ULTRALOW-POWER FRACTIONAL-N DIGITAL PLL

(AS FREQUENCY SYNTHESIZER AND MODULATOR)
FOR IoT APPLICATIONS IN 40nm CMOS

DESCRIPTION

IMEC's divider-less All-Digital Phase Locked Loop (ADPLL) combines world's lowest power consumption with state-of-the-art performance and small silicon area. The ADPLL supports industrial requirements for popular 2.4GHz and SubGHz IoT radio standards, such as Blue-tooth Low Energy (Bluetooth Smart), IEEE 802.15.4 (ZigBee, Thread) and others.

Analog PLLs are traditionally one of the major power consumers in a radio and can take up to 30% of the radio area. All-digital PLLs enable a smaller footprint, better control and testability, and improved scaling to advanced CMOS nodes. However, to-date, they have lagged behind in terms of performance as compared to analog solutions.

This new sub-sampling ADPLL features a small area (0.18mm² in 40nm CMOS), low-power consumption (0.67mW) and excellent performance for IoT radio applications with all spurs lower than -55dBc and jitter below 2ps, which is beyond state-of-the-art digital PLLs.

This dividerless fractional-N digital PLL features a power-efficient spur mitigation technique and a digital phase unwrap technique. Both approaches contribute to its state of the art performance.

Moreover, this digital PLL implements dynamic-element-matching

(DEM), reset and retime techniques to further improve the linearity of the digital-to-time converter (DTC) and therefore achieves lower.

KEY FEATURES

Support ulp 2.4GHz/subGHz iot, e.g.,

- 2.4GHz
    - Bluetooth 4.0 (BLE), 4.2 and 5.0
    - IEEE802.15.4 (ZigBee, ISA100.11a, WirelessHART, Thread, 6LoWPAN)
- SubGHz:
    - IEEE802.15.4g (Wi-SUN), IEEE802.11ah (HaLow)

Ultra-low power (ULP) consumption

- < 0.7mW

Best-in-class performance

- Jitter < 2ps
- Spur < -55dBc (in-band)
- Spur< -70dBc (>2MHz)
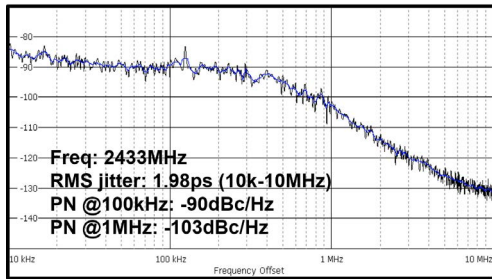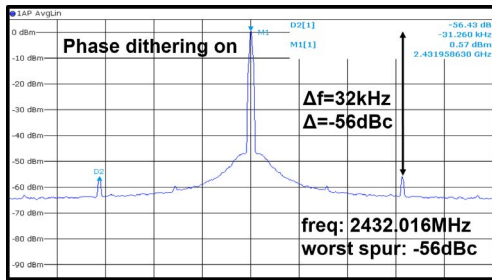- Settling time< 15µs

Features

- Extensive built-in self calibrations
- Advanced power-efficient spur mitigation
- Robust against freq. pulling/pushing with digital unwrap

APPLICATIONS

2.4GHz/SubGHz ULP IoT radios (Bluetooth 5, 802.15.4, 802.15.4g, 802.11ah) for

- Smart watches and wearables
- Smart phone accessories
- Hearing aids and audio applications
- Remote controllers
- Home and commercial automation

MEASUREMENT RESULTS

Phase dithering on
Δf=32kHz
Δ=-56dBc
freq: 2432.016MHz
worst spur: -56dBc

Freq: 2433MHz
RMS jitter: 1.98ps (10k-10MHz)
PN @100kHz: -90dBc/Hz
PN @1MHz: -103dBc/Hz

SUBGHZ SPECIFICATIONS

Frequency range (GHz)	1.75-2.5
Freq. settling time (μs)	<15
Phase noise @>1MHz (dBc/Hz)	<-103
Integrated RMS jitter (ps)	<2
Frac. spur	<-55dBc (in-band)
	<-70dBc (>2MHz)
Freq. modulation resolution	<1 kHz
Power consumption (mW)	<0.7
Area (mm²)	<0.18
Nominal supply	1V
Technology	TSMC 40nm LP CMOS

STATE-OF-THE-ART PERFORMANCE
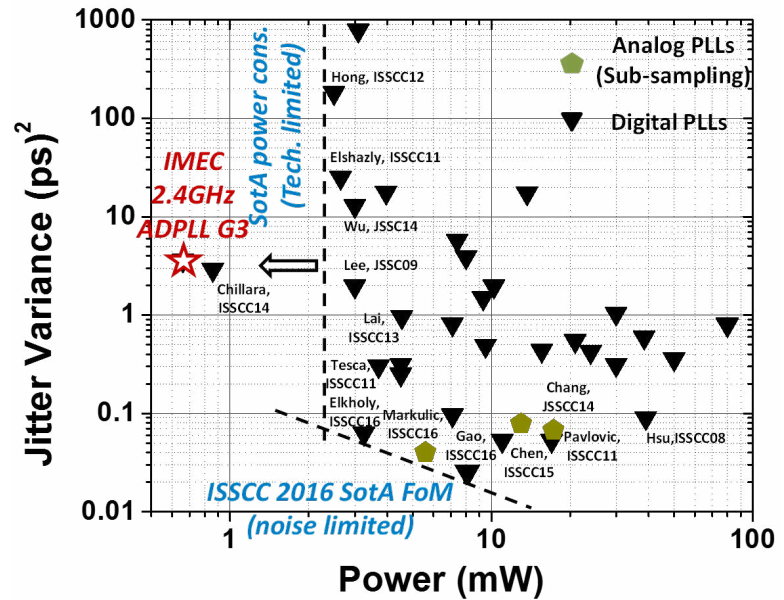
BLOCK DIAGRAM
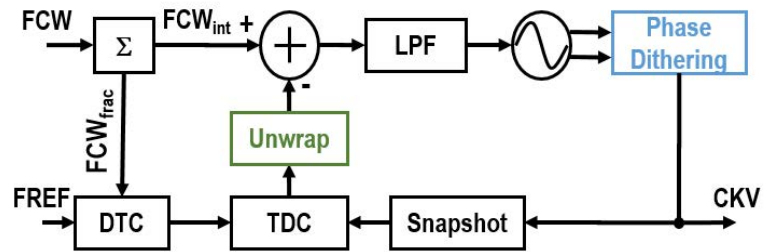
EVALUATION BOARDS

Imec provides evaluation boards on request to prospective customers and partners interested in licensing imec's IC designs and IP.

Evaluation PCB: Allows complete evaluation of the 2.4 GHz All-Digital PLL.

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