Integrated Low Voltage, Power Efficient DC-DC Converters for Dynamic Power Supplies of Power Amplifiers

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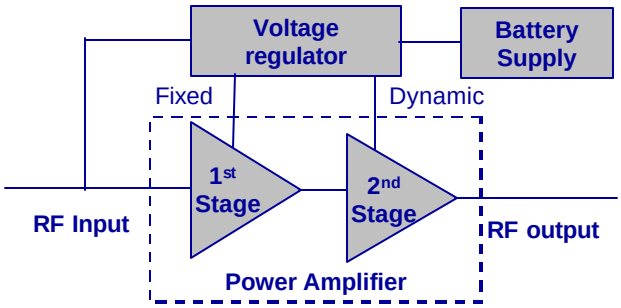
Abstract

- **Power Amplifiers**
  - Consume majority of power in radio transceivers
  - Maximum efficiency when output signal is rail-to-rail
  - ⇒ Dynamic power supply for the PA depending on signal strength
  - ⇒ High efficiency voltage regulators
- **DC-DC Converters**
  - High efficiency compared to linear regulators
  - Dynamic control loop for selection of supply voltage
  - Efficient and stable control of high speed converters
- **Implementation**
  - SiGe BiCMOS process technology
  - Prototype: Converter and PA separately
  - Goal: High efficiency linear integrated PA

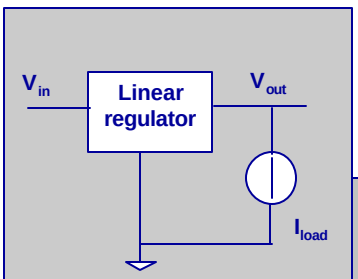
Objective

- **Power Amplifiers are "long pole" in the tent**
  - **Cost, reliability and battery life**

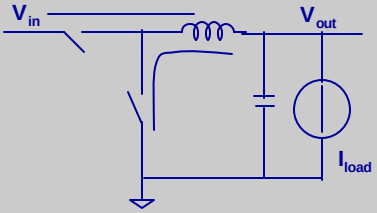


- **Variable supply voltage to the PA on demand**
  - **Optimum efficiency, improves battery life**

Why Switching Regulators?

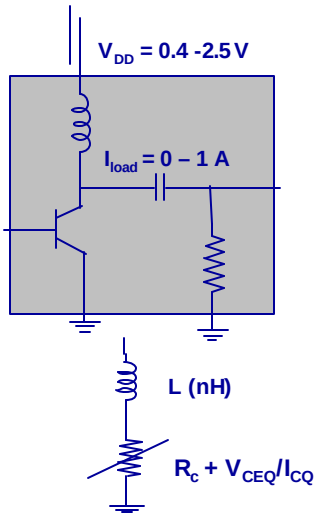


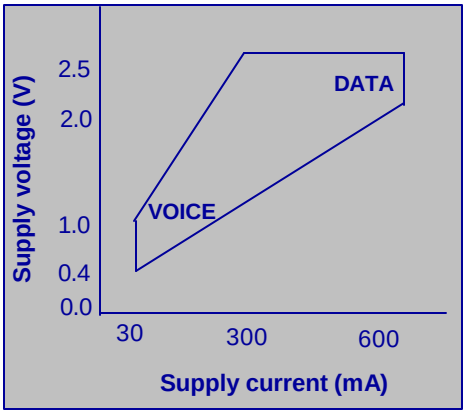
$$\eta = \frac{P_{out}}{P_{out} + P_{reg}}$$



- **Linear regulators**
  - **Simple, low cost**
  - **Poor efficiency**
- **Switching regulators**
  - **Complex, costlier**
  - **High efficiency (80-95%)**
  - **Noisy**

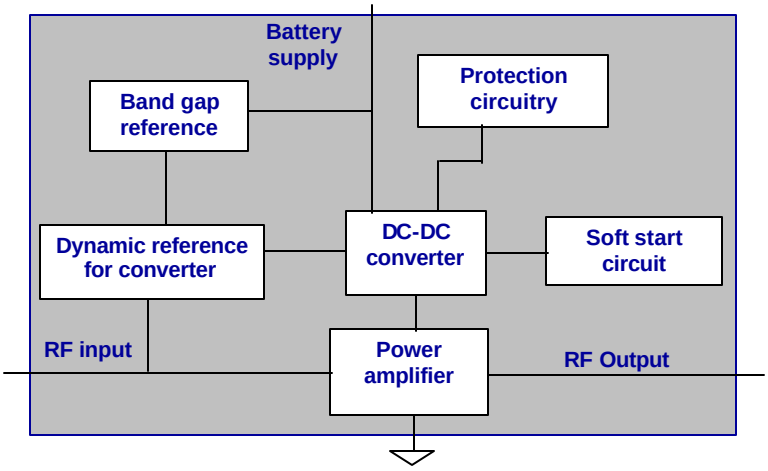
PA as a Load for Converter



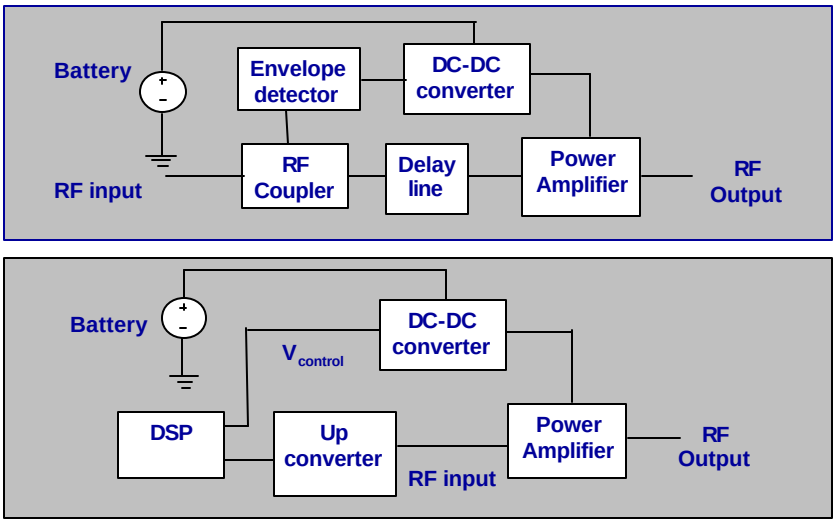


CDMA-IS 95 requirements

Functional Block Diagram



Supply Selection Schemes



DC-DC controllers

Control mode	*Voltage*	*Peak-I*	*Average-I*	*Hysteretic*
$V_{out\text{-}ripple}$	Worst	Worst	Worst	Best
D-limit	Poor	Poor	Poor	Best
Frequency	Best	Best	Best	Poor
Complexity	Good	Poor	Poor	Best
Compensation	Worst	Good	Poor	Best
V_{in}- $t_{response}$	Worst	Worst	Good	Best
I_{load}- $t_{response}$	Worst	Worst	Worst	Best

Source: G. A. Rincon-Mora, "Self-oscillating hysteretic V-mode controllers: From the ground up," *2001 Power Electronics Specialist Conference.*

Design Considerations

- High efficiency over wide loading conditions
  - Conduction loss at heavy load
  - Switching loss at low load
- Dynamic voltage adjustment
  - 0.4 V to 2.5 V on demand
- Fast response, output slew rate
  - V_{ref} variation at 1.22 MHz
  - Power adjustment of 1 dB in 666 msec as directed by the base station
- Stability over duty cycle range
  - Duty cycle variation: 16% to 100%
- Switching frequency
  - Smaller external components at higher frequency
  - Higher switching loss
- Noise
  - Switching noise
  - Substrate coupling
- Layout

Work Plan

Activity	Status
Specifications	: In progress
Design of prototype converter	
Evaluation of prototype	
Design of Integrated PA	
Evaluation of integrated PA	