Project: IEEE P802.15 Working Group for Wireless Personal Area Networks (WPANs)

Submission Title: Wake-up Radio Presentation for IEEE TG4a PHY
Date Submitted: May 2005
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Re: [Response to IEEE 802.15.4a Call for Proposals (04/380r2)]
Abstract: [Proposal for the IEEE 802.15.4a PHY standard based on wake-up radio system technology.]
Purpose: [Proposal for the IEEE 802.15.4a PHY standard.]

Wake-up Radio Presentation for IEEE 802.15.4a PHY

Presented by: Jae-Hyon Kim

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Objective

- Propose inclusion of wake-up radio to provide ability of controlling wake-up and to reduce power consumption
  - Ultra-low Power Receiver

Requirements

Power Consumption (TG4a Technical Requirement)

-The device (complete communication system including alt-PHY and MAC) must operate while supporting a battery life of months or years without intervention.
-Therefore very efficient power saving modes are desirable, in particular for devices that transmit sporadically. In addition the coordination of nodes must not induce frequent wake up of nodes. These mechanisms must be supported by the alt-PHY layer.

Power Management Modes (TG4a Selection Criteria)

-The ability to reduce power consumption for devices compliant with this standard is important.
-Definition: Power management modes and protocols allow device sleep, wakeup, and poll. The IEEE 802.15.4 standard provides such power management capabilities.

Wake-up: Procedure

All zeros to bypass or a code to wake up

Transmitter

| Preamble | ID | ● ● ● | Preamble | ID | Data |

#1 Receiver

Carrier Sensing

Carrier Sensing

ID Sensing

discarded

Wake-up

#2 Receiver

Carrier Sensing

Carrier Sensing

ID Sensing

Receive Data

#N Receiver

Carrier Sensing

Carrier Sensing

ID Sensing

discarded
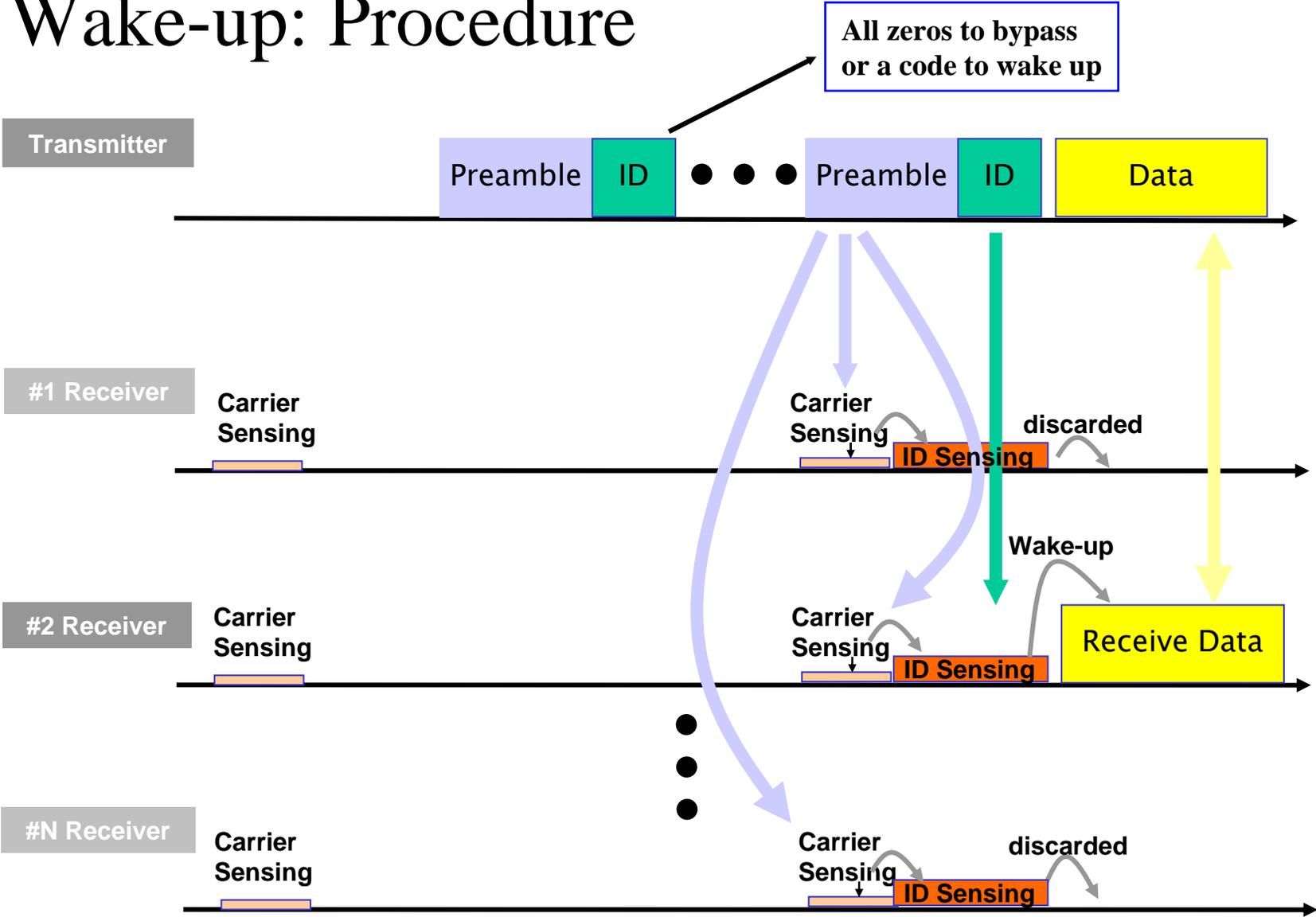
Wake-up: ID

To provide wake-up ability it requires to include wake-up ID in the header

802.15.4 **PPDU**

Preamble	SFD	PHR	PSDU

4 + 1 + 1 Bytes → 32 Bytes

Proposed **PPDU**

Preamble	WU-ID	SFD	PHR	PSDU

4 + 2 + 1 + 1 Bytes → 0 ~ 127Bytes
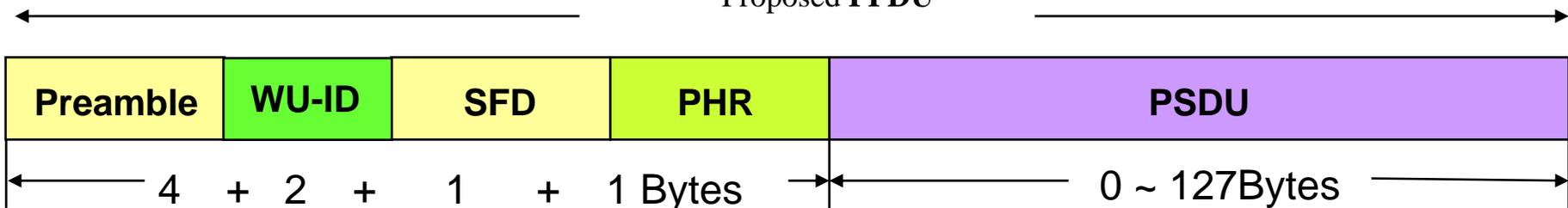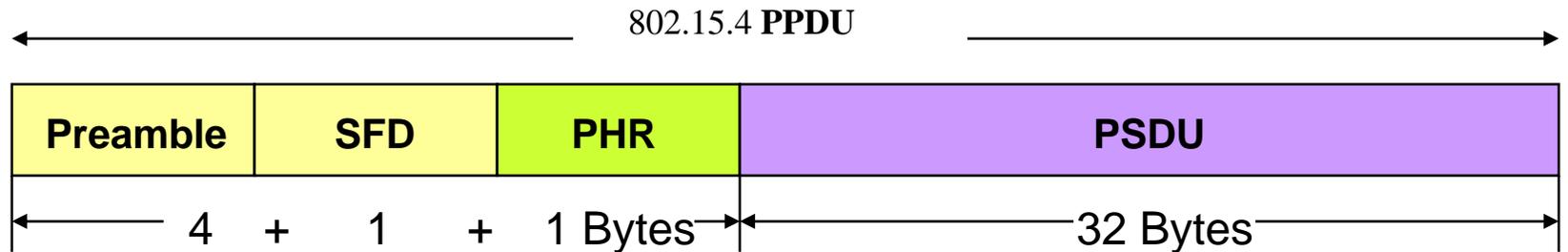
WU-ID: Wake-up ID

WU-ID can be all 0 sequence (to bypass) or a code (to wake-up)

Wake-up: Radio Structure

Power

Carrier Signal Detector

Wake Up Signal

Super-regenerative OSC — **Detector**

Carrier Sensing Signal

Switch | **LNA** — **Correlator** — **High Gain Amplifier** — **Detector**

Wake-up Signal Detector

Wake-up Signal

Main Transceiver
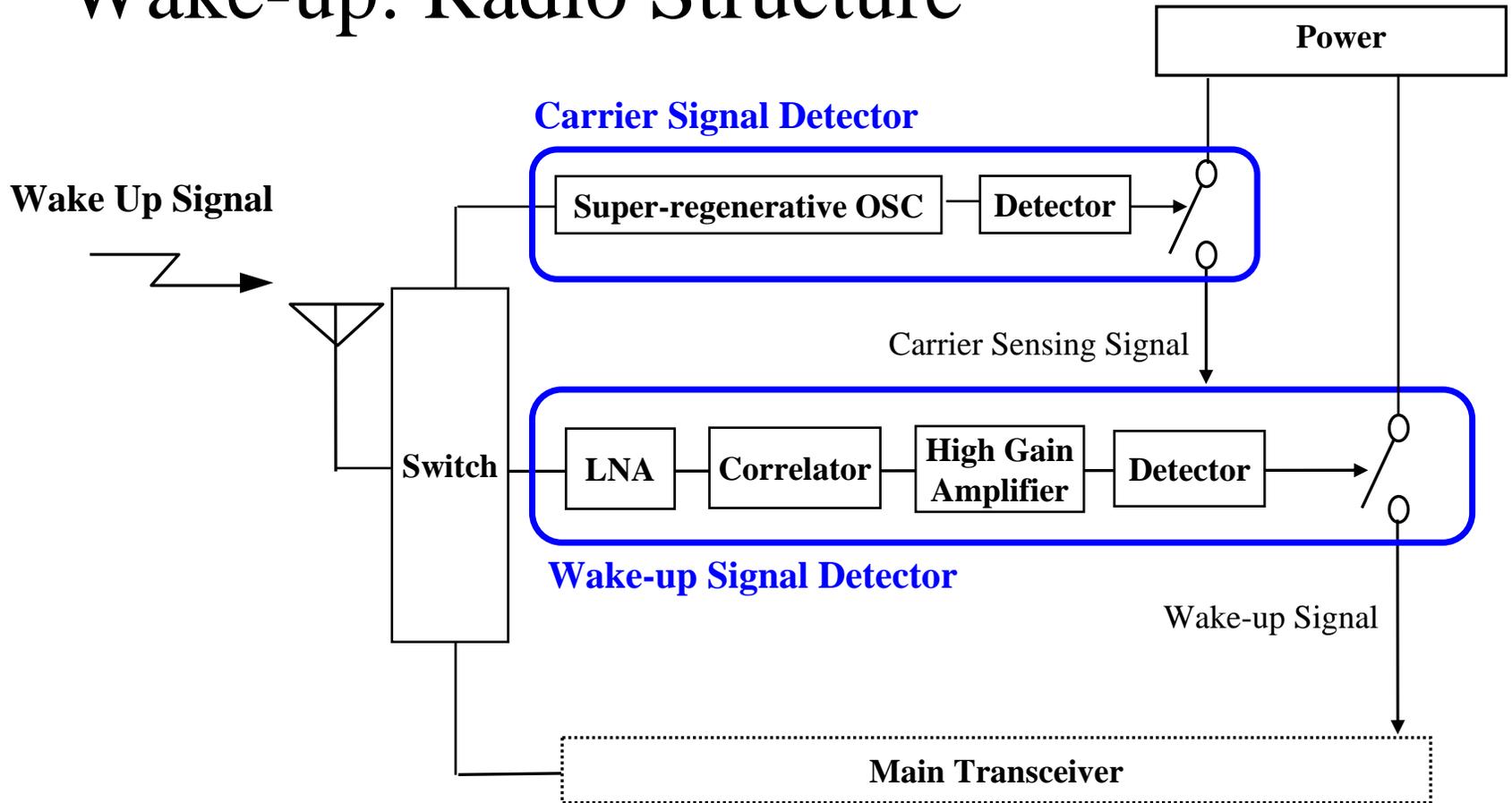
- **Wake-up radio detects broadcast wake-up carrier signal and activates wake-up signal detector for wake-up signal detection**

- **Conserves power by only turning on wake-up signal detector when it is needed; carrier detector consumes little power on its own compared to wake-up signal detector**

Wake-up: Signal Flow of Radio

Signal

↓

Carrier Signal Detector ON

↓

Carrier Signal ?

No ←

↓ *YES*

**Wake-up Signal Detector ON
& Carrier Signal Detector OFF**

↓

Wake-up Signal ?

No ←

↓ *YES*

**Main Data Radio ON
Wake-up Signal Detector OFF**

↓

Data Communication
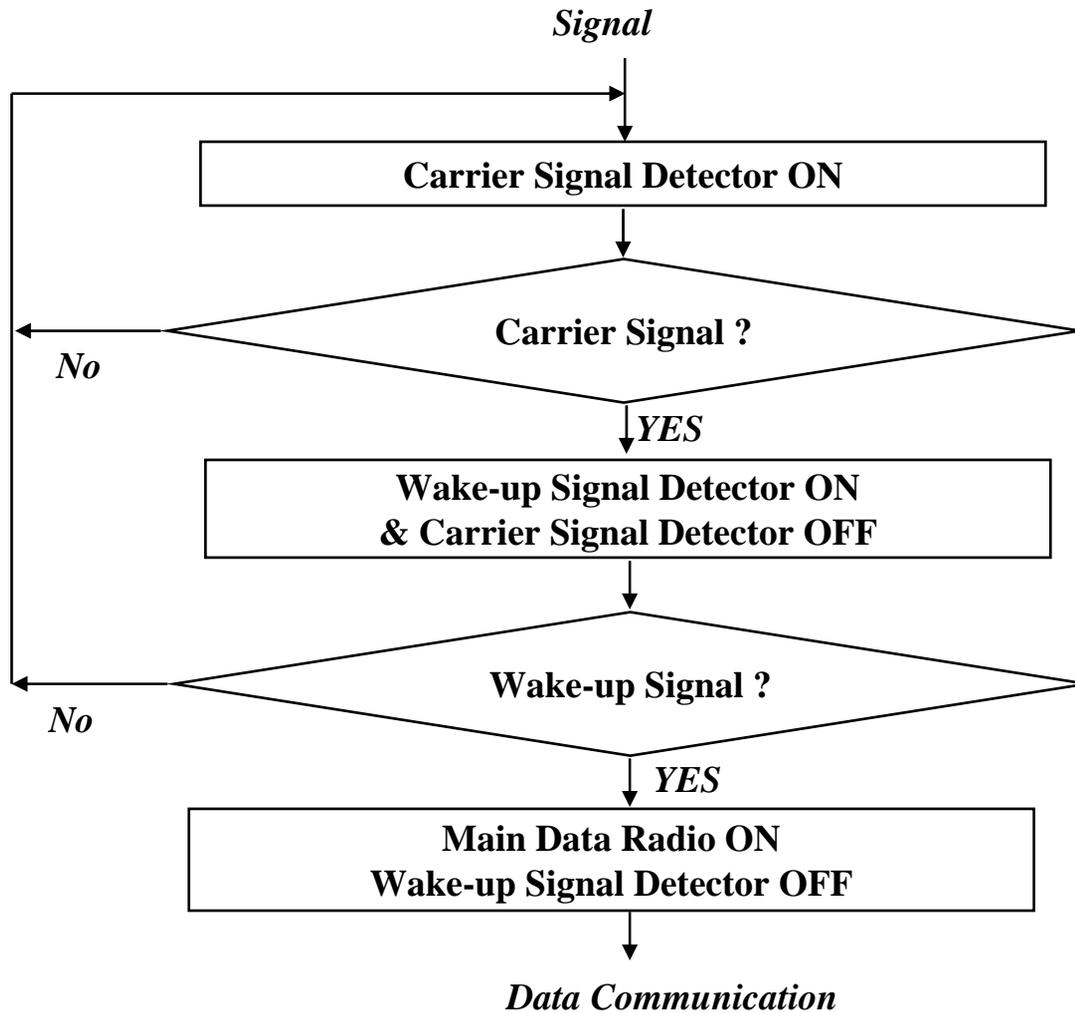
Back-up Slide

Wake-up: Carrier Signal Detector

Super-regenerative OSC
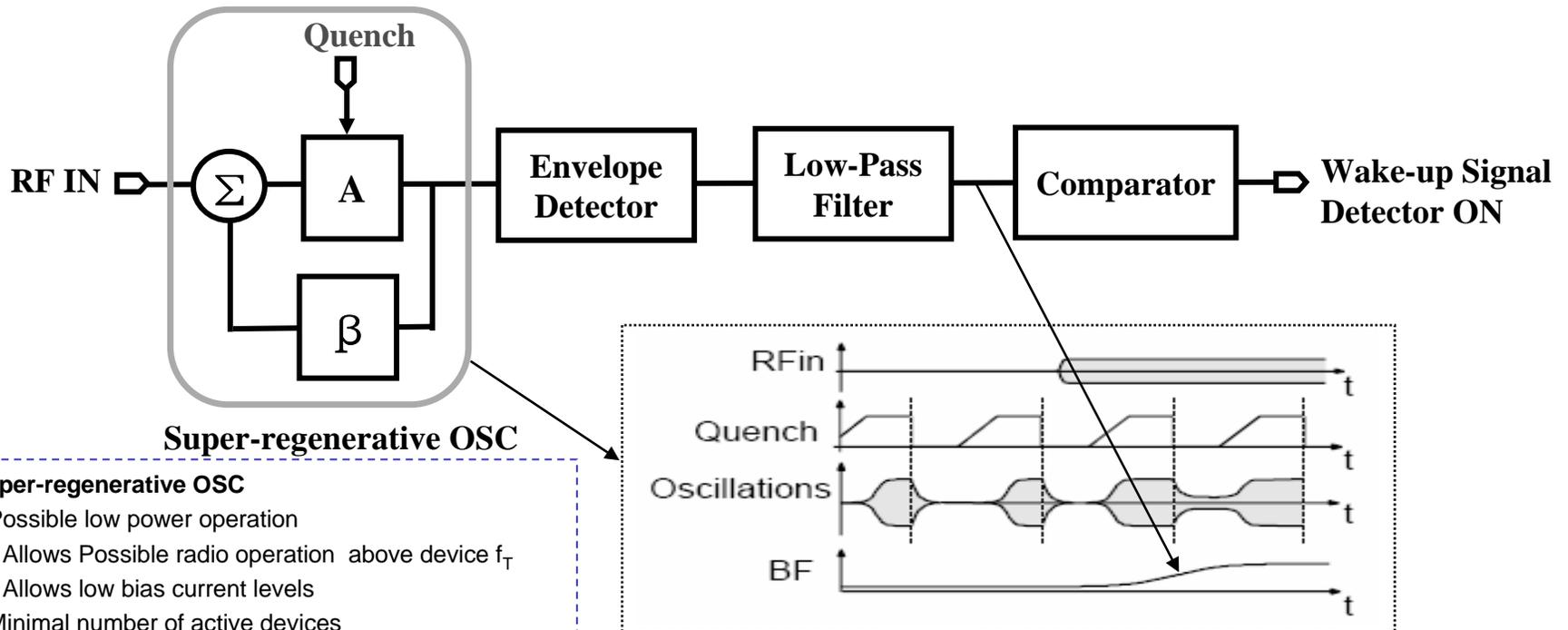
Super-regenerative OSC
- Possible low power operation
  - Allows Possible radio operation above device f_T
  - Allows low bias current levels
- Minimal number of active devices
  - A very simple architecture
- Very good sensitivity
  - Due to High RF gain
 - Allows reduction in transmit power

- **Super-regenerative receiver has essentially infinite gain and high output level.**

- **The principle of super-regeneration allows a very simple architecture and appears to be particularly suited to micro-power applications, compared to the super-heterodyne, the low IF or the direct conversion receiver.**

Wake-up: Signal Detector
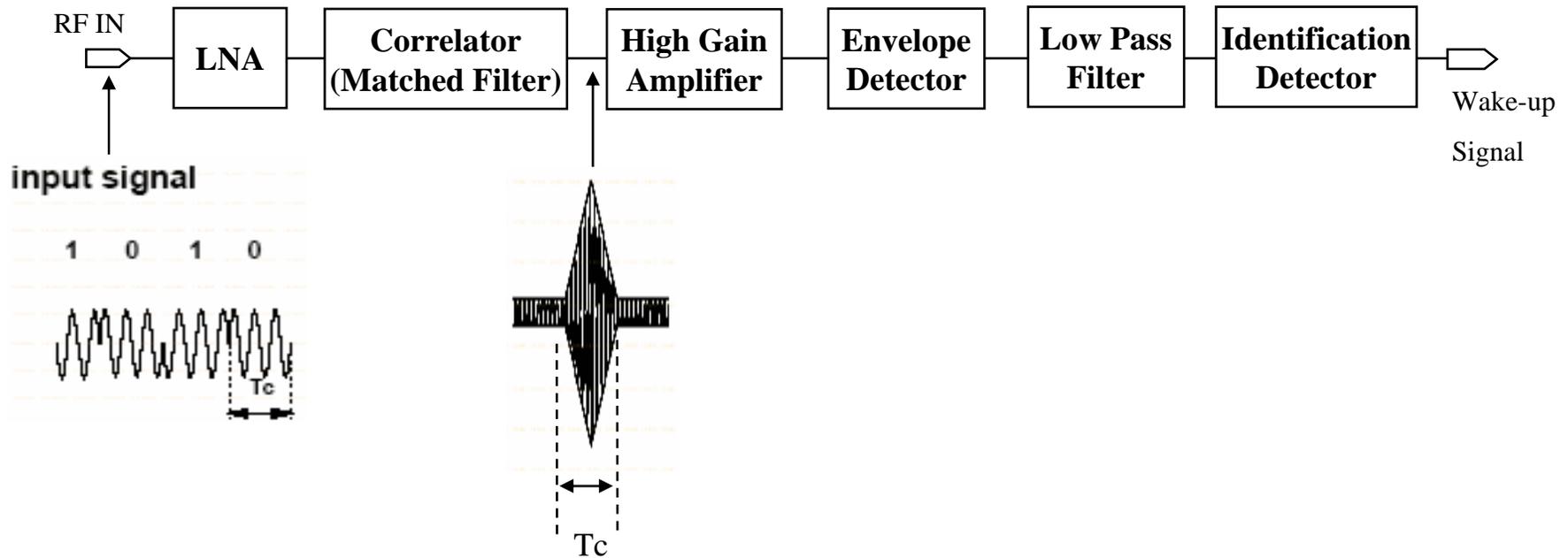
- **Simple architecture and low power operation**
  - **Does not require many high-frequency active components such as Mixer, PLL, OSC.**

- **The signal is reinforced by the correlator (matched filter) while the disturbances contribute only as basic noise (system gain). Therefore, wake-up signal detector is very resistant against narrowband noise and interferer.**

Wake-up: Characteristics of Signal

Data   **1**   **0**   **1**   **1**   **0**

1 0 111 0 1 …
Barker Code/BPSK

OOK

Transmitter

Demodulated wake-up signal
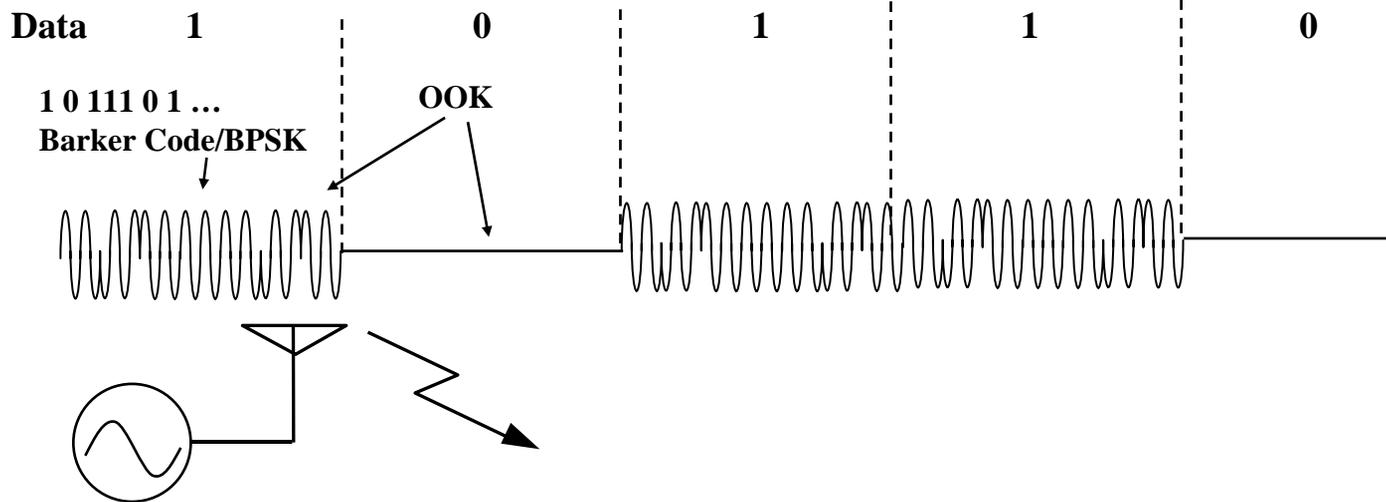
- **The signal is modulated by OOK.**
  - **It has less complexity.**
- **Each symbol is modulated by BPSK and is coded by barker code.**
  - **It has very resistance against narrowband noise and interferer.**

Correlator
(Matched Filter)
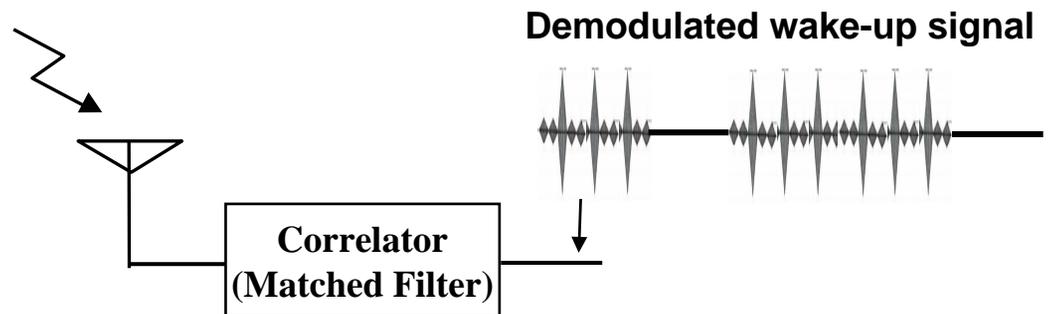
- Colpitts Oscillator
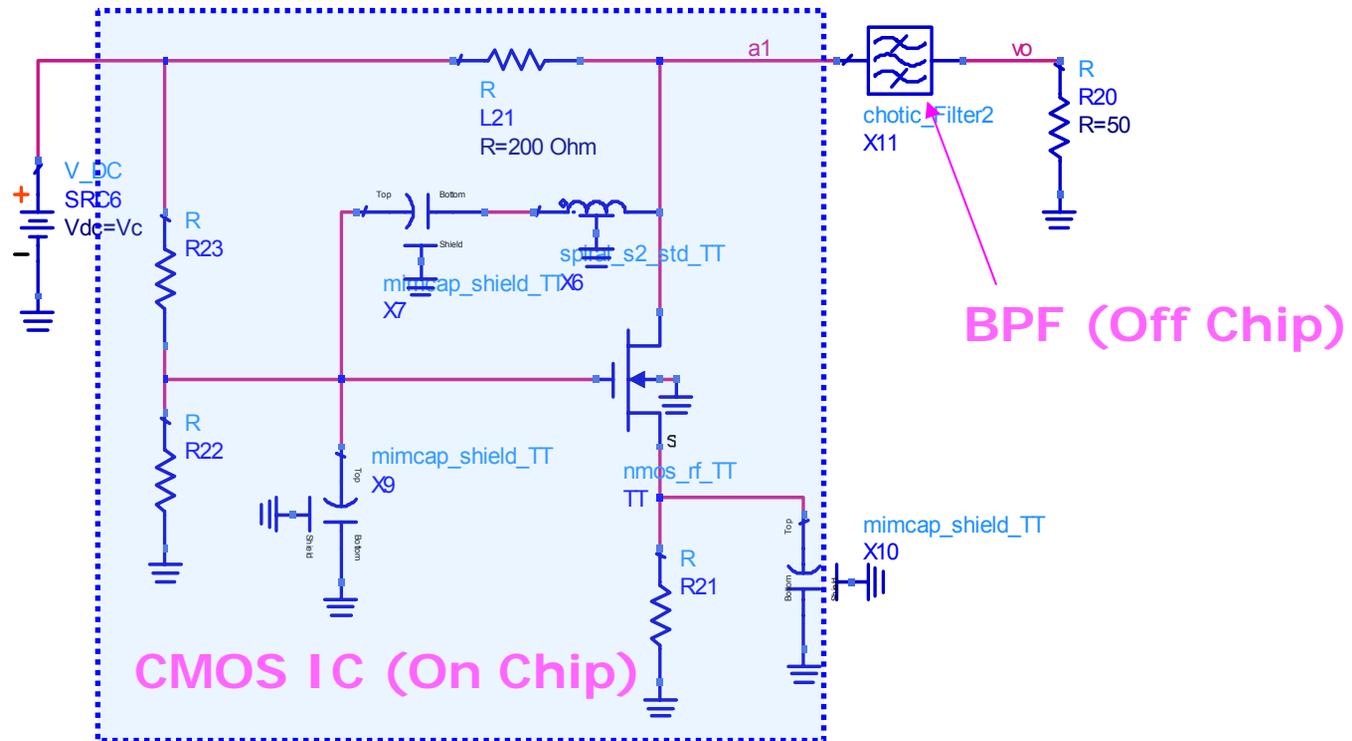
➢**TSMC 0.18um CMOS Process**

➢**Power Consumption:1.8mW(1mA, 1.8V)**

- Simulation Results

.State trajectory

Layout of Chaotic Source

- Colpitts Oscillator

400um

300um