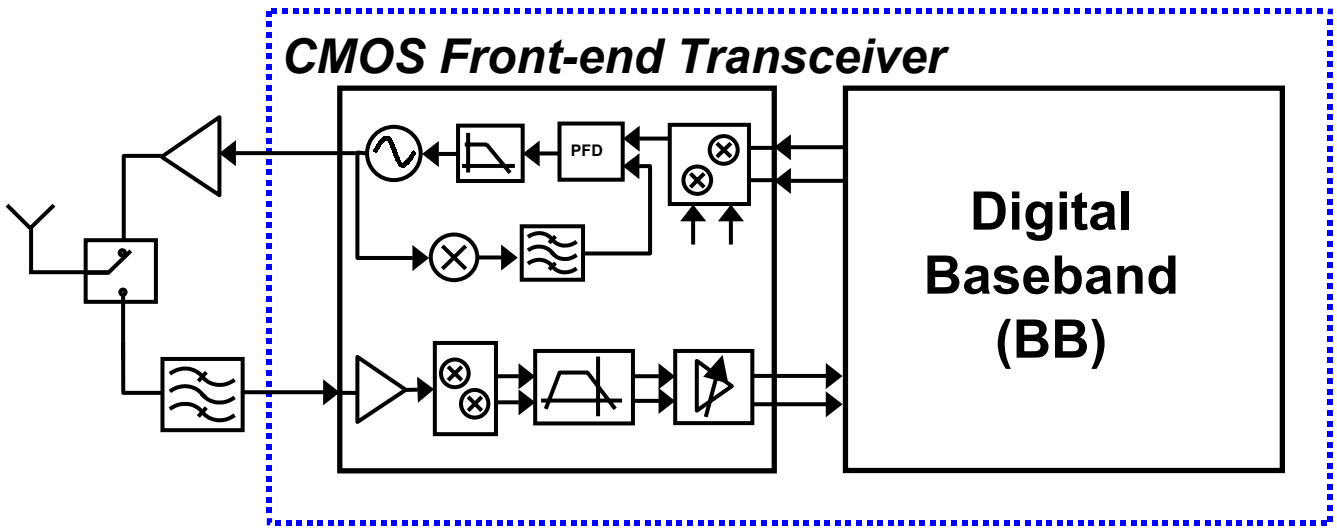
A Single-Chip Quad-Band GSM/GPRS Transceiver in 0.18μm Standard CMOS

Berkäna Wireless Inc.

Campbell, California

Desired Features of Commercial Radios

- Low Cost
- Small Form Factor
- Long Range

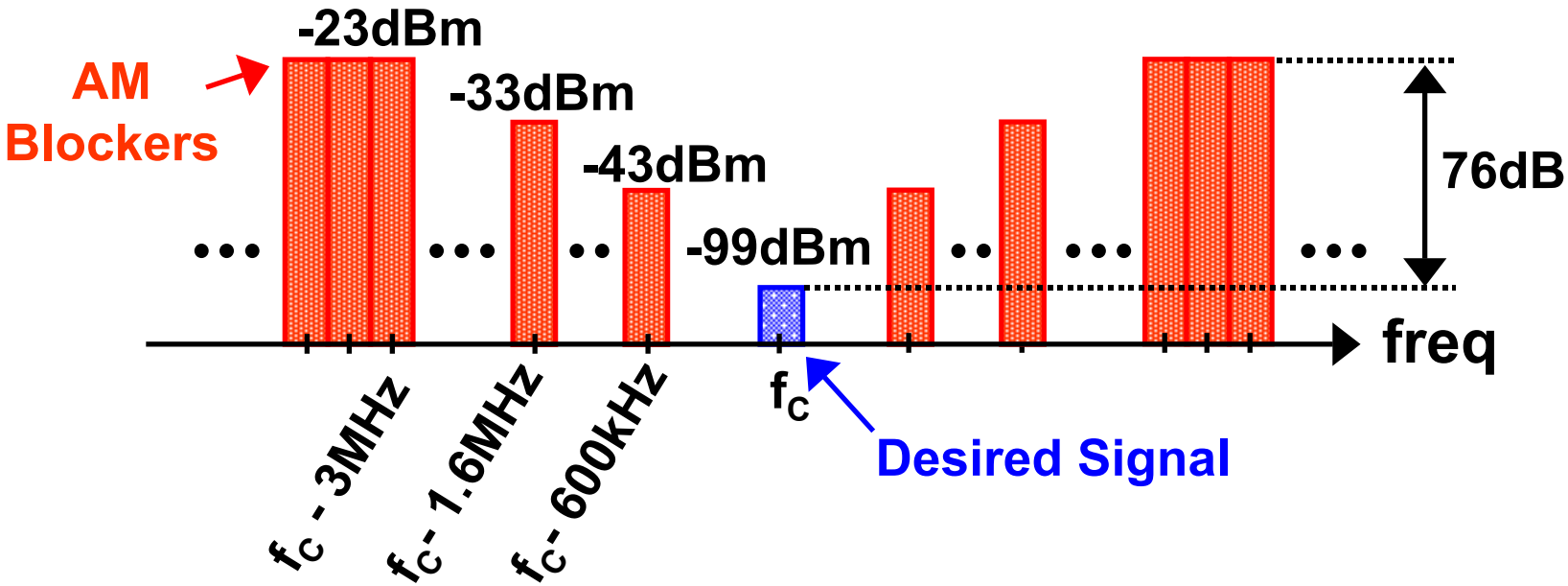


Presentation Outline

- GSM/GPRS Implementation Challenges
- Transceiver Architectural Tradeoffs
- CMOS Quad-Band GSM/GPRS Transceiver
- Test Results
- Conclusions

Key Receiver Specifications

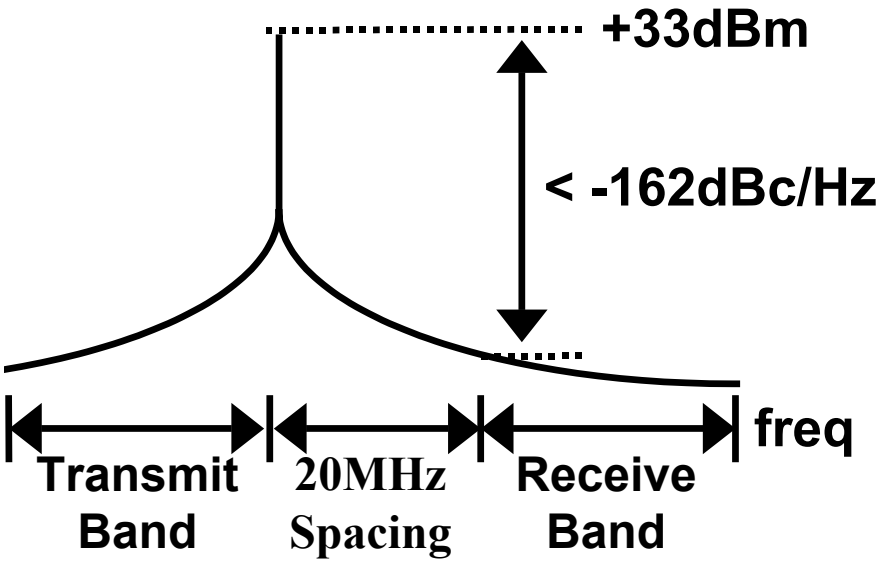
GSM 900 Blocking Profile



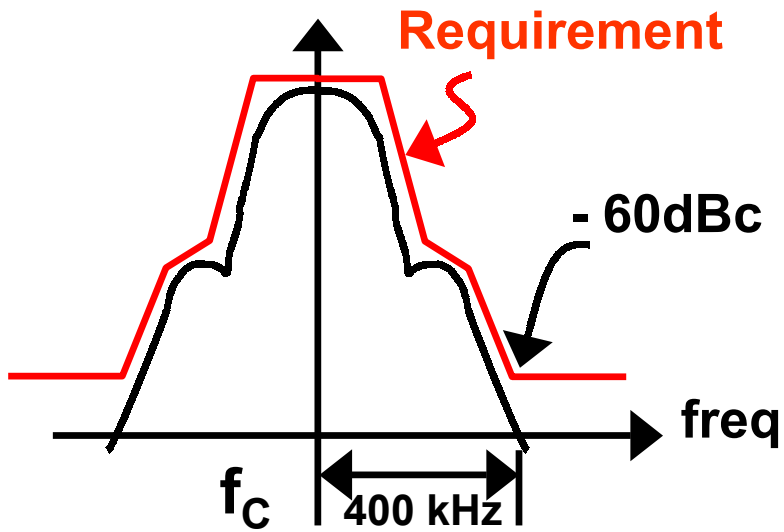
- Range of the Mobile => Sensitivity < -102dBm
- Near-Far Problem => Large Dynamic Range
- Presence of Nearby Users => IIP3 > -17dBm

Key Transmitter Specifications

TX Noise in RX Band

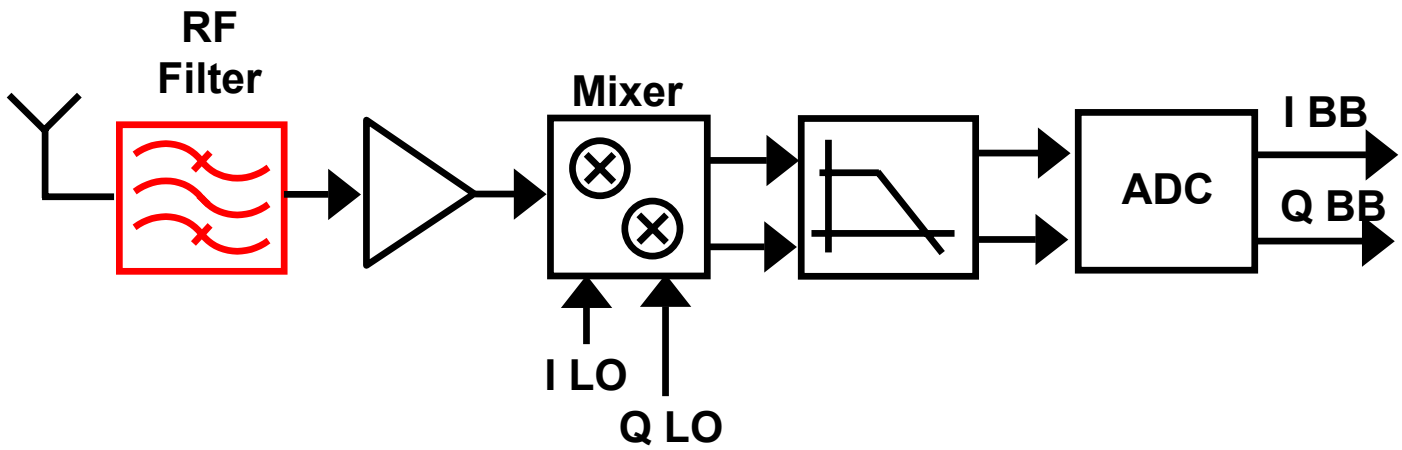


Modulation Mask



- Receive Band Noise at 20MHz offset, PN < -162dBc/Hz
- Modulation Mask at 400kHz offset requires high linearity and low phase noise
- Modulation Accuracy of: $\varphi_{RMS} < 5^o$

RX Direct Conversion

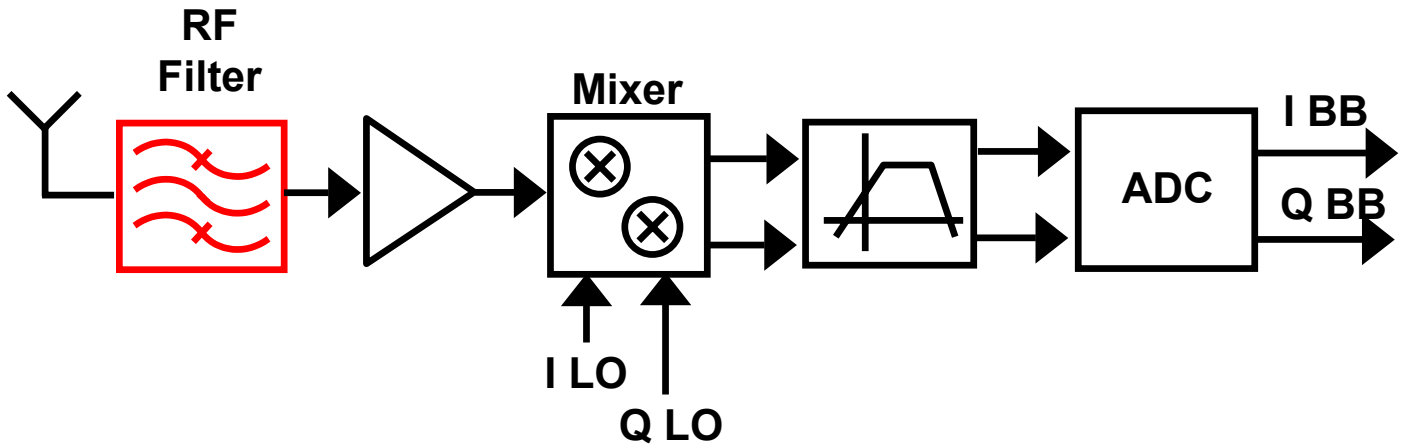


Properties of Direct Conversion

+ Low frequency signal facilitating programmable filters

− Problematic 1/f, DC offset and IP2 interference

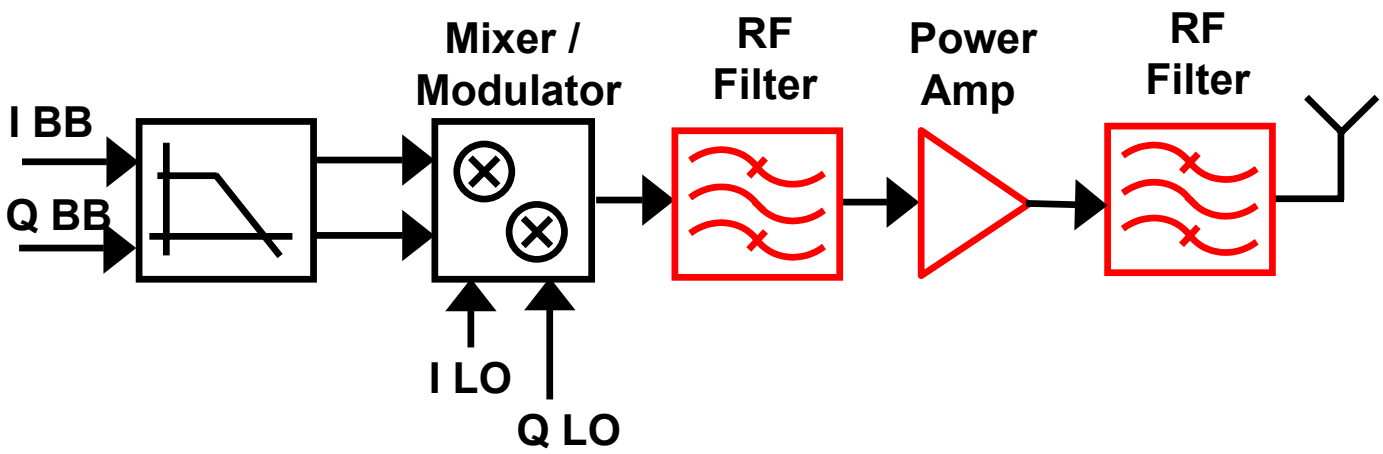
Low IF Receiver



Properties of Low-IF Receivers

+ Less susceptible to low frequency interference
− Image rejection must be addressed
+ Leverage narrowband signal to facilitate integration

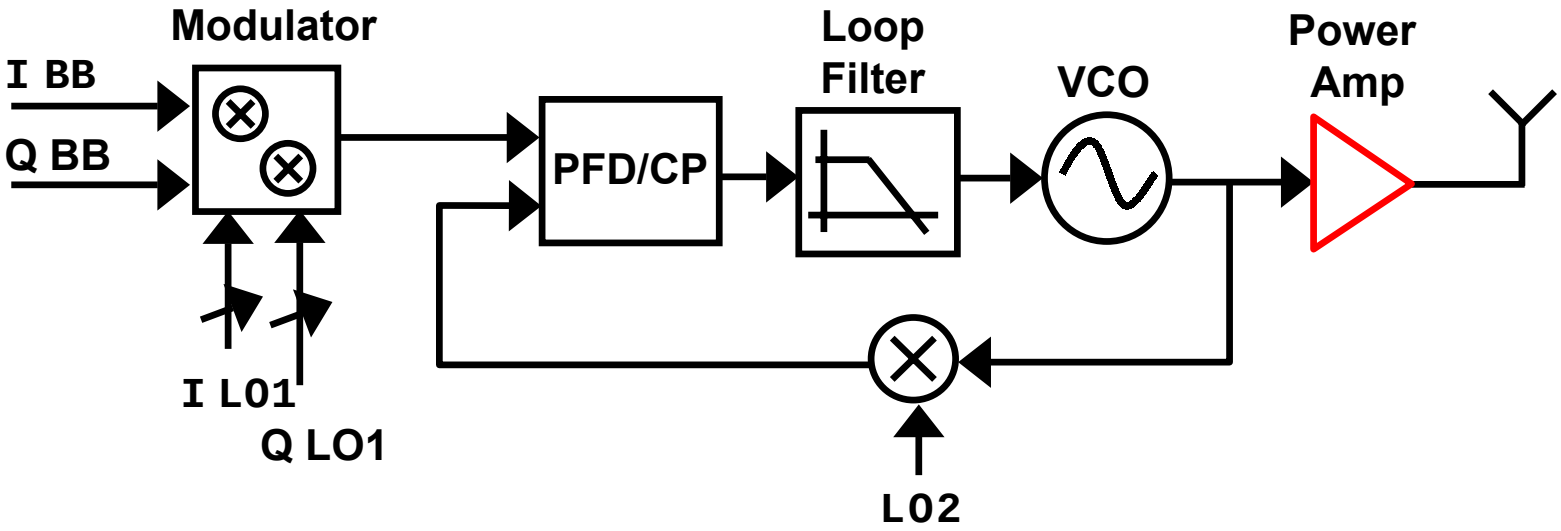
Direct Conversion Transmitters



Properties of Direct Conversion Transmitters

+ Single conversion eliminates IF filter
− Requires Pre-PA filter for harmonic rejection
− Wideband modulator noise demands filtering

TX Offset Phase-Locked Loop



+ PLL frequency translates phase modulated signal
+ PLL transfer function filters mixer spurs and noise
– More design complexity compared to Direct Conversion
+ Leverage narrowband signal to enable integration

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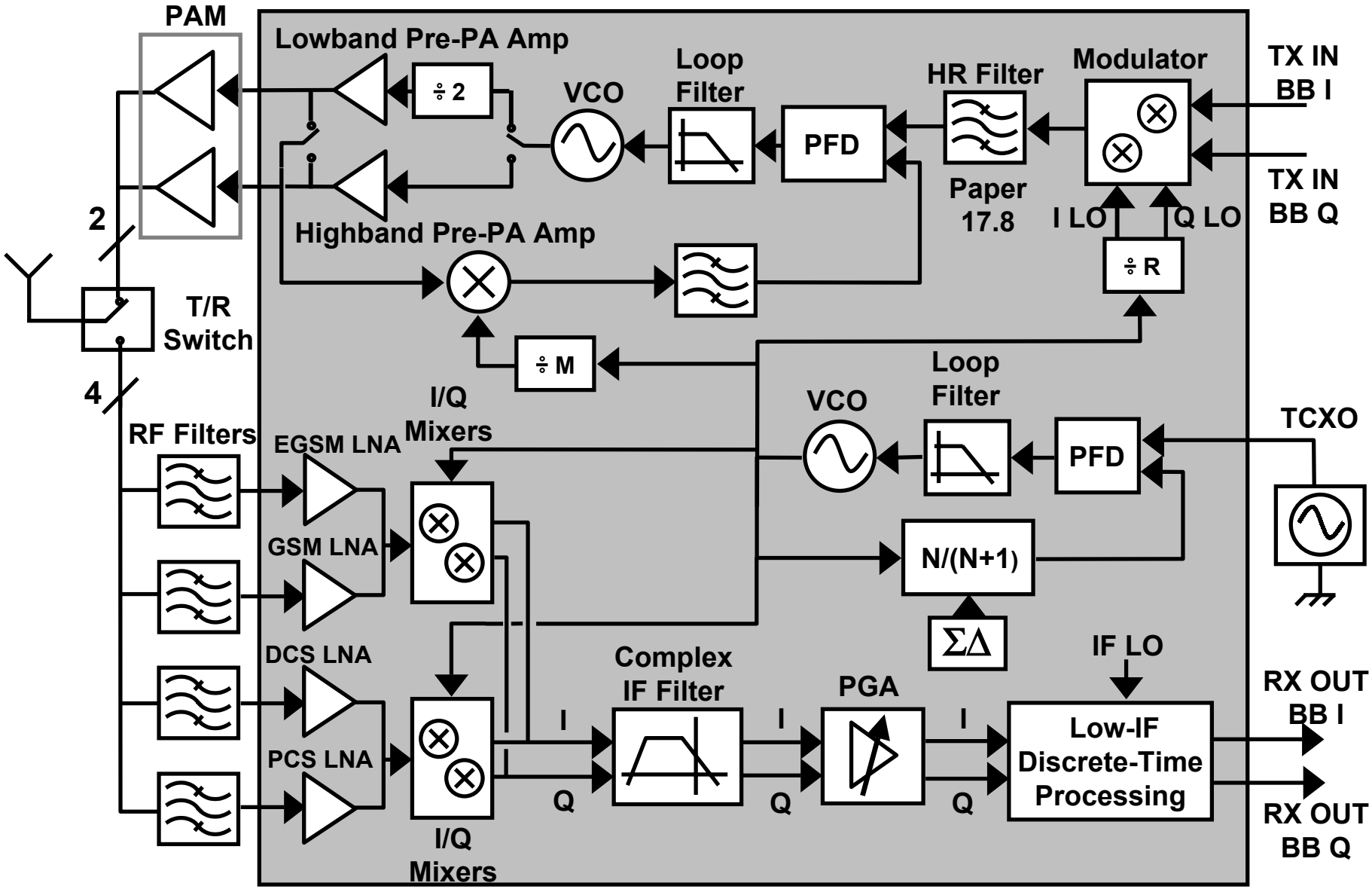
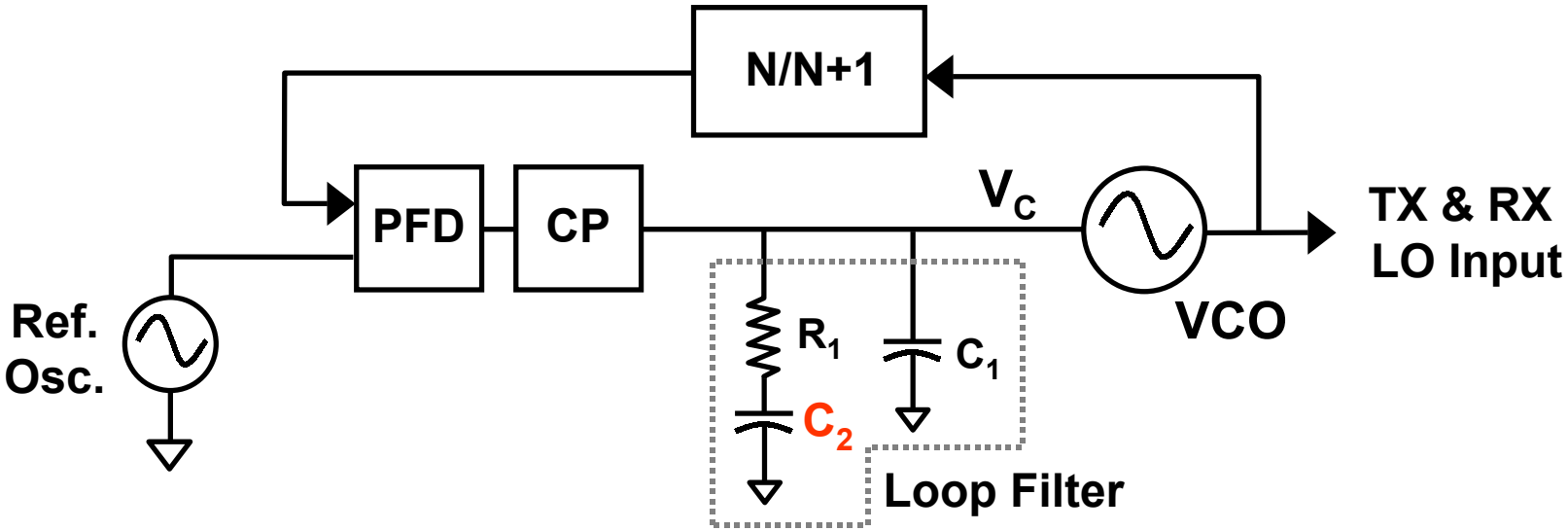
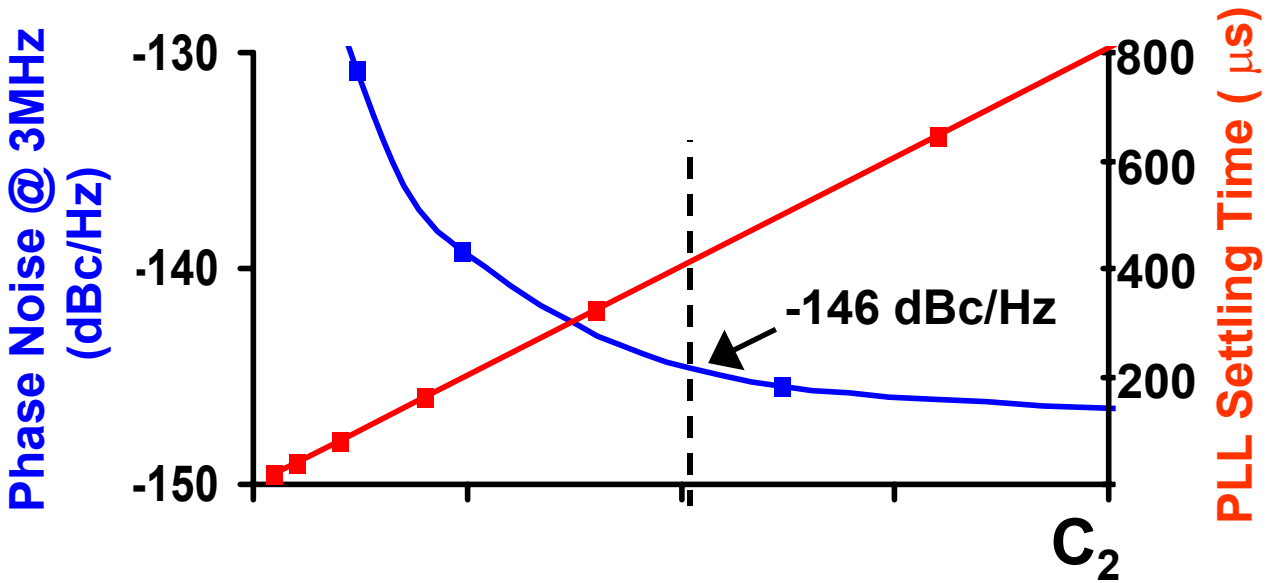
Quad-Band GSM/GPRS Transceiver

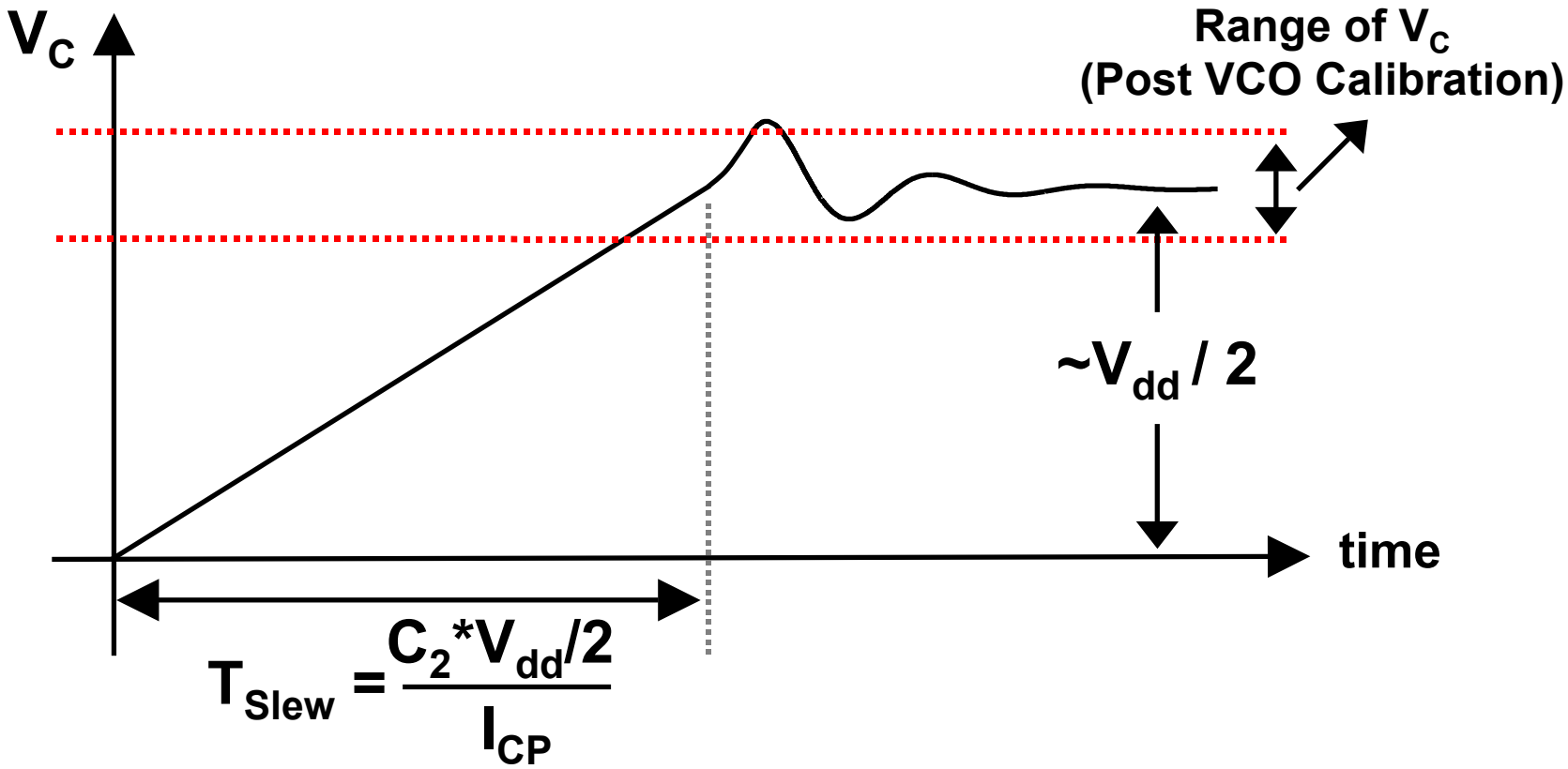


PLL Phase Noise vs. Settling Time



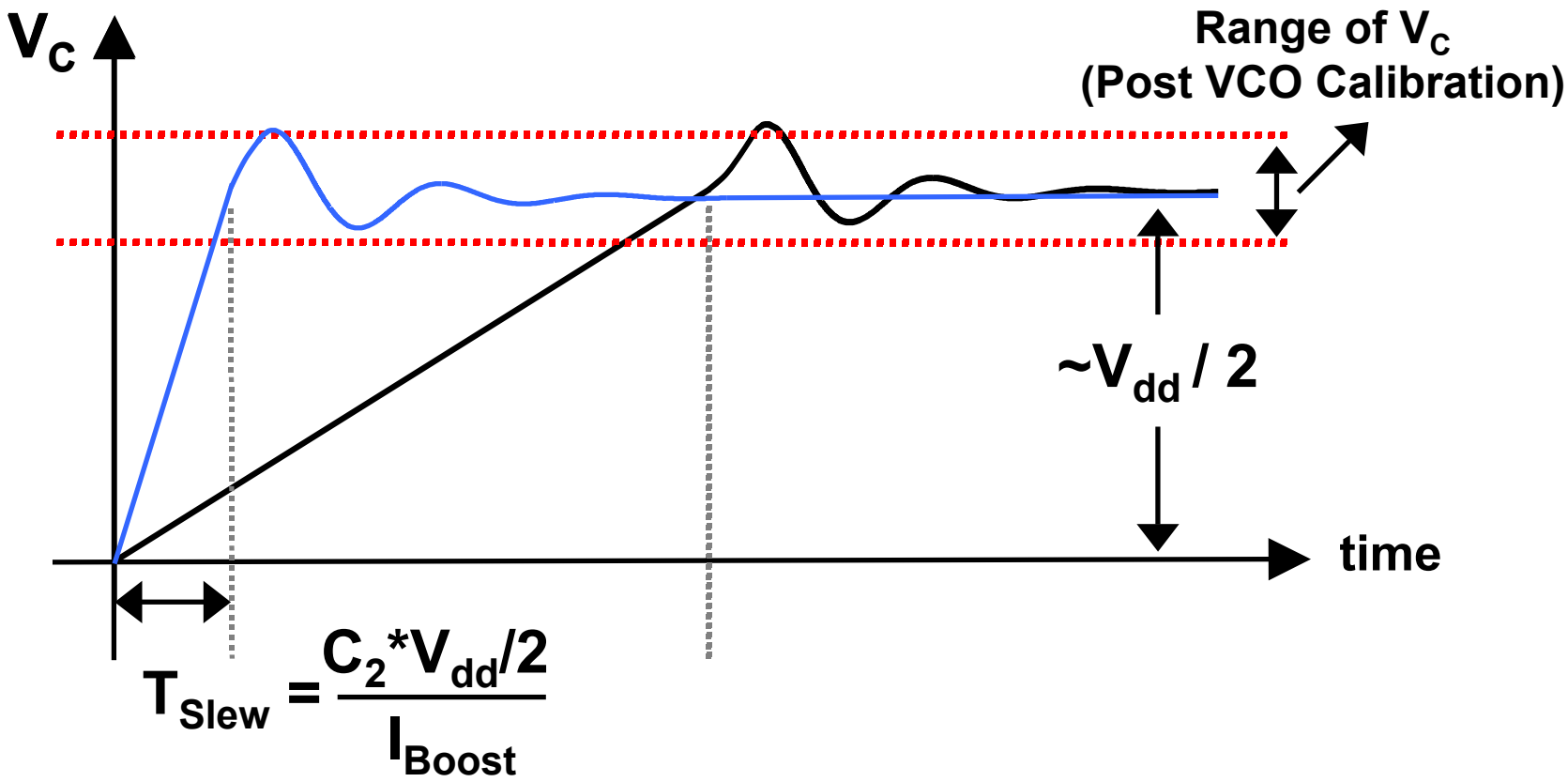


Typical PLL Settling Characteristics



- VCO calibration minimizes control voltage range
- Small charge pump current

Principle of Fast Charging PLL



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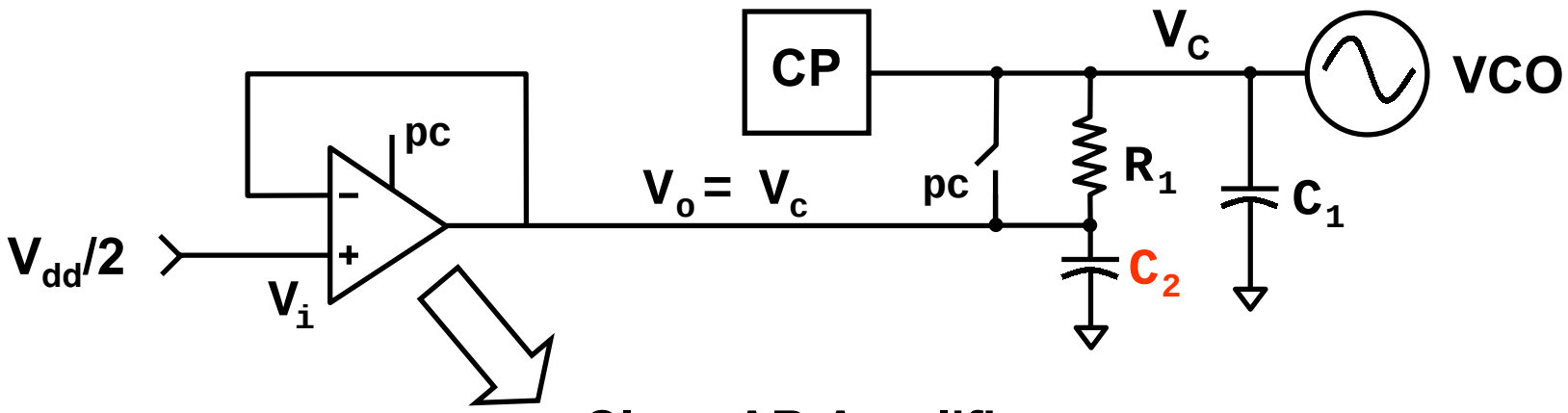
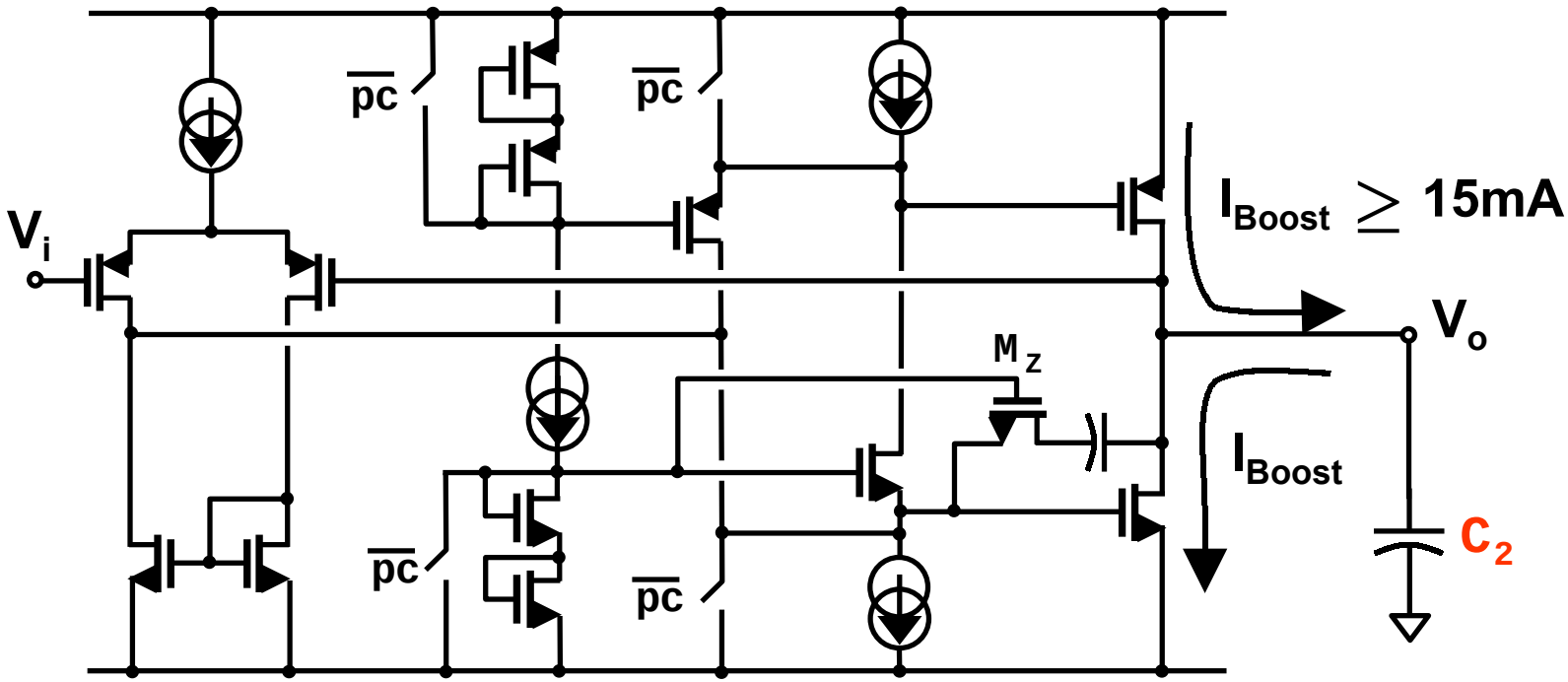
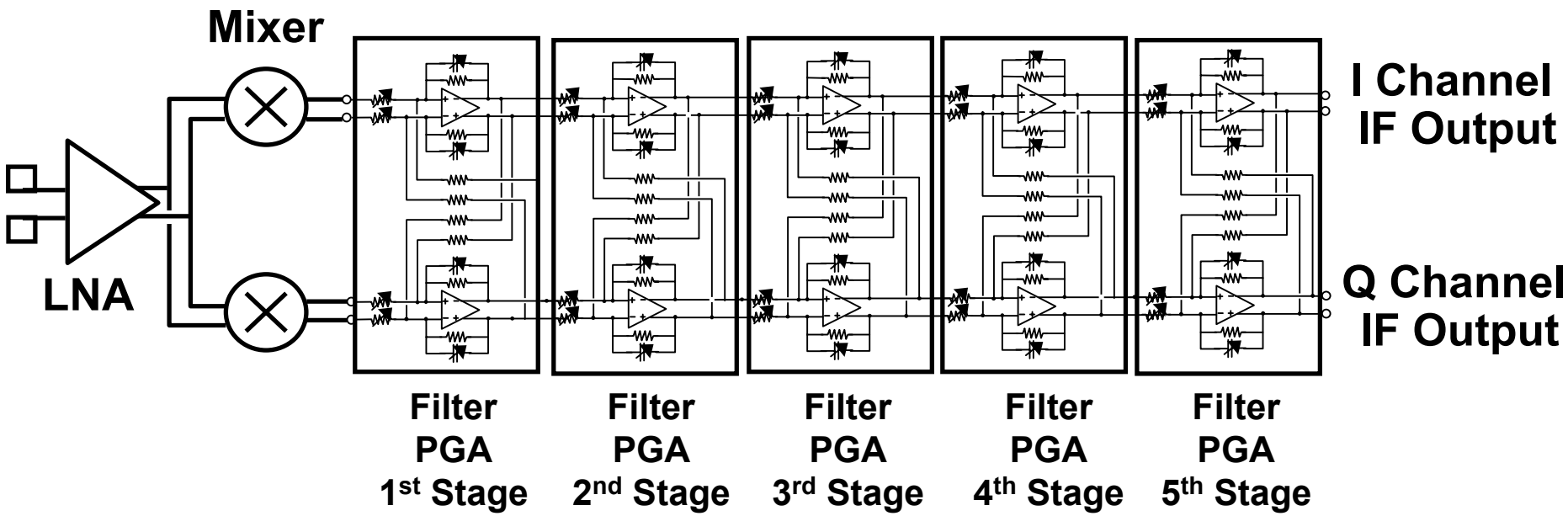
PLL Fast-Charge Amplifier



Class AB Amplifier

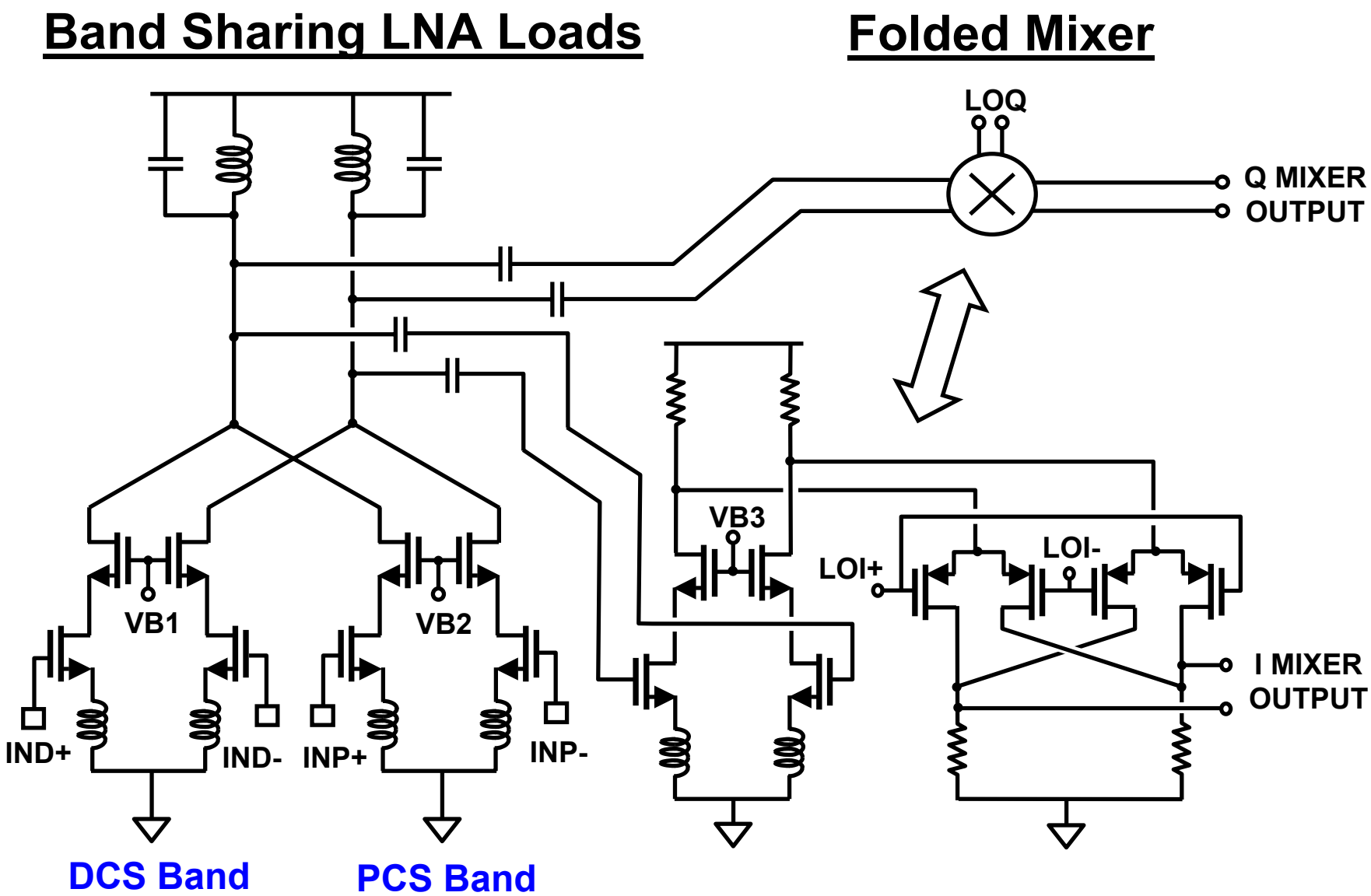


Receiver RF and IF

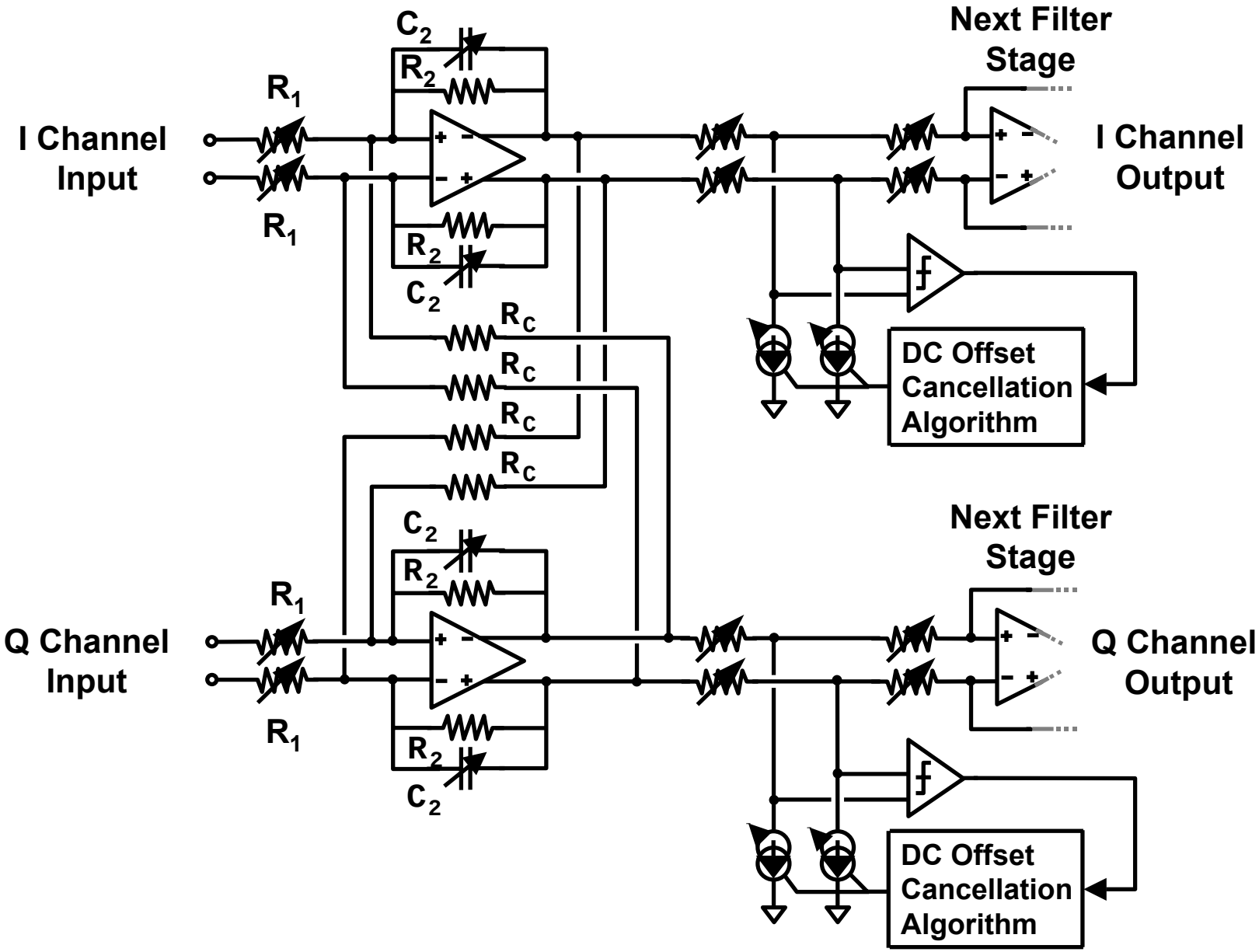


- Fully differential signal path
- Complex Butterworth filter response
- Receive gain is 100dB in 2dB steps

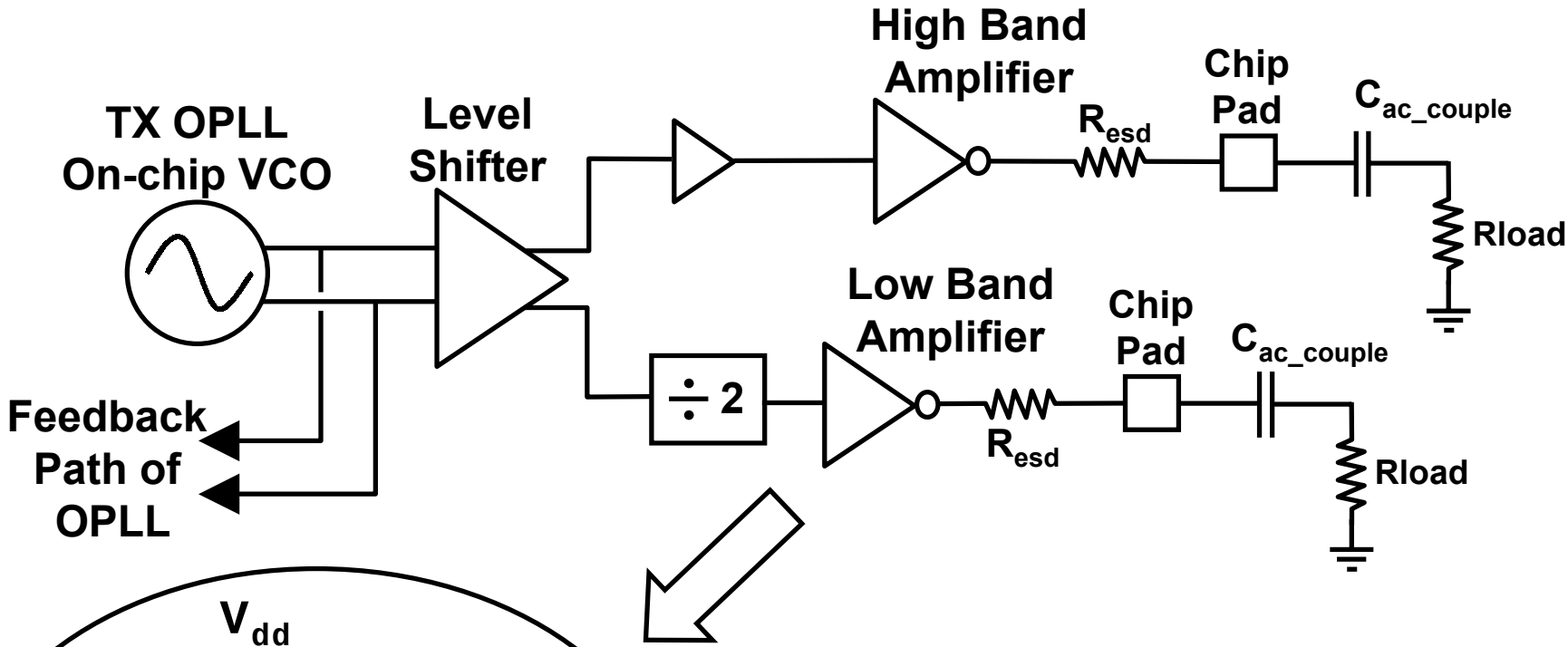
High-Band RF Front End

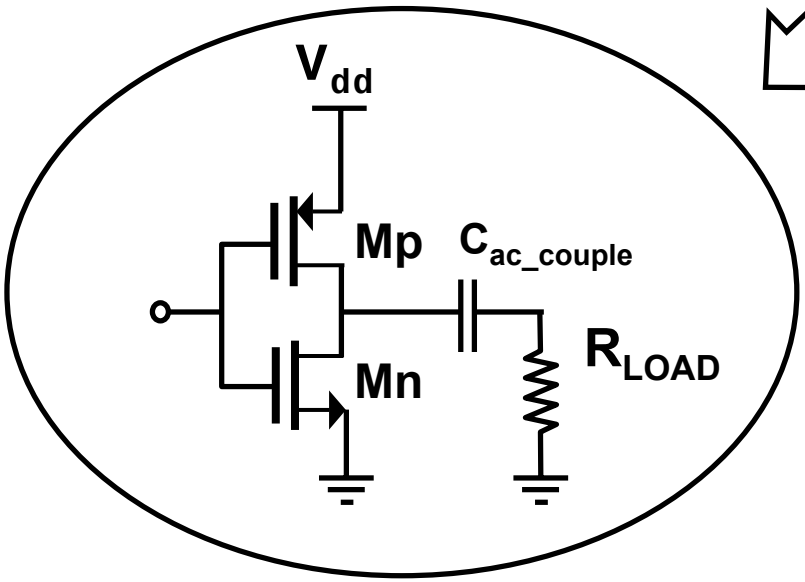


Receive IF Filter and PGA Stage



Transmit Output Driver

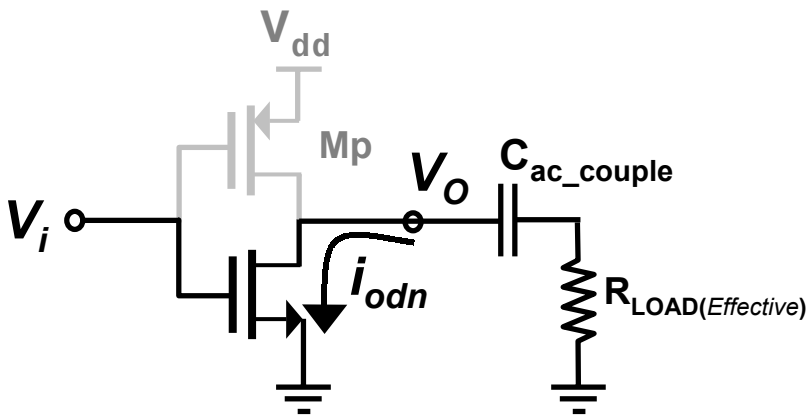




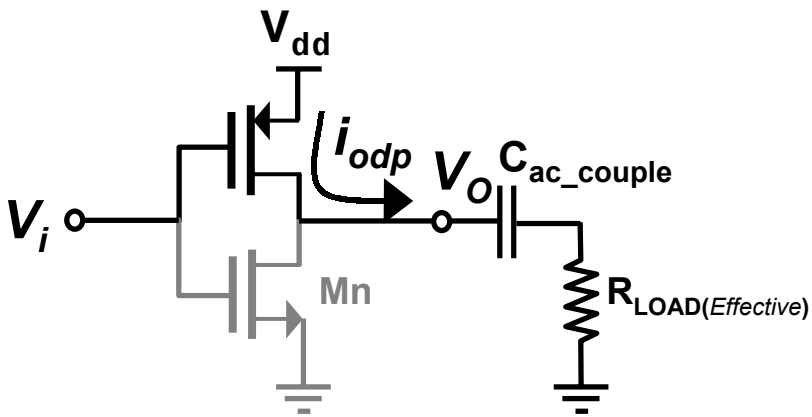
- Rail-to-Rail Signal Path
- Ko Push-Pull Driver
- $P_O \cong i_{op}^2 * R_{LOAD}/2$
- Minimal Area

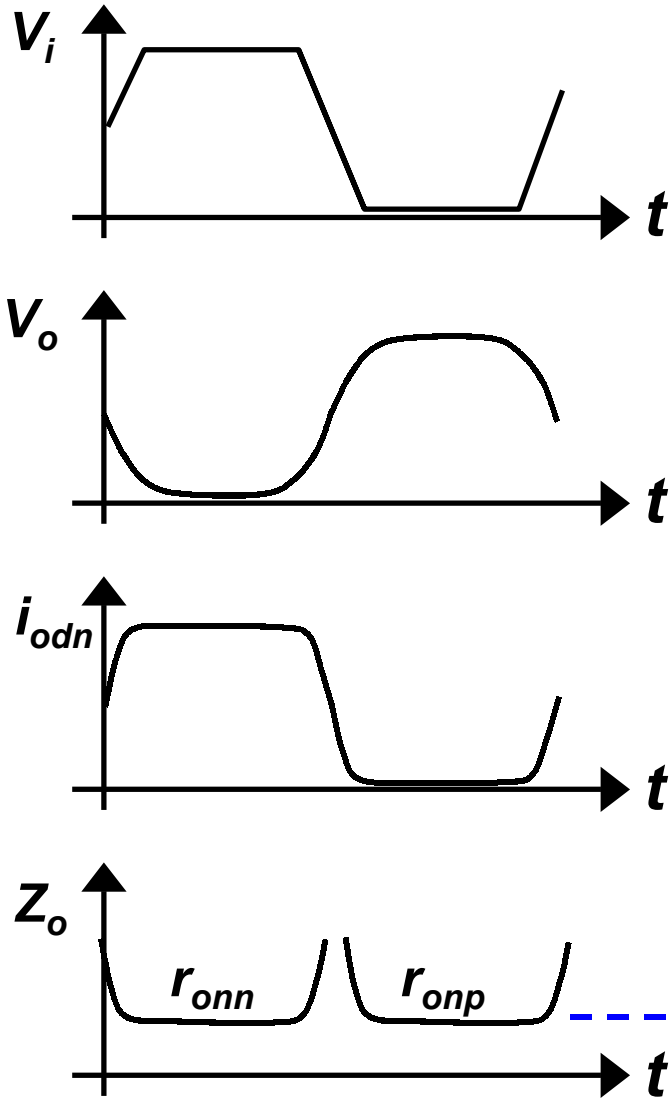
Principle of the Ko Push-Pull Amp

High Input State



Low Input State





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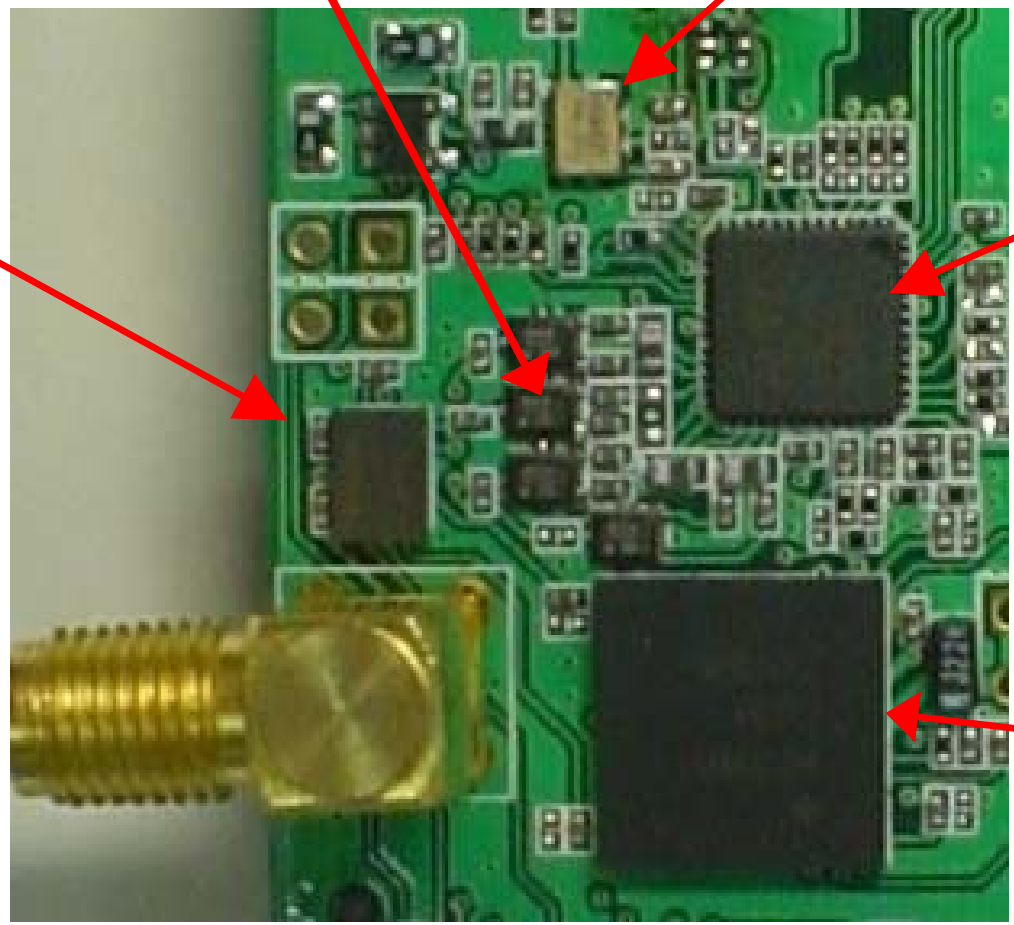
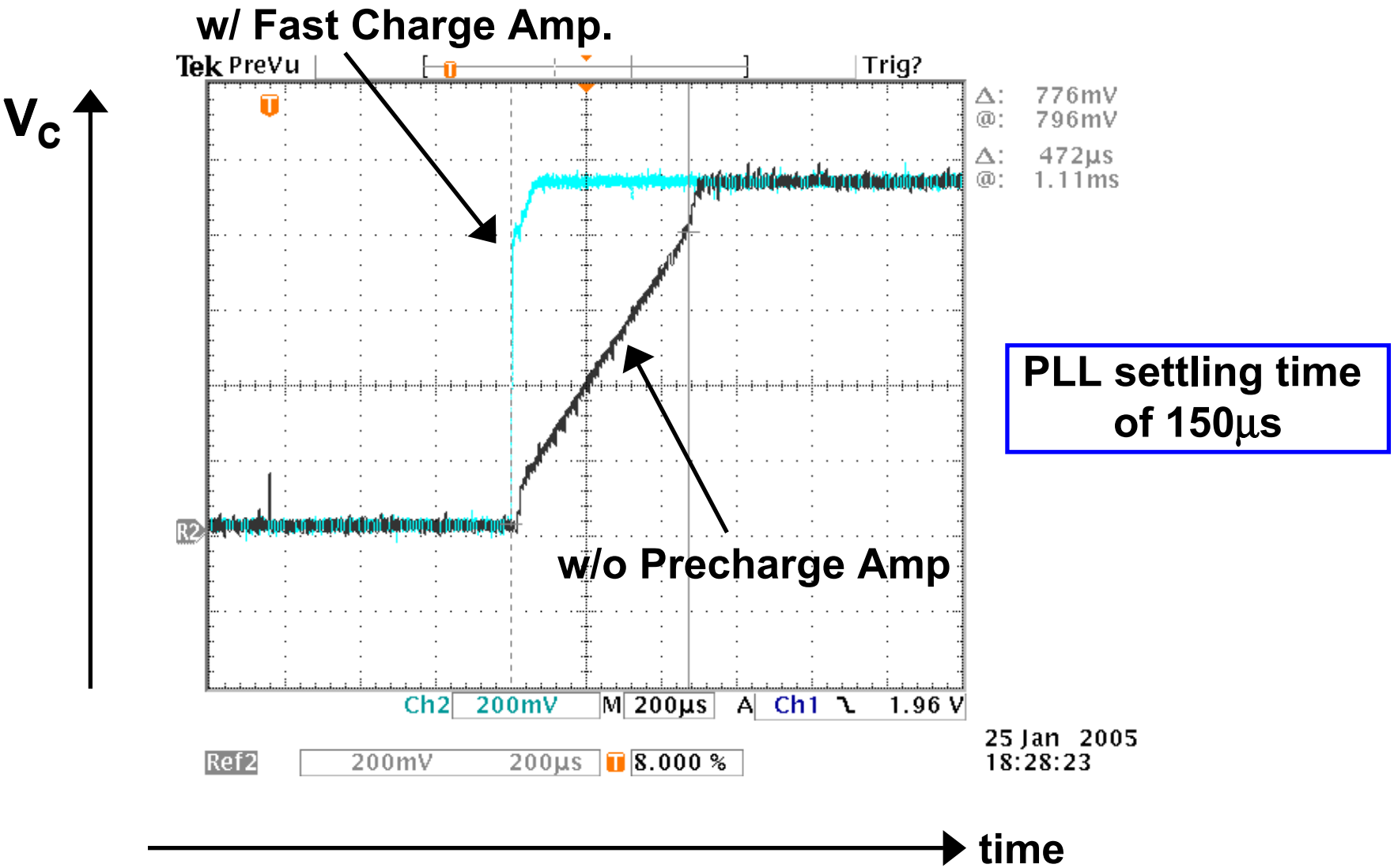
Chip Radio Evaluation Board

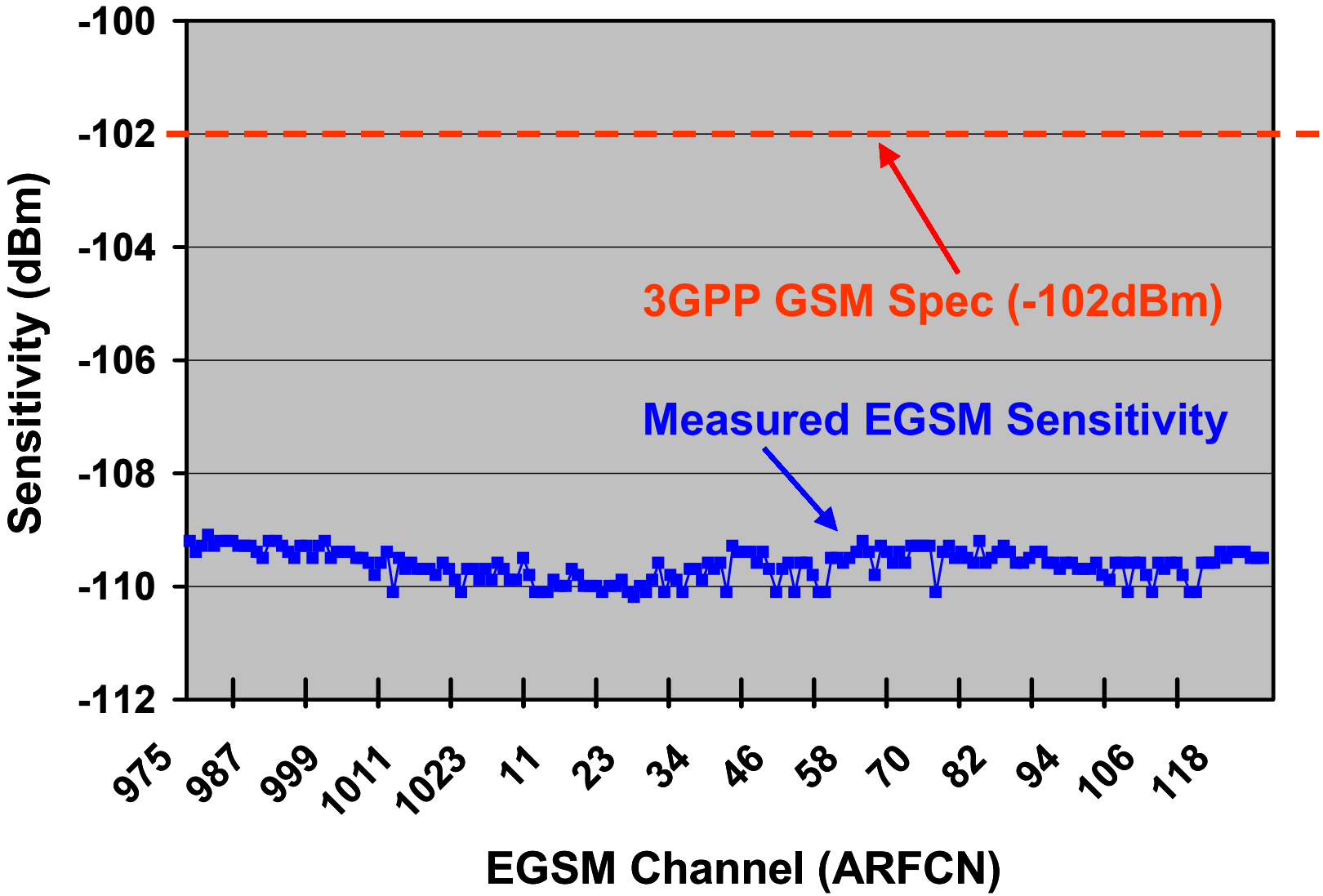


PLL Settling Time

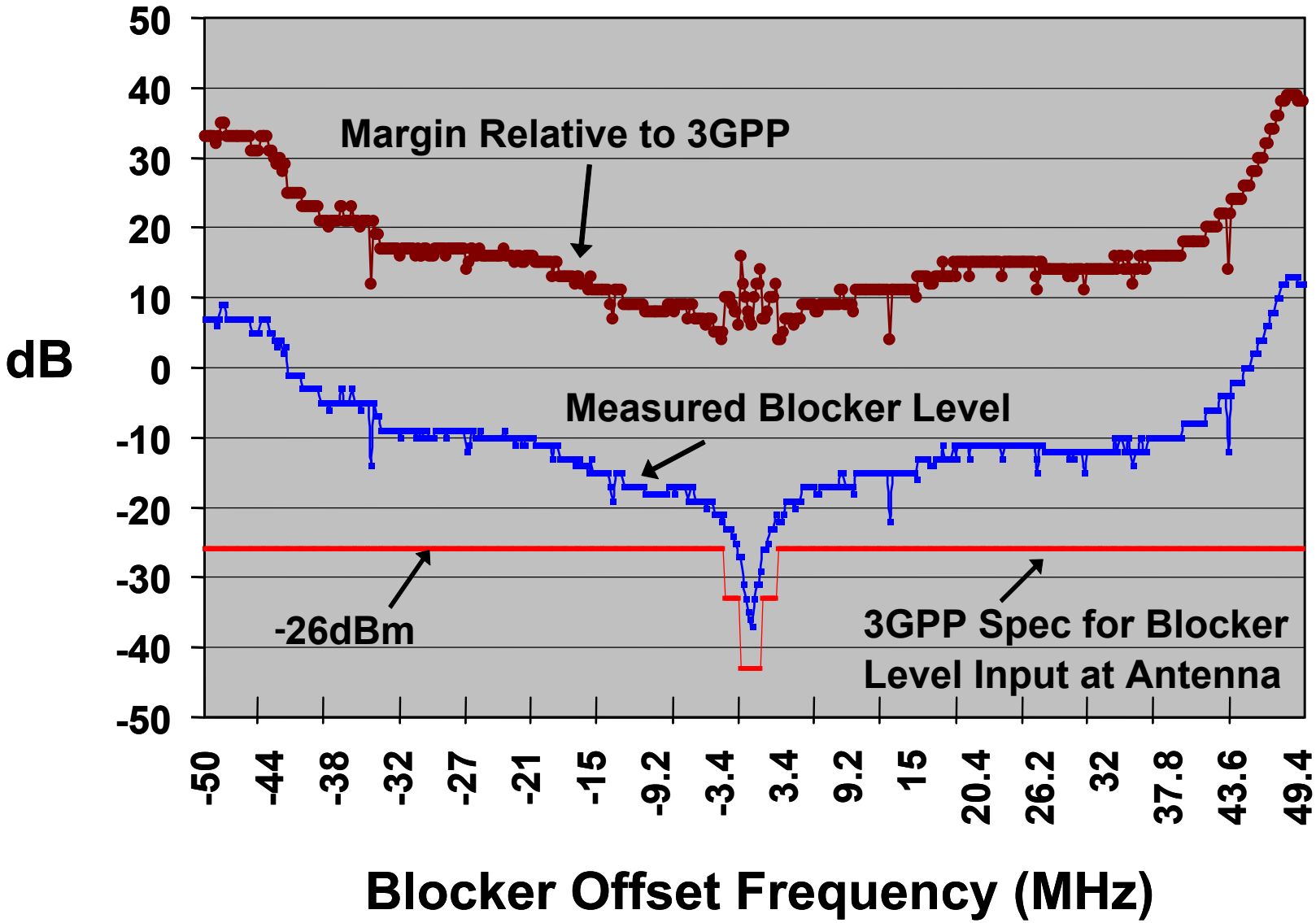


PLL settling time of 150µs

Receiver Sensitivity (EGSM900)

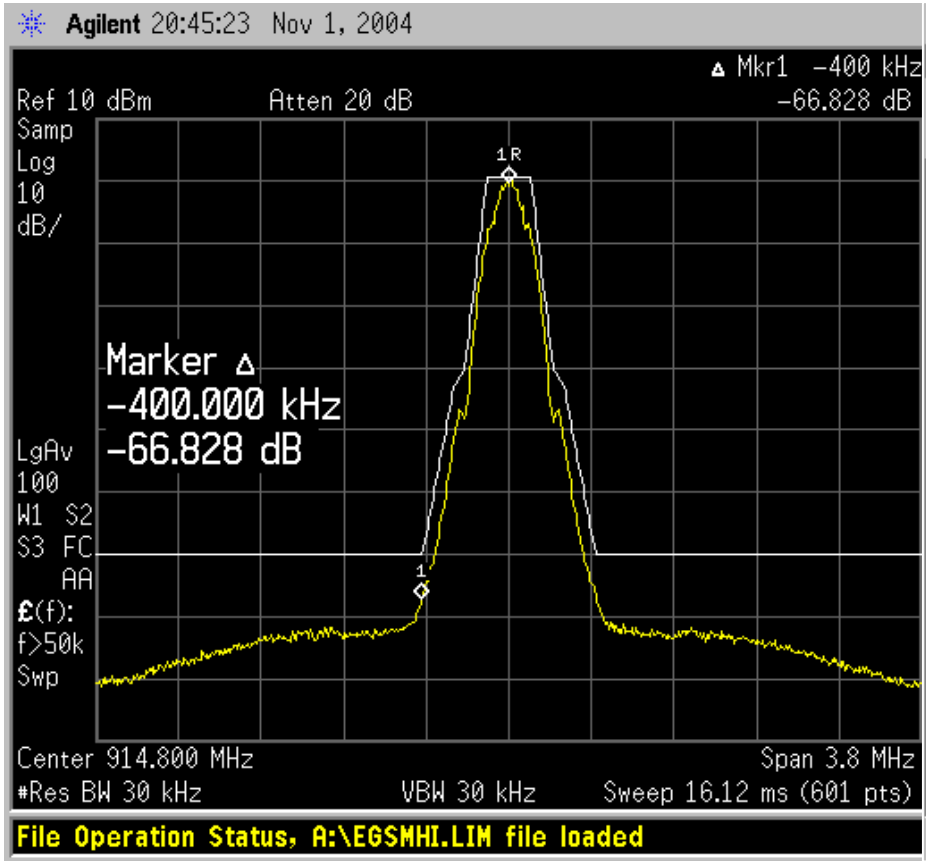


In-Band Blocker Performance (PCS)

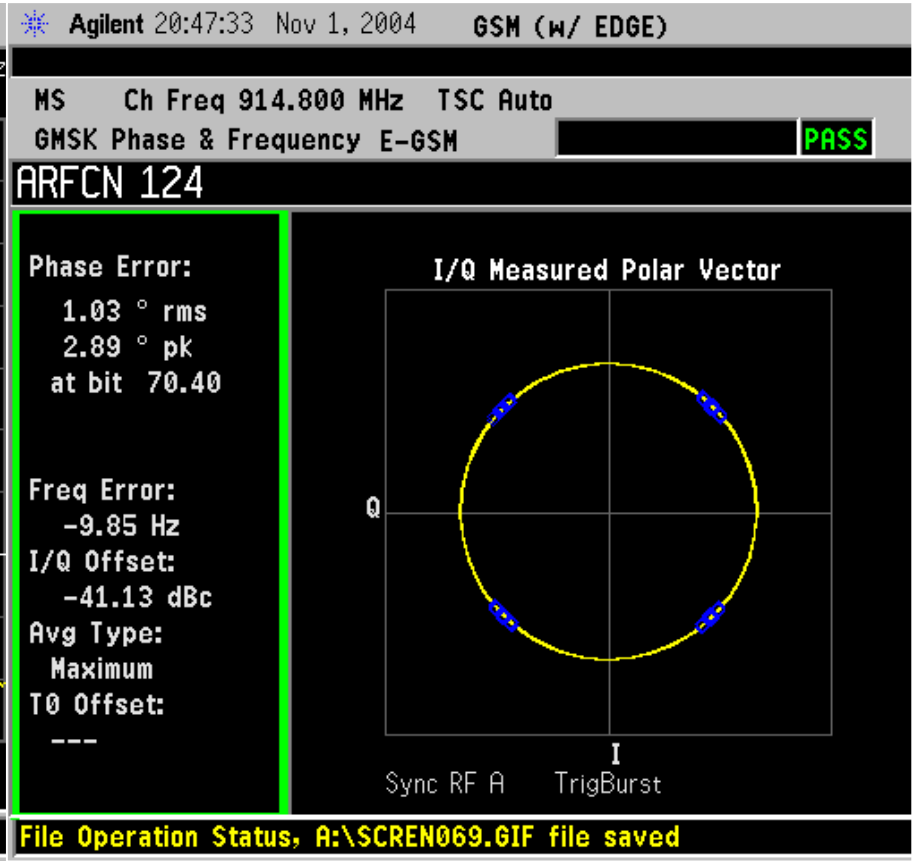


TX Modulation Mask & Phase Error

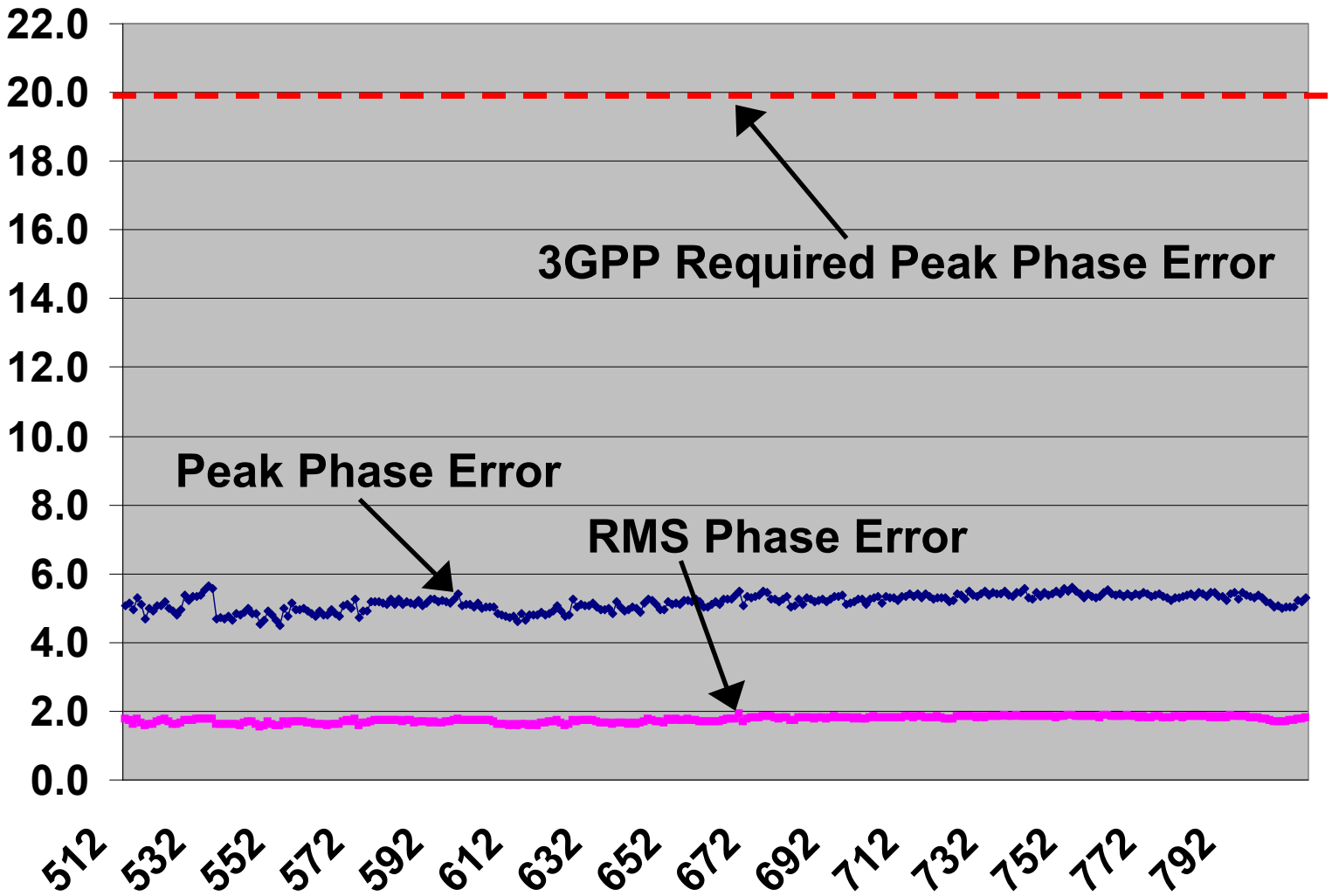
EGSM900 Modulation Mask



EGSM900 RMS Phase Error



TX Phase Error at PA Output (PCS)



Receiver Performance Summary

Receiver Measurements	GSM850 /EGSM900	DCS1800 /PCS1900
Noise figure (dB)	2.7	2.7
Input IP3 (dBm)	-15	-15
Input IP2 (dBm)	40	40
RX gain (dB)	100	100
Sensitivity at antenna (dBm)	-110	-109
RX current (mA)	93	95

Transmitter Performance Summary

Transmitter Measurements	GSM850 /EGSM900	DCS1800 /PCS1900
RMS Phase Error (degrees)	1.0	1.2
Output Modulation Spectrum at 400kHz Offset (dBc)	-66	-65
Noise at 20MHz Offset (dBc/Hz)	-165	-162
Worst Case PLL settling time (μs)	160	160
Output Power (dBm)	+6	+6
Carrier Suppression (dBc)	40	40
Sideband Suppression (dBc)	45	45
Current (mA)	108	112

Conclusions

- **Single-Chip CMOS Transceiver Demonstrates Cellular Performance**
- **Low Power/Noise Inductorless PA driver**
- **Fast Settling PLL Supports GPRS Class 12 Operation**
- **State of the Art RX Sensitivity Performance in Standard CMOS**