

# 2020 Research Day

## Digital Lock-In Controller IC for Data-Centers

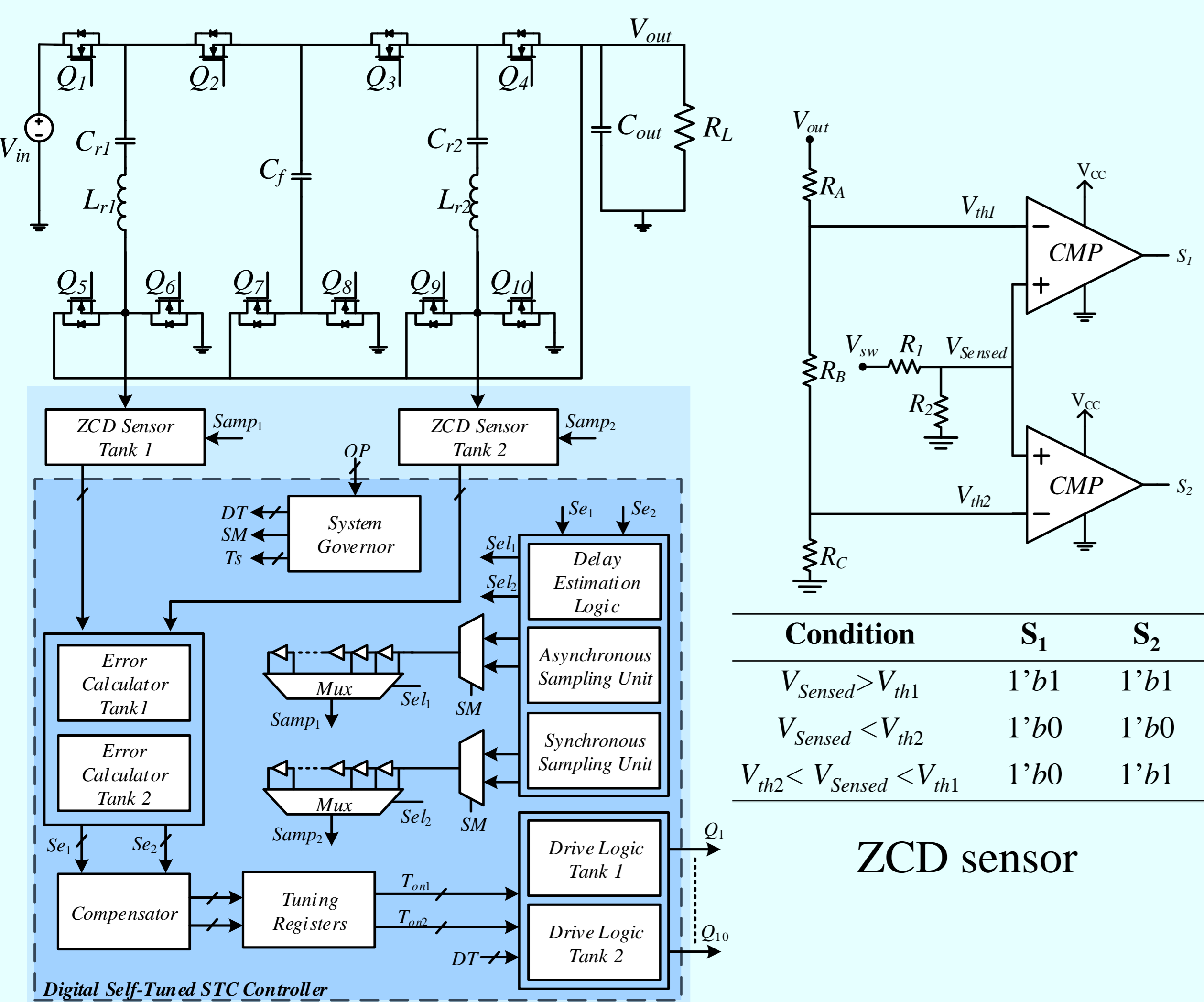
### 48V-12V ZCS-STC

Tom Urkin, Guy Sovik, Erez Masandilov, and Mor Mordechai Peretz

The Center for Power Electronics and Mixed-Signal IC  
 Department of Electrical and Computer Engineering, Ben-Gurion University of the Negev, Israel

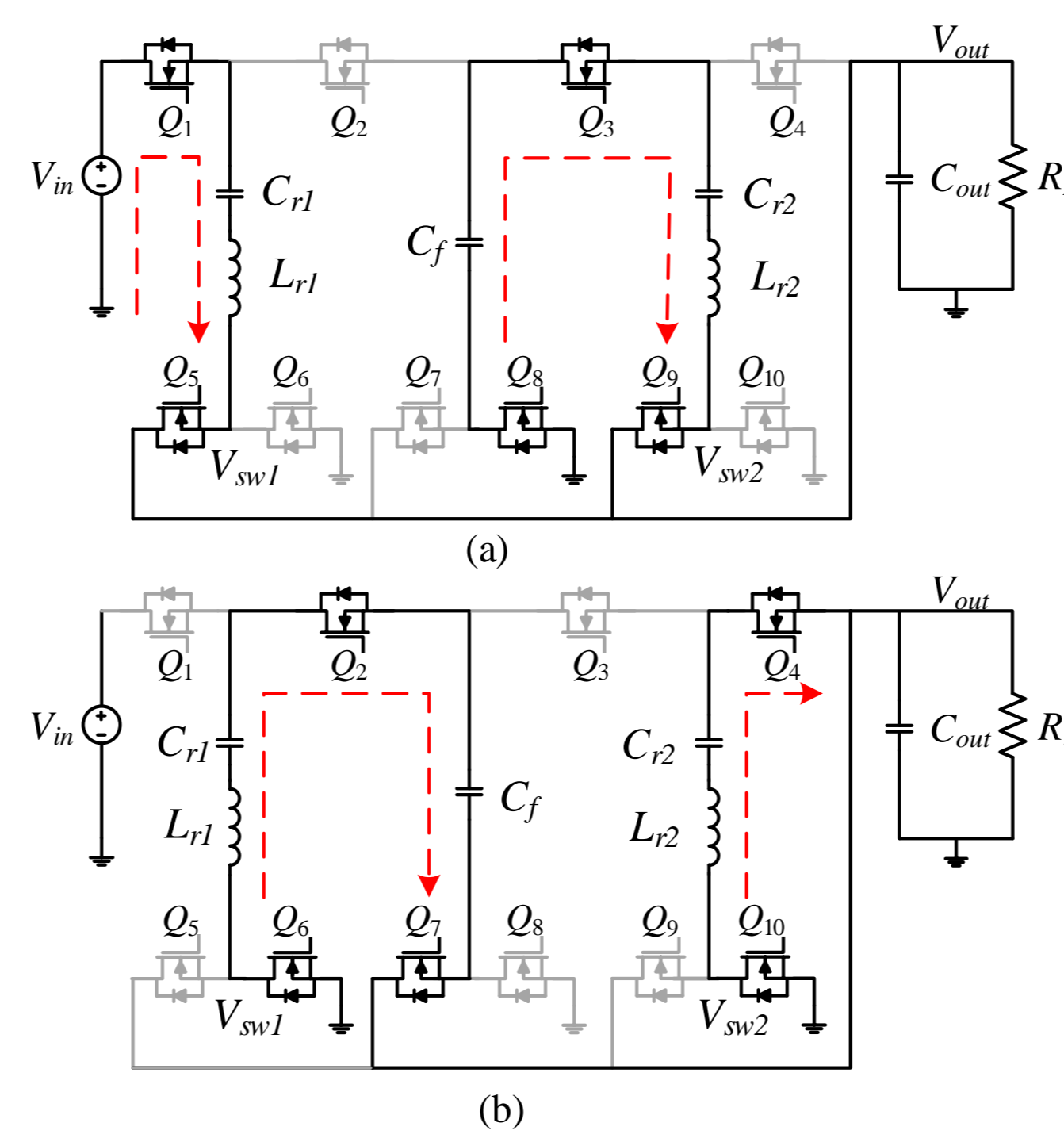
#### Introduction

- This work introduces a **lock-in integrated controller for 48V-12V ZCS switched-tank converters (STC)**
- The controller identifies the resonant period of **each sub-circuit on-the-fly** and locks-in on the correct switching time
- Key building blocks of the system:** two independent ZCD sensors, digital HR-DPWM, Sigma-Delta ADC and a programmable dead-time module
- Two approaches have been developed for the sensors' data acquisition,** taking into account the inherent delay between the gating-command and the actual turn-off of the switches
- All units of the digital controller have been designed through **asynchronous architecture, eliminating the need of high-speed clock**

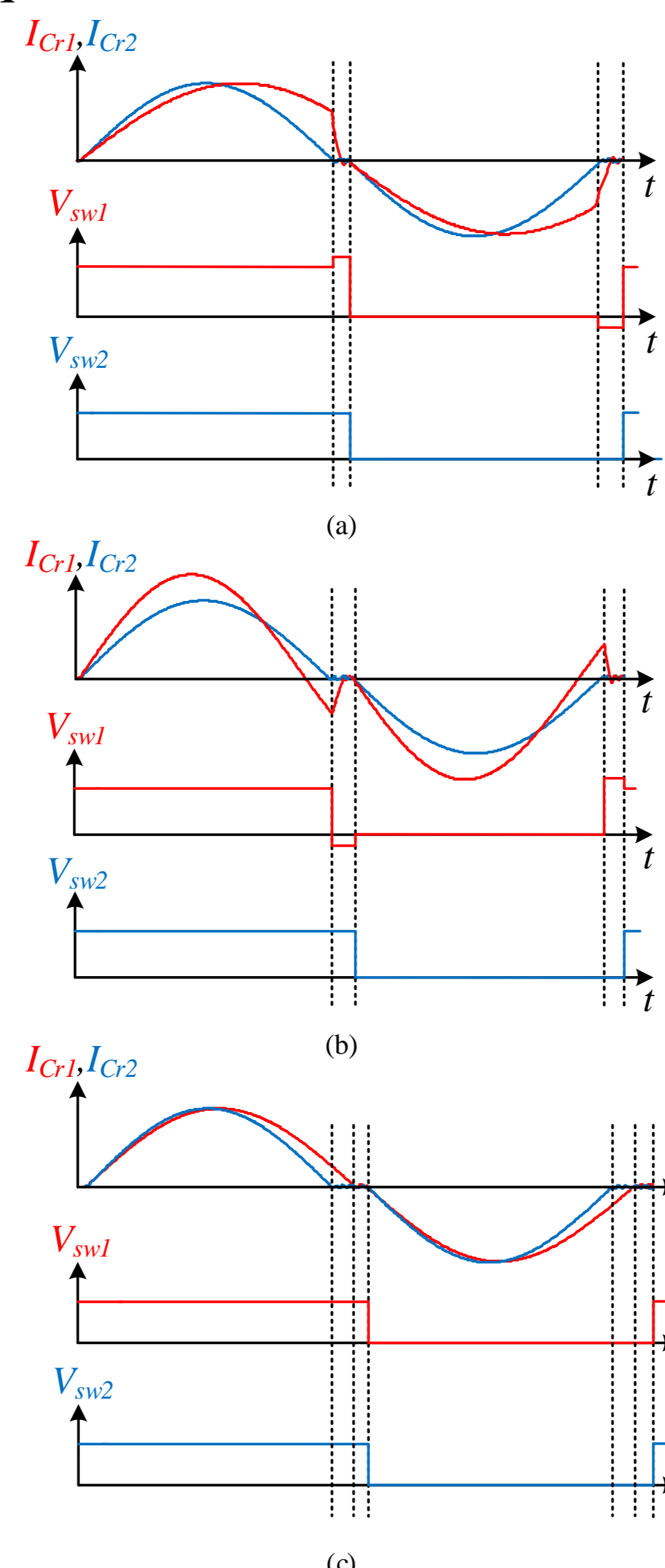


Simplified schematic diagram of a 4:1 STC with digital lock-in controller

#### STC Operation



Equivalent circuits of the 4:1 STC

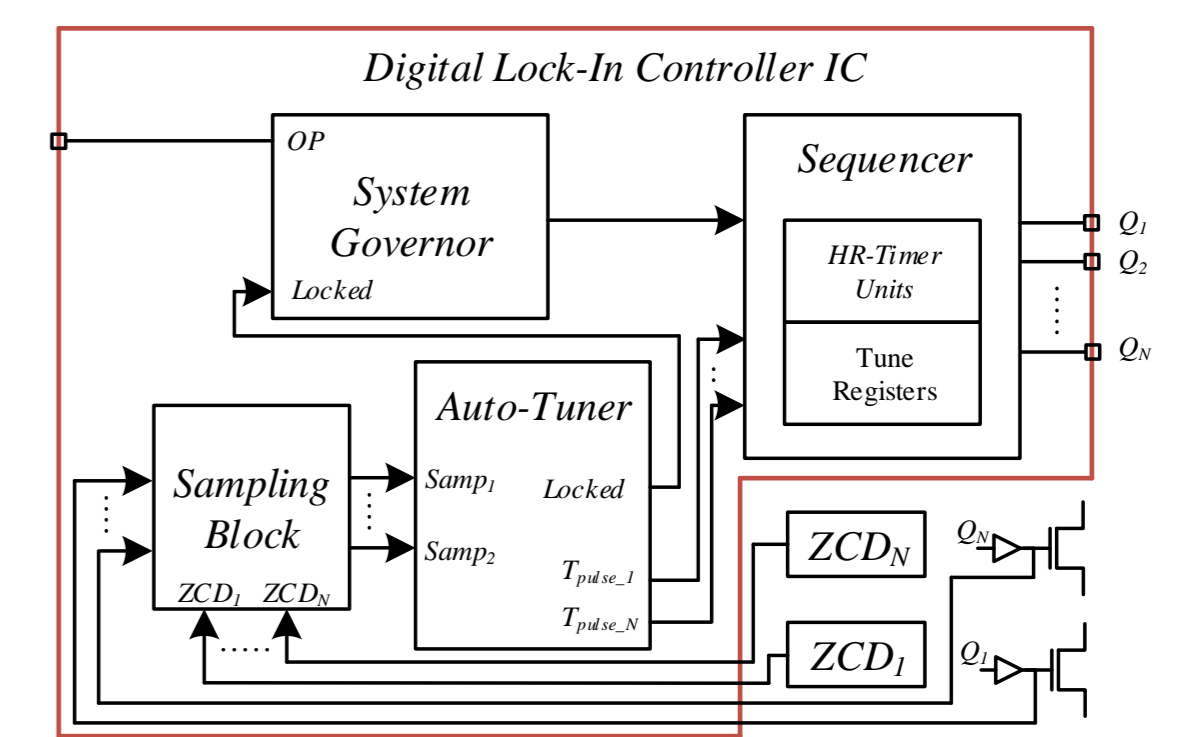


Mismatched resonators steady-state current waveform

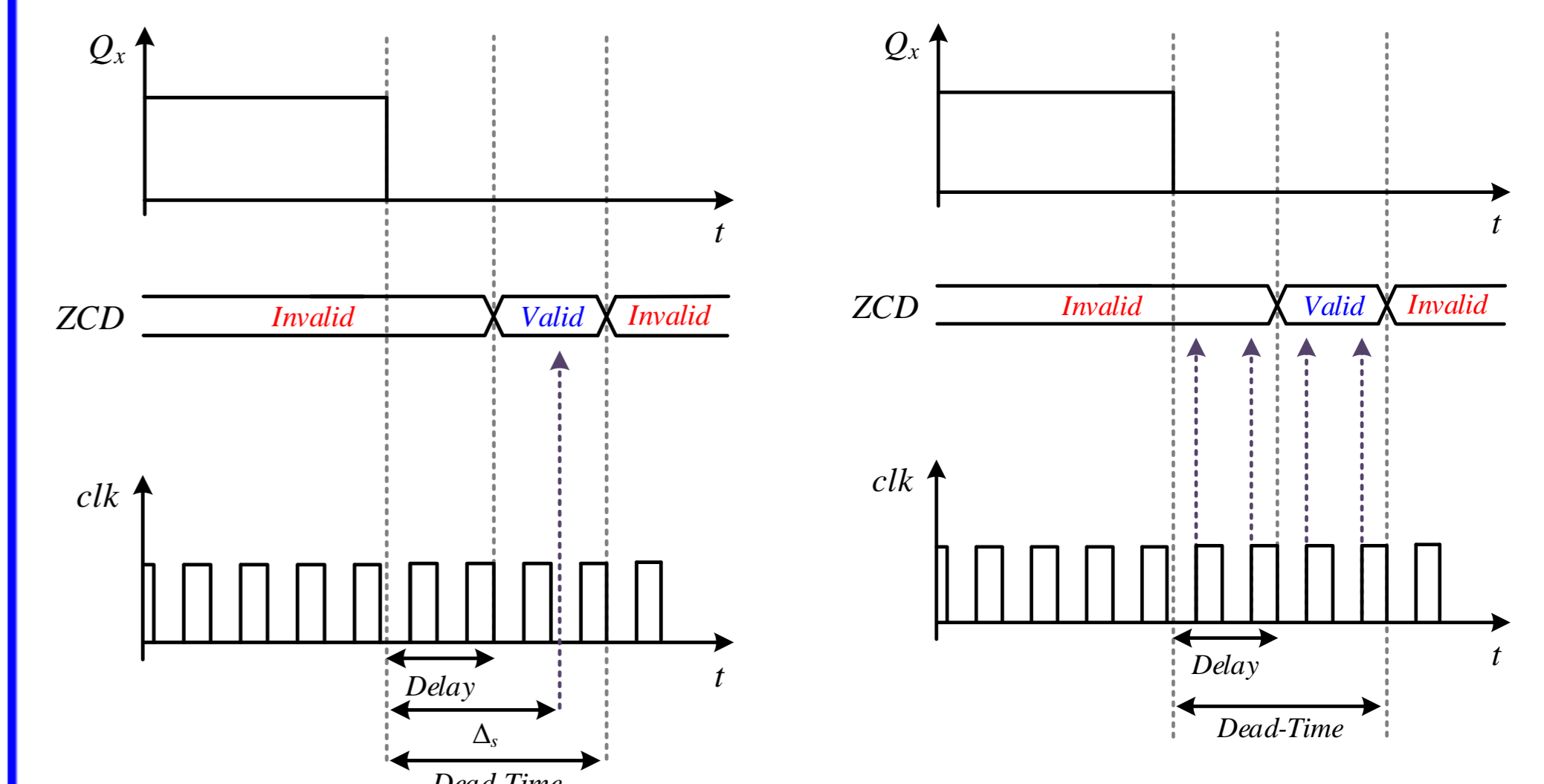
#### IC Controller

- Effective silicon area of 0.64mm<sup>2</sup>
- The IC has been designed and fabricated on a 0.18μm 5V process by pure digital means
- All synchronization and calculations are based on an internal 20MHz clock

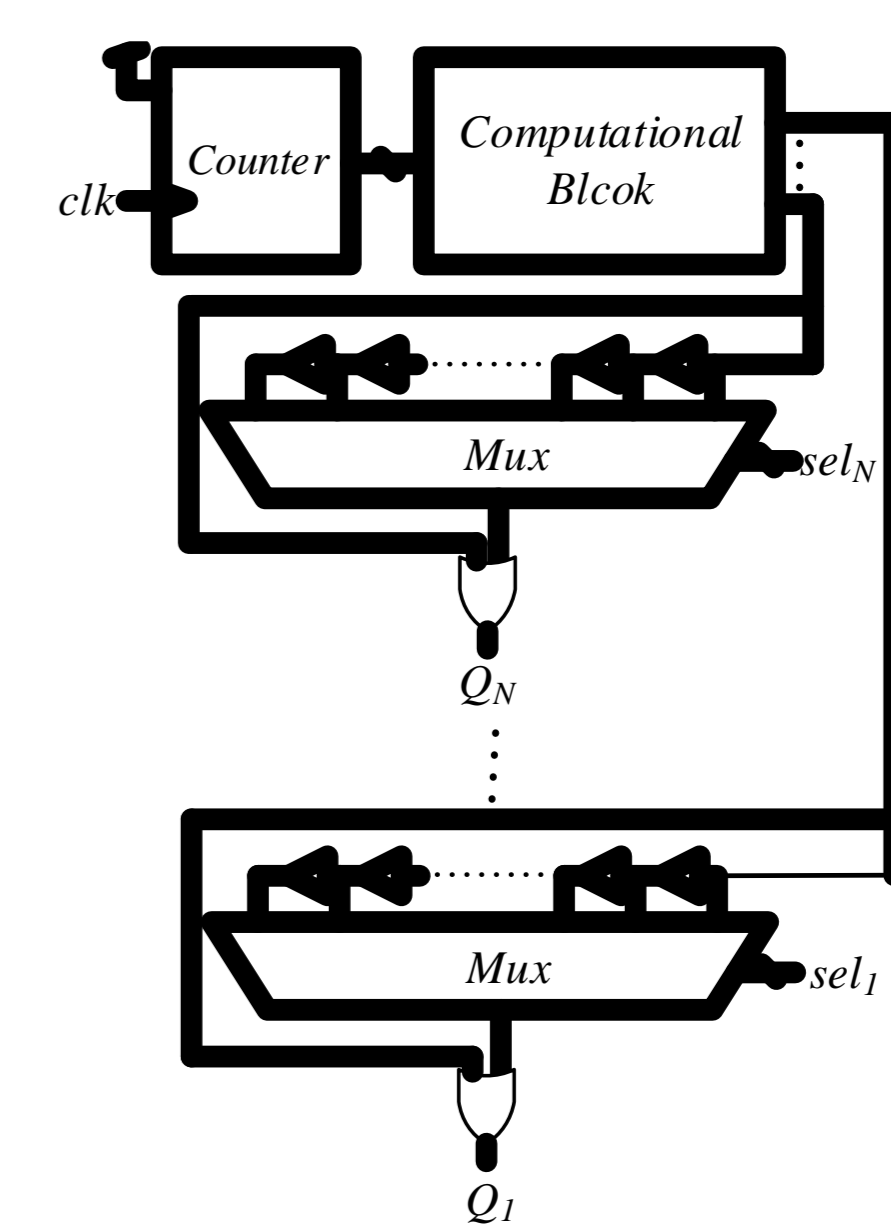
Block diagram of the auto-tuner module



Sensors' data acquisition procedures



Single delay element based drive circuitry



#### Experimental Verification

##### EXPERIMENTAL PROTOTYPE VALUES AND PARAMETERS

Component	Value
Input voltage $V_{in}$	48V
Output power	650W
Resonant capacitor $C_{r1}, C_{r2}$	2.35μF
Resonant inductor $L_{r1}, L_{r2}$	70nH
Flying capacitor $C_f$	40μF
$Q_1-Q_4$	40V/2.5mΩ
$Q_5-Q_{10}$	25V/1.3mΩ

