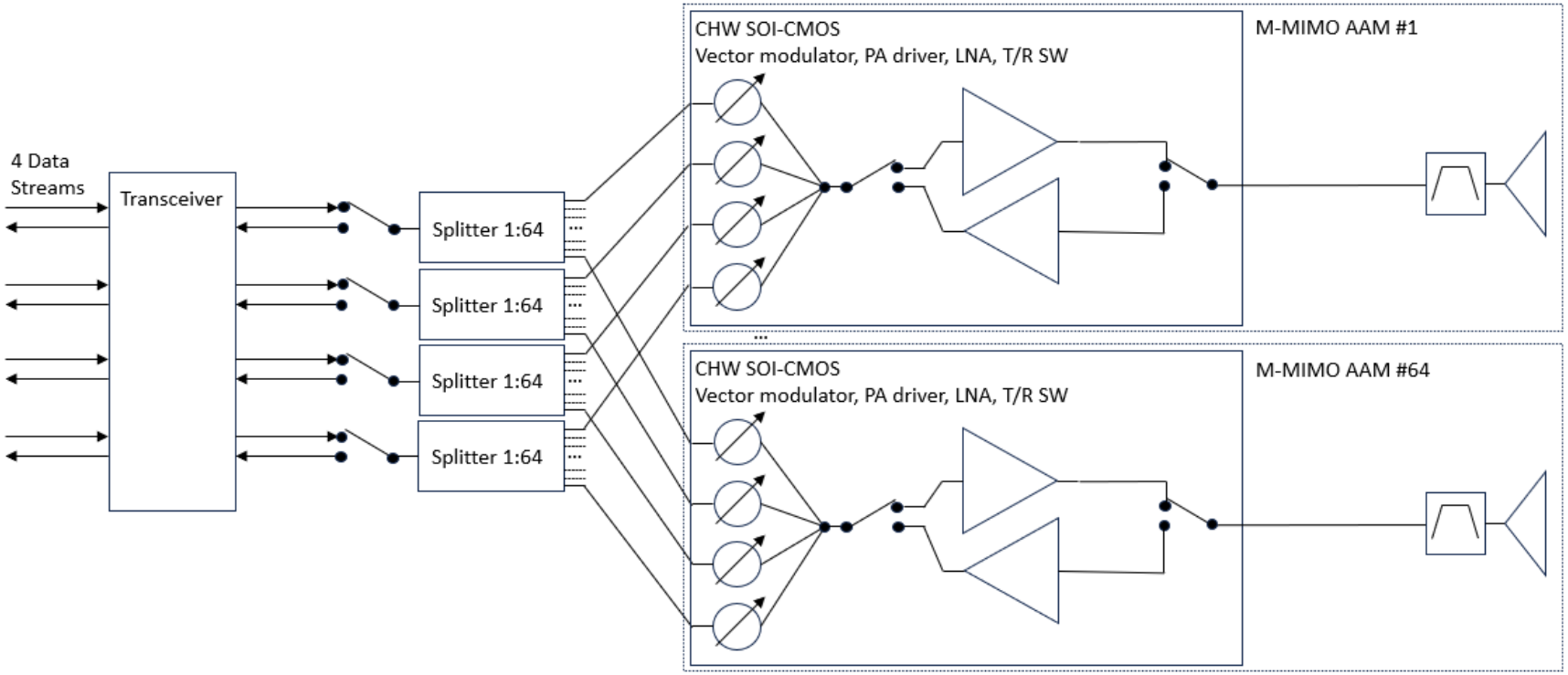
# CoreHW PA for antenna arrays

- **Phased antenna array transmitter performance**
  - In phased arrays, the signal coupled from other nearby antennas impacts to the effective antenna impedance.
  - The coupling depends on the steering angle
  - A typical single-ended PA performance (linearity, efficiency, output power) can degrade significantly due to the load change, which can limit the phased array performance and steering range. In worst case the VSWR can lead to transistor failure.
  - CoreHW PA is robust against load impedance variation, and thus perfect for RF and mmWave phased arrays

- **Phased antenna array antenna performance**
  - In antenna array design, it is usually expected that each antenna is terminated with real (usually 50 ohm) load.
  - Typical PA S22 is >-10dB, which can significantly impact to the antenna array behavior.
  - CoreHW PA presents <-18 dB S22 over frequency band and PVT, which is excellent for array behavior

# CoreHW PA for hybrid beamforming

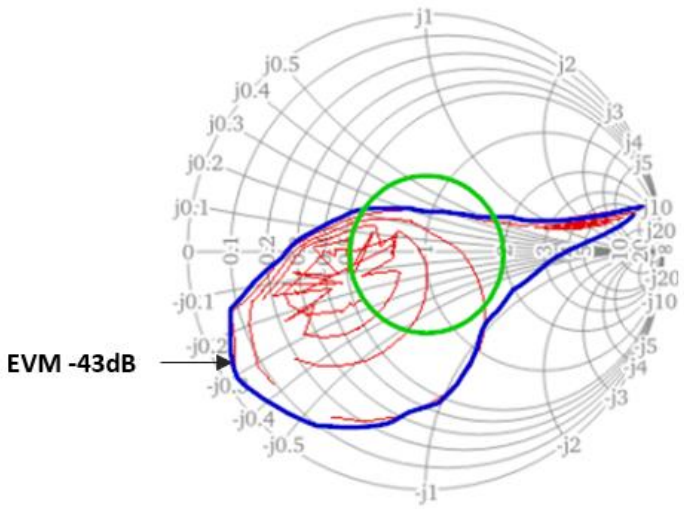
- **New CoreHW PA architecture is well suited for highly integrated hybrid beamforming**
  - Applications like MU-MIMO, mmWave Radar, Low/Medium Range Base-Stations



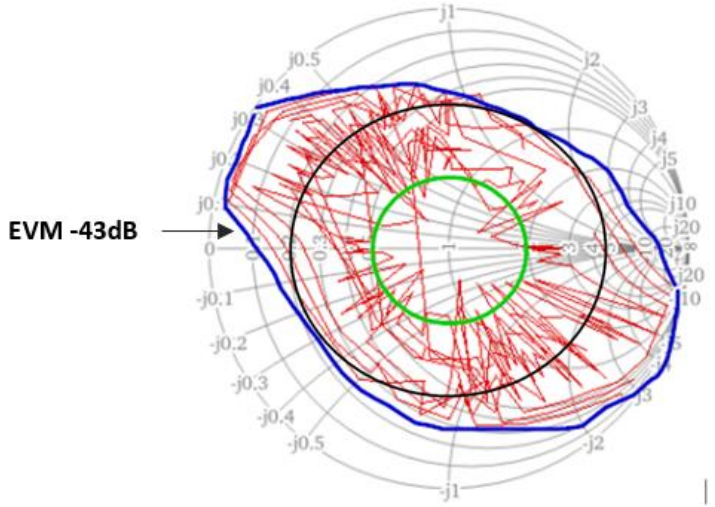
# CoreHW PA Architecture Studies vs typical PA

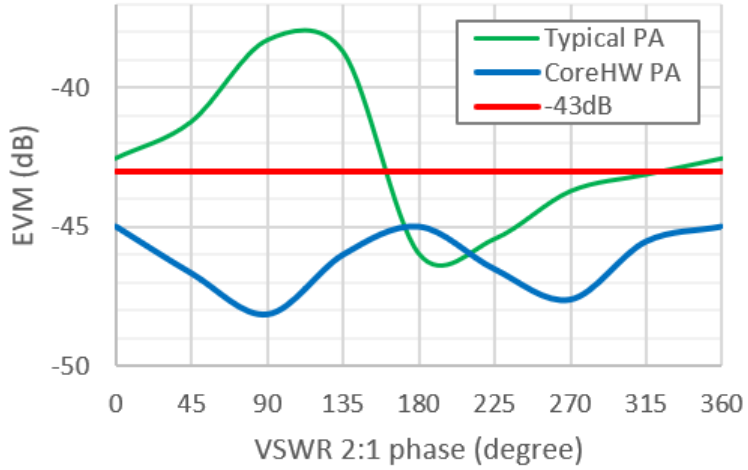
- **Simulation results**
  - Typical PA is the same design, but without CoreHW PA methods. Both have equal linearity and efficiency for 50-ohm load.
  - Red lines are simulated 802.11ax MCS10 (1024QAM 160MHz) constant EVM contours for which EVM <-43dB
  - VSWR 2:1 circle (green line) presents a typical antenna matching target.
  - CoreHW PA EVM is <-43 dB up to VSWR 5:1 mismatch (black circle), while typical PA fails even in the well-matched case.
  - To fulfill the system requirements using the typical PA, either:
    - signal power needs to be backed off - degreasing range
    - modulation coding scheme must be stepped down - reducing throughput

**Typical PA**




**CoreHW PA**



# Thank You!