THE LPC84X MCU FAMILY – A ‘SWISS ARMY® KNIFE’ OFFERING OF FEATURES FOR YOUR NEXT IOT DESIGN

PART II

KEVIN TOWNSEND
BRENDON SLADE
ZELJKO STEFANOVIC

PUBLIC

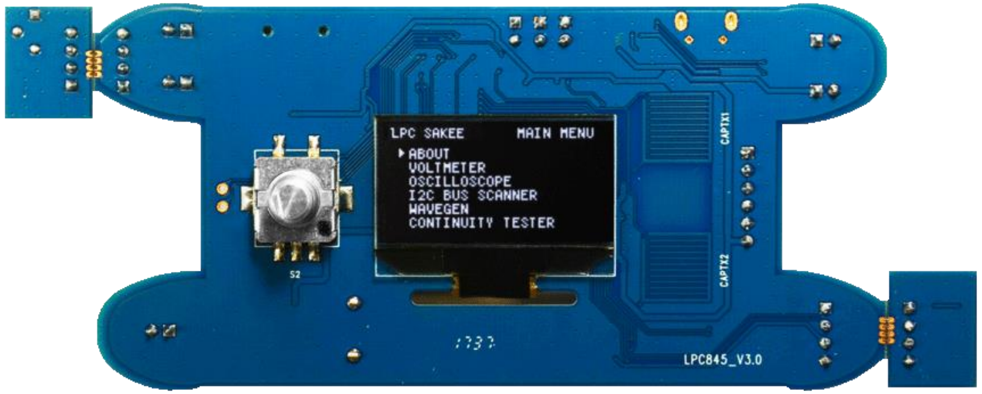
SECURE CONNECTIONS
FOR A SMARTER WORLD

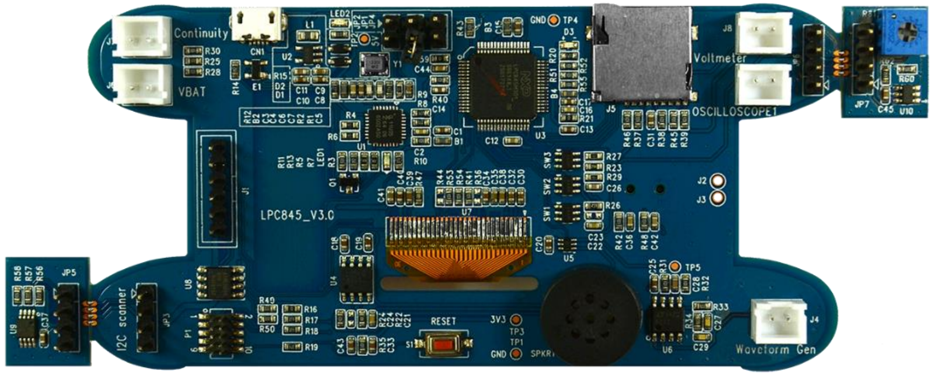
Agenda – Part II

- Brief recap of the LPC84x multi-tester "Swiss army knife" for EEs (SAKEE) project
- Quick review of LPC84x series from NXP
- Digital and HMI features:
  - Rotary encoder using SCT (quadrature decoder)
  - I^2C bus scanner
  - SPI OLED display
  - Capacitive touch vs GPIO buttons
- What's coming in the final webinar

Overview of Swiss Army Knife for EEs project

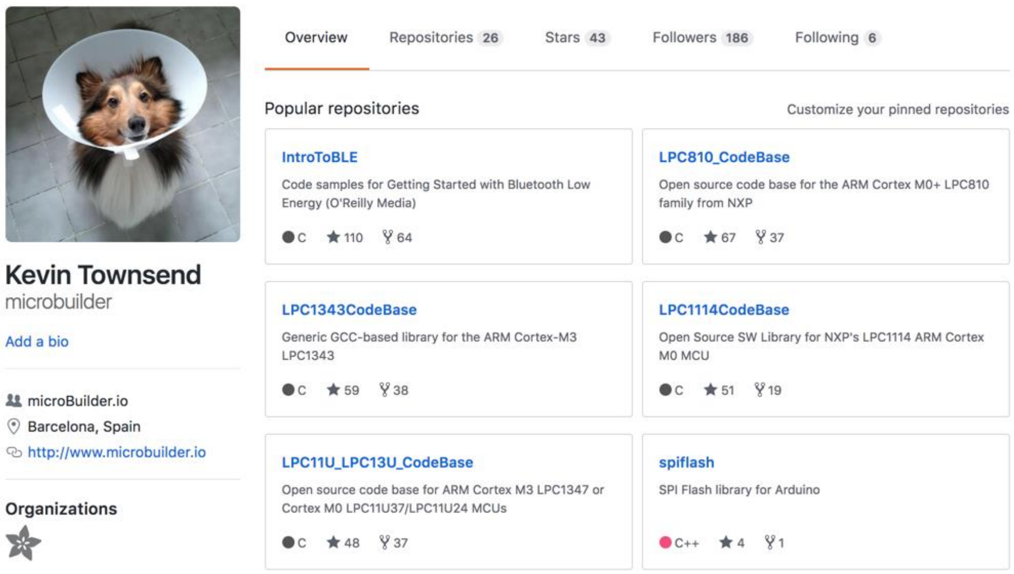
- Project aims
  - Develop a handy tool for basic testing tasks EEs frequently need to accomplish
  - Design a platform that can be easily customized and extended for specific testing tasks
  - Showcase how to use the main features of the highly flexible LPC845
  - Provide open source hardware and software to the LPC community of users for easy access to the design



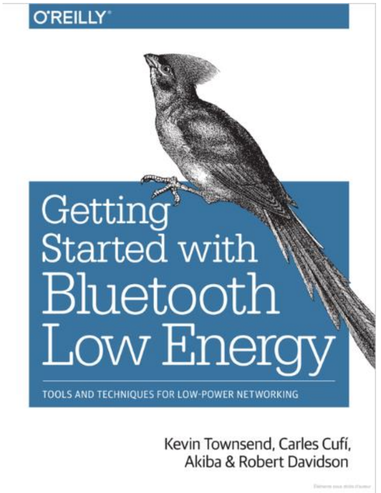


Kevin Townsend

- Lead Engineer at Adafruit Industries
- Cortex-M user since the first commercially available M0 device (the LPC1114 in 2009)
- Published some of the earliest open source Cortex-M codebases for the LPC800, LPC1100, and LPC1300 families
- Many area of interest is extremely low cost 32-bit MCUs and RF solutions



www.github.com/microbuilder



THE LPC84X MCU FAMILY

LPC 32-bit Microcontrollers for the Mass Market

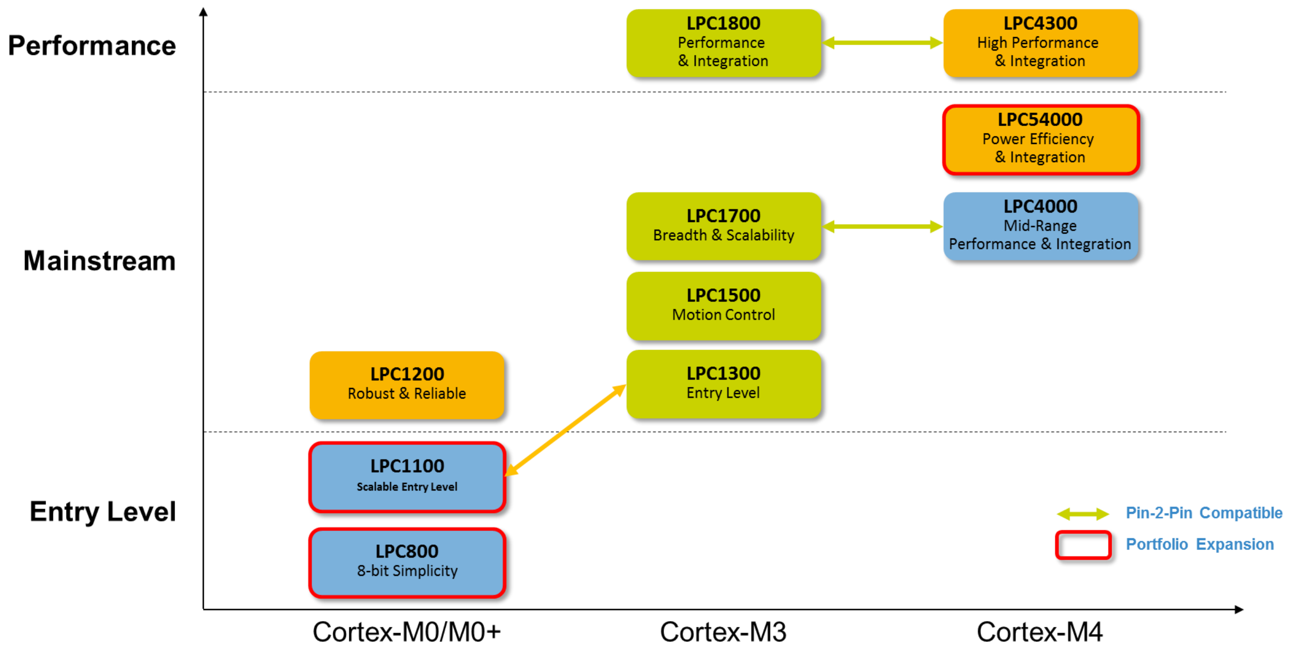
- Over 1B units shipped
- >400 part numbers
- Thriving ecosystem
- Complementary professional development suite (HW/SW)

Open Development Environment

- MCUXpresso IDE with Easy to Use Software Code Bundles
- Development, Debug & Expansion Boards
- Developer Community

Easy Development

Complete Portfolio of Cortex-M MCUs



Scalable Expansion

LPC84x Part of NXP's Rapid Expansion of the LPC800 Series

Expansion

2017 Q3 — **LPC845** 64K Flash, 16K RAM

More memory
Feature upgrade: *FRO*
New features: *FAIM, 2x DAC, Cap Touch*
More packages: *48-pin, 64-pin*

2017 Q3 — **LPC844** 64K Flash, 8K RAM

More memory
Feature upgrade: *FRO*
New features: *FAIM*
More packages: *48-pin, 64-pin*

Compact

LPC824 32K Flash, 8K RAM → 2018 Q1 — **LPC804** 32K EEPROM, 4K RAM

Page Flash
Feature upgrade: *FRO*
New features: *DAC, Cap Touch, PLU*
Level shifter option

Compact

LPC822 16K Flash, 4K RAM → 2017 Q4 — **LPC802** 16K EEPROM, 2K RAM

Page Flash
Feature upgrade: *FRO*
Level shifter option

LPC812 16K Flash, 4K RAM

LPC811 8K Flash, 2K RAM

Production

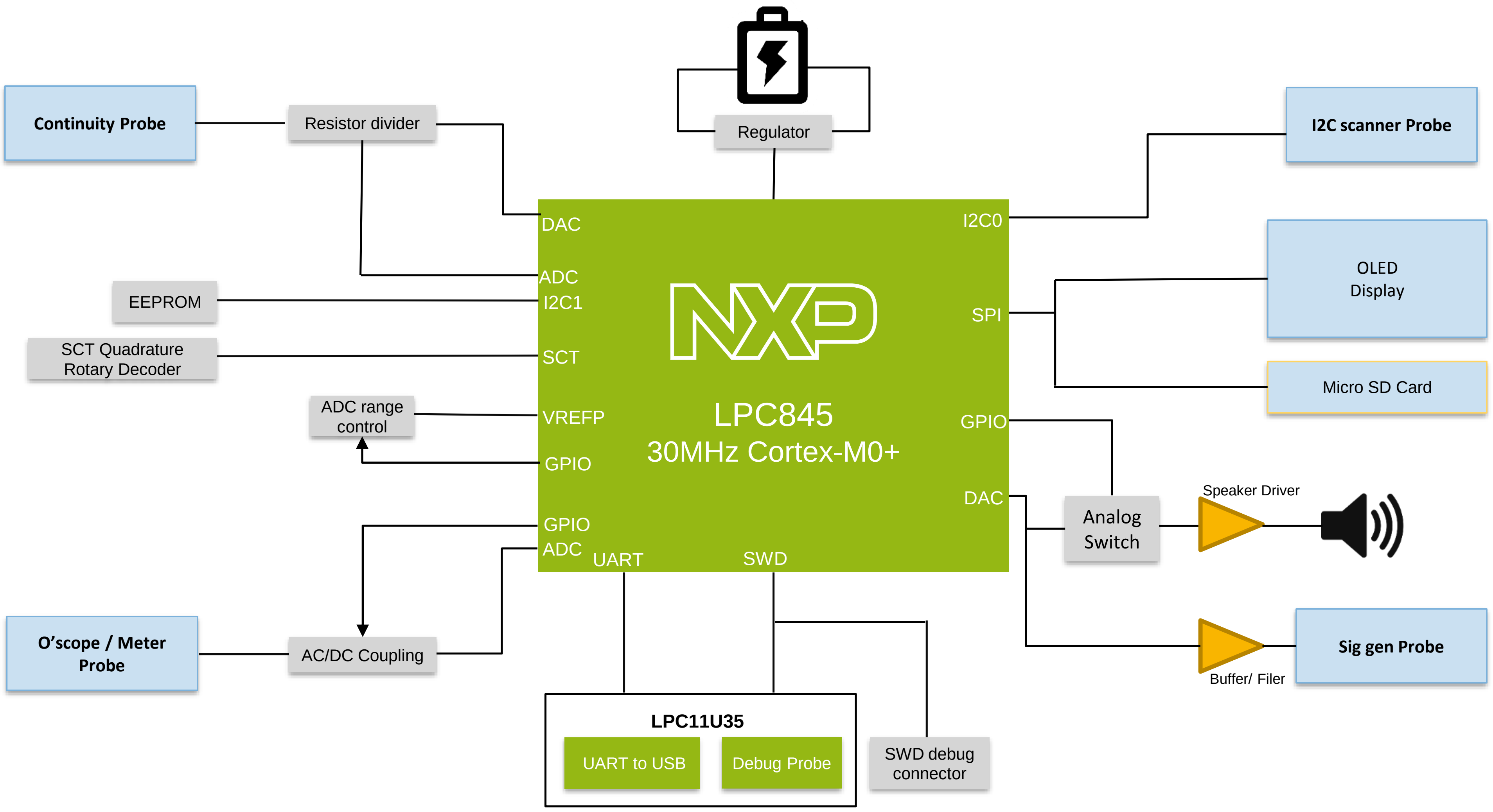
2017 Roadmap

LPC800 Series of Scalable MCUs

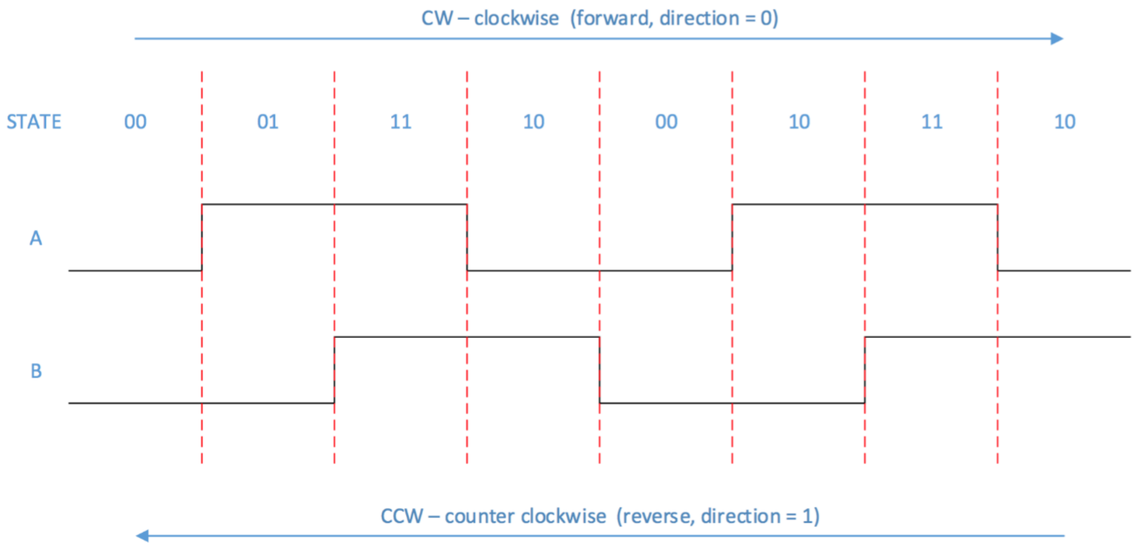
- Addressing the market's transition from 8- to 32-bit
- Providing differentiated features at a low-price
- Offering power-efficient performance
- Simple SW Code Bundles & ROM drivers

SAKEE MULTI-TOOL REVIEW

Block diagram



SCT Quadrature/Rotary Decoder



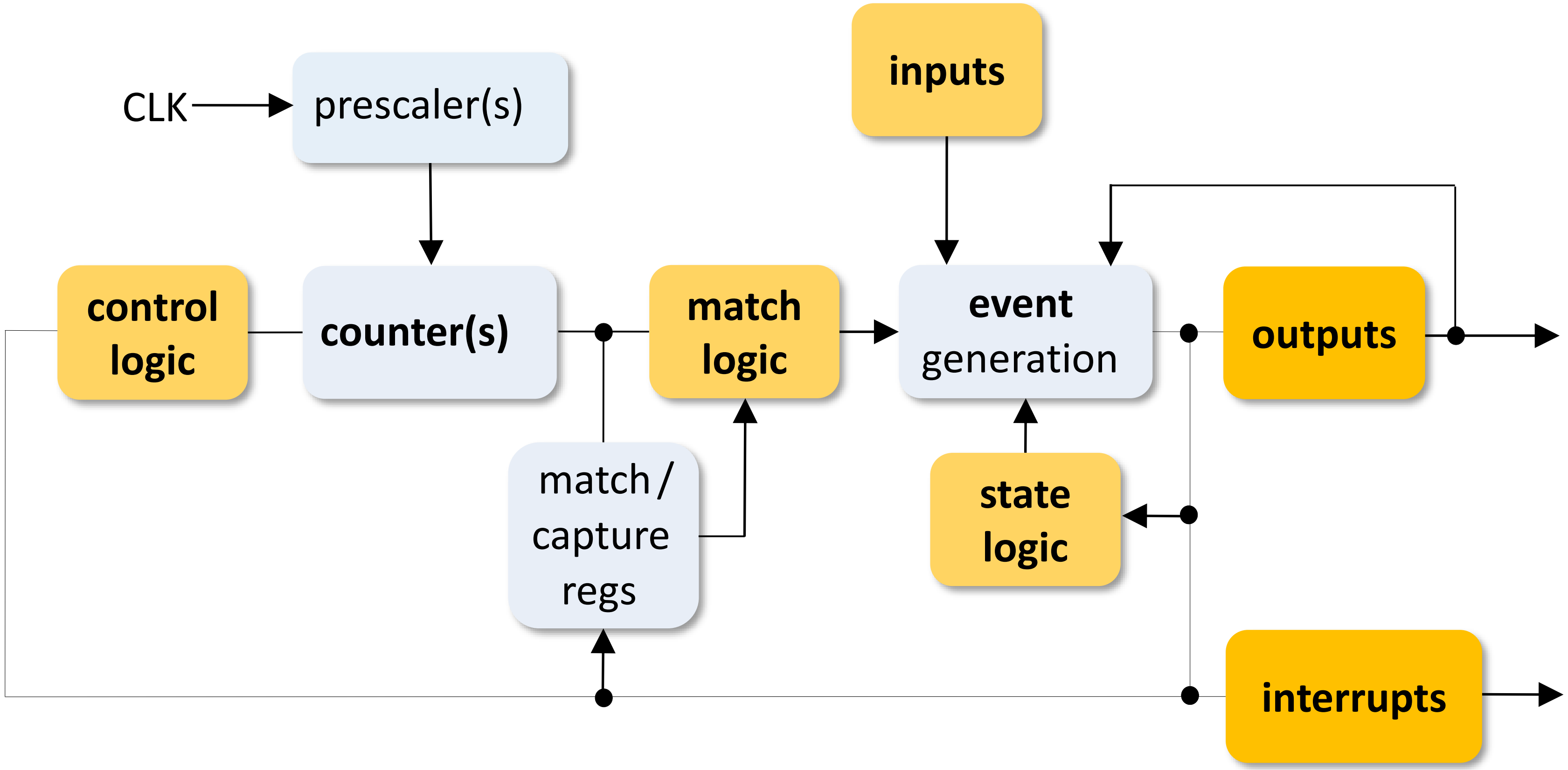
- Rotary encoder provides flexible user input with a single knob (forward, backward, select)
- Common feedback mechanism (easy to source, thousands of variants available)
- Cumbersome to implement reliably using standard GPIO
- SAKEE uses the State Configurable Timer (SCT) to track the state and direction of the quadrature rotary encoder
- Offloads most of the timing sensitive quadrature decoding to HW and ISR
- Simplifies ISR code significantly

SCT ISR

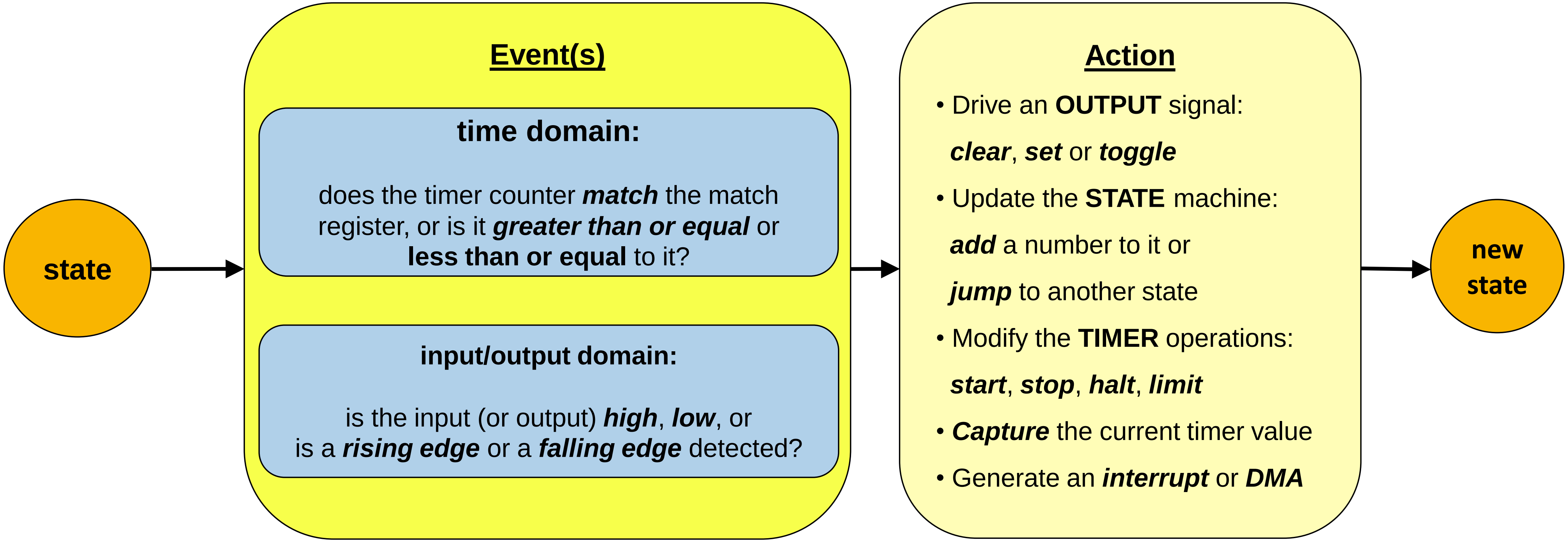
```
void SCT_IRQHandler(void)
{
        LPC_SCT0->EVFLAG = 0x000000FF;    // Clear all event flags

        // Update relative step counter based on the direction
        if ((LPC_SCT0->OUTPUT & (1 << sct_out_qei_direction)) == 0)
        {
                _qei_step++;     //CW direction
        }
        else
        {
                _qei_step--;     //CCW direction
        }

        return;
}
```

The State Configurable Timer (SCT)

- The SCT is a timer/capture unit coupled with a highly flexible event driven state machine block.
- Can be configured as 32-bit counter or two 16-bit counters with – another NEW!

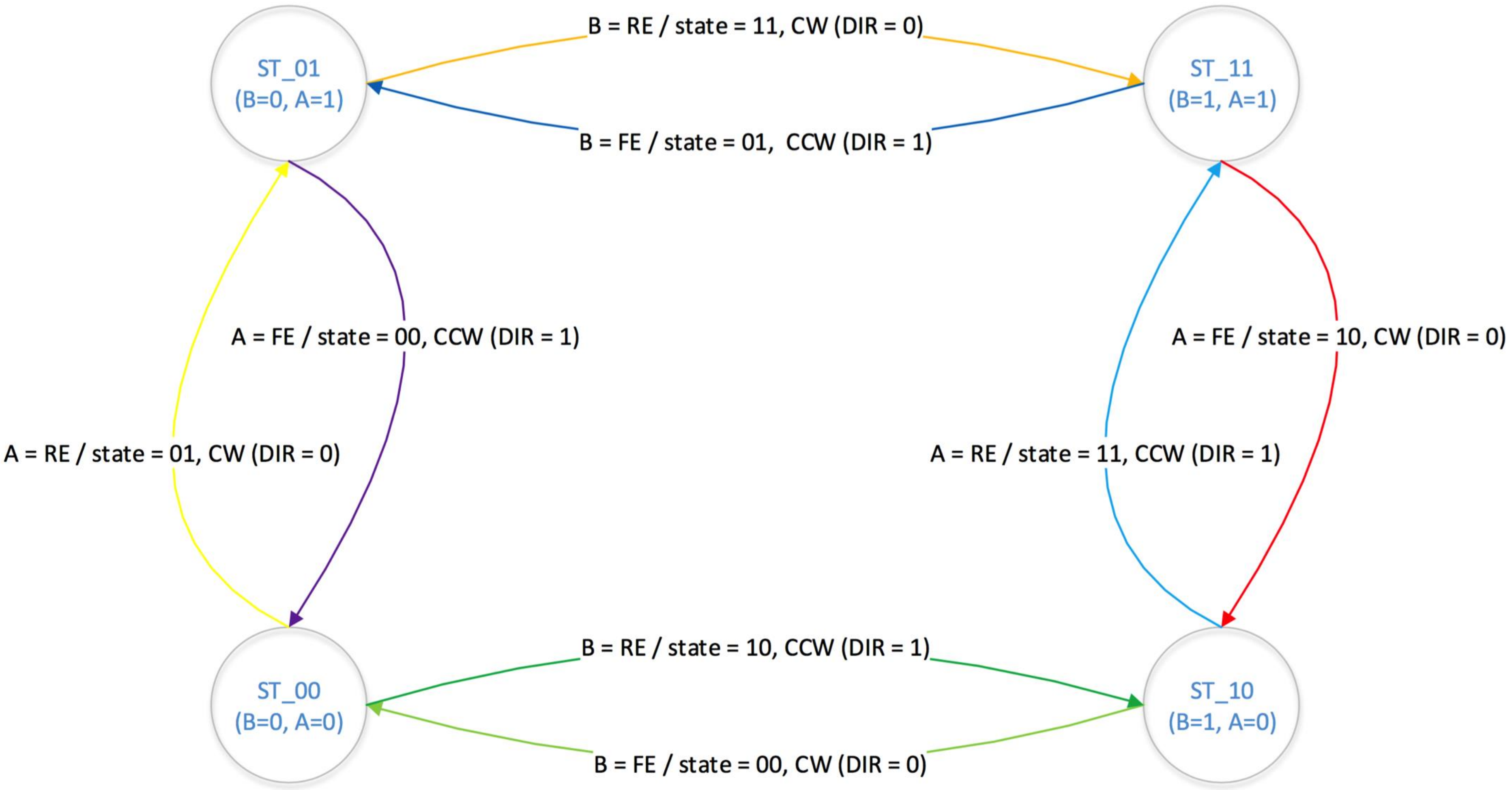


How does the SCT work?

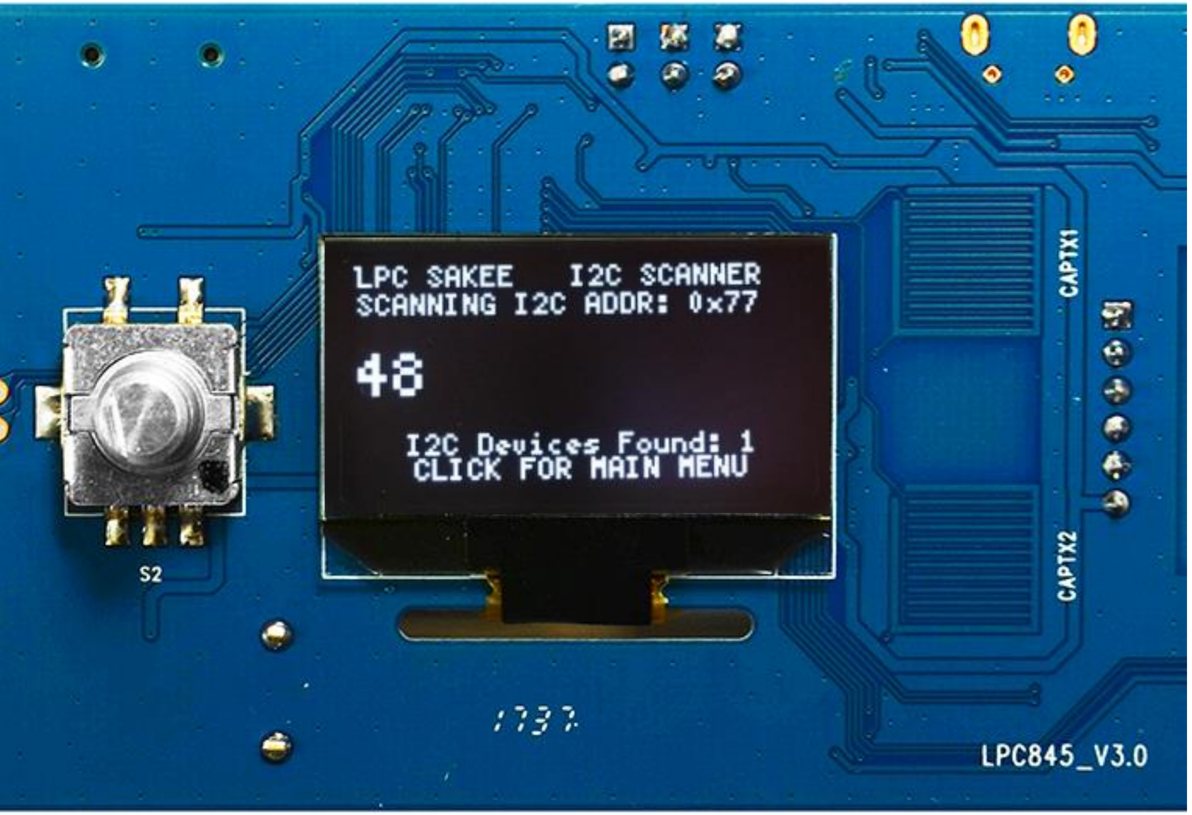


an event chooses no more than one element per domain; the event can be sourced from either of the domains or it can combine both of them by using logical operations AND and OR

SCT Quadrature/Rotary Decoder Implementation



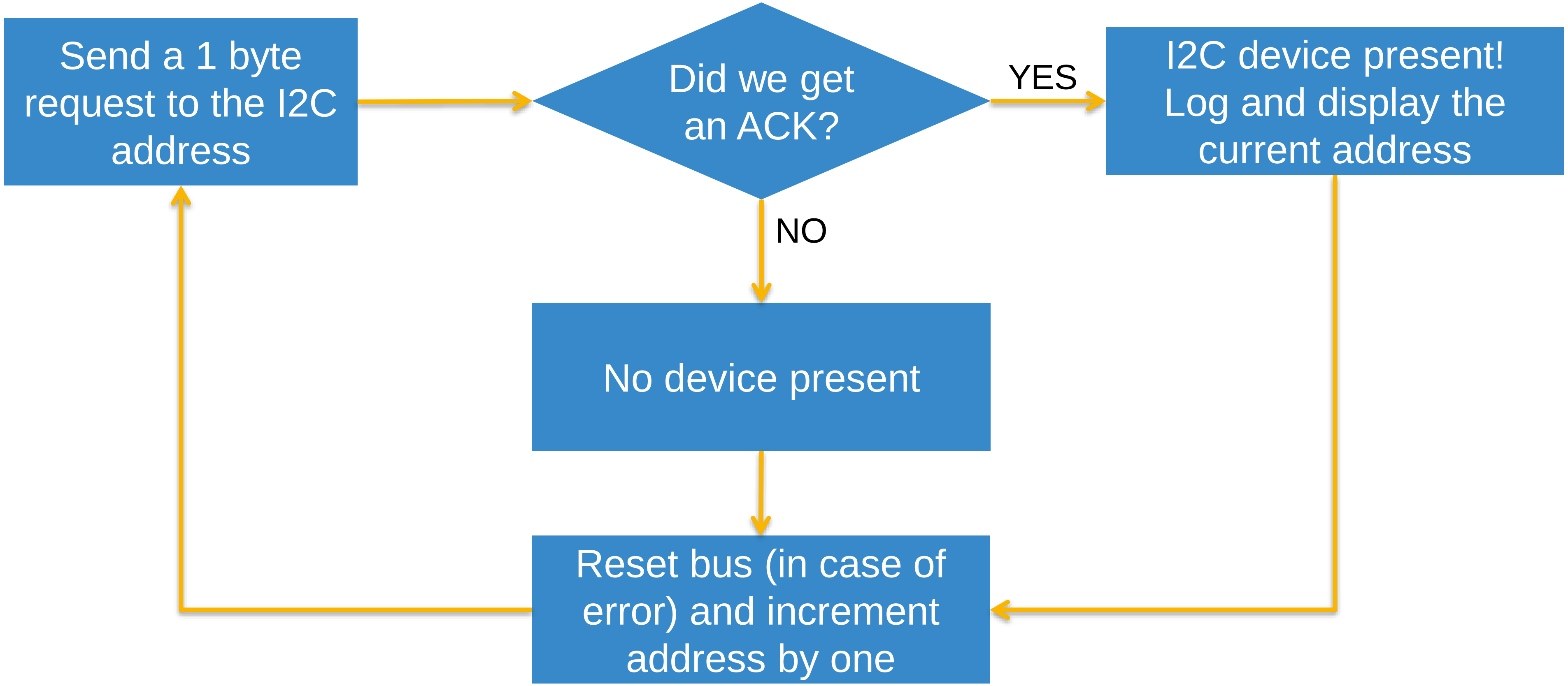
Feature: I2C bus scanner



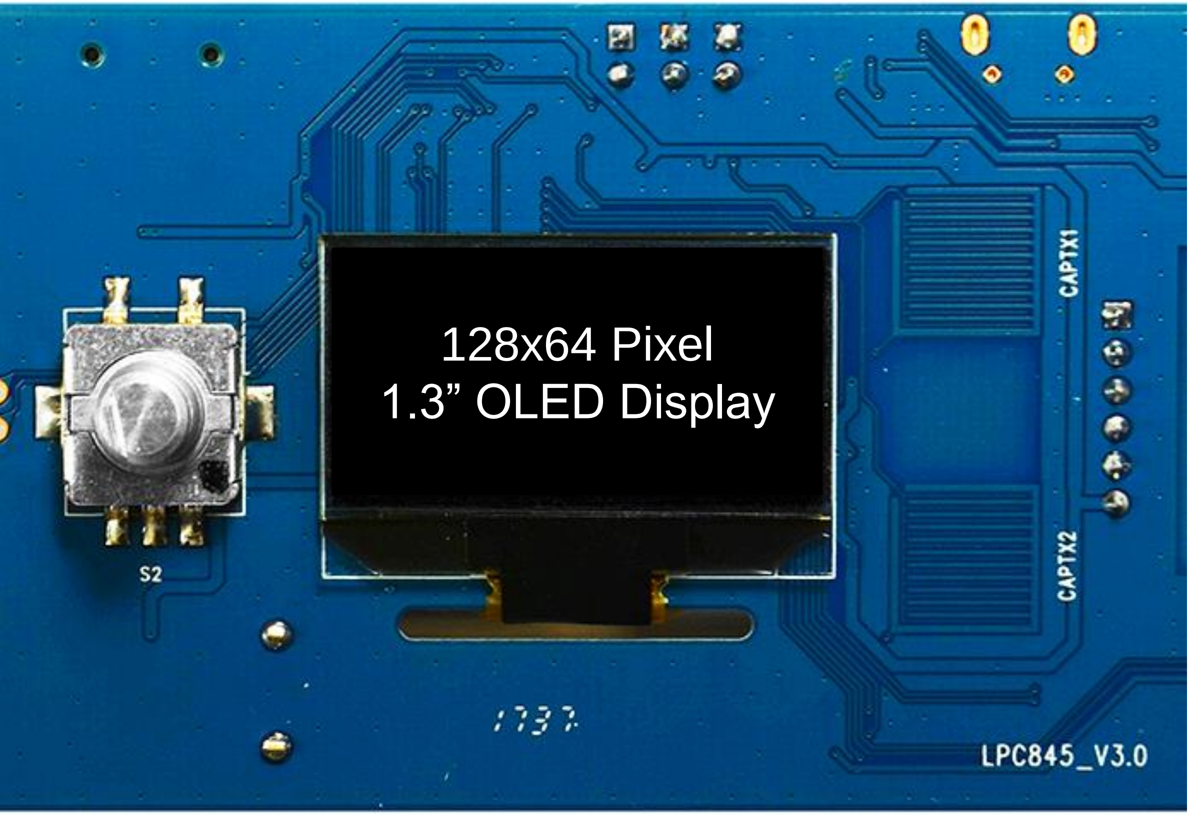
- Provides quick and easy sanity check that I^2C devices are “alive”
- Ideal for basic check of sensor boards
- Scan entire 127 device address range and reports all correctly responding devices
- Works by sending a request, waits for an ACK on bus to indicate a match

- LPC845 features used:
  - I^2C Master interface
  - SPI (display)
  - SCT (rotary encoder)

I2C Scanner Functionality



Feature: SPI OLED Display



- Inexpensive ($2-4), low pin count and highly readable display option
- Widely available in I2C or SPI and 128x32 or 128x64 pixel variants
- Can be driven at high speed via SPI, or with very low pin count via I2C

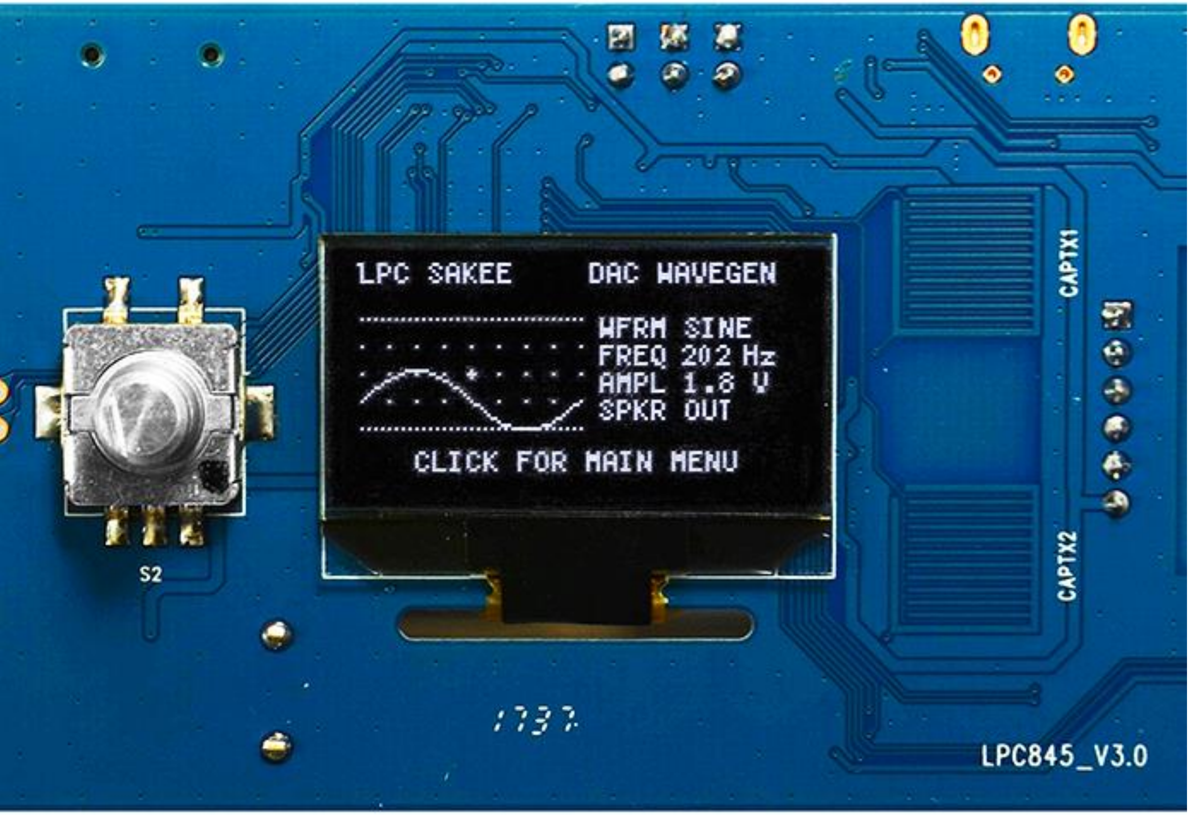
- LPC845 features used:
  - SPI
  - I^2C (Optionally)

I2C versus SPI for OLED

	I2C Bus		SPI Bus
Pros	• Low pin count (SCL+SDA) • Multiple devices on a single two-pin bus	**Pros**	• Higher throughput (10's of MHz, much better refresh rate) • Multiple voltage levels possible
Cons	• Relatively slow (can be faster, but generally 400kHz) • All devices on bus pulled up to same logic level	**Cons**	• More pins (3 + 1 per device) • Can become complex to manage with multiple devices on the bus since there are four distinct SPI 'modes'

We started the design with I2C for convenience, but ended up moving to SPI for flexibility to enable high refresh rates if the need arises later, such as life streaming analog waveform Inputs directly to the OLED display.

Feature: Capacitive Touch



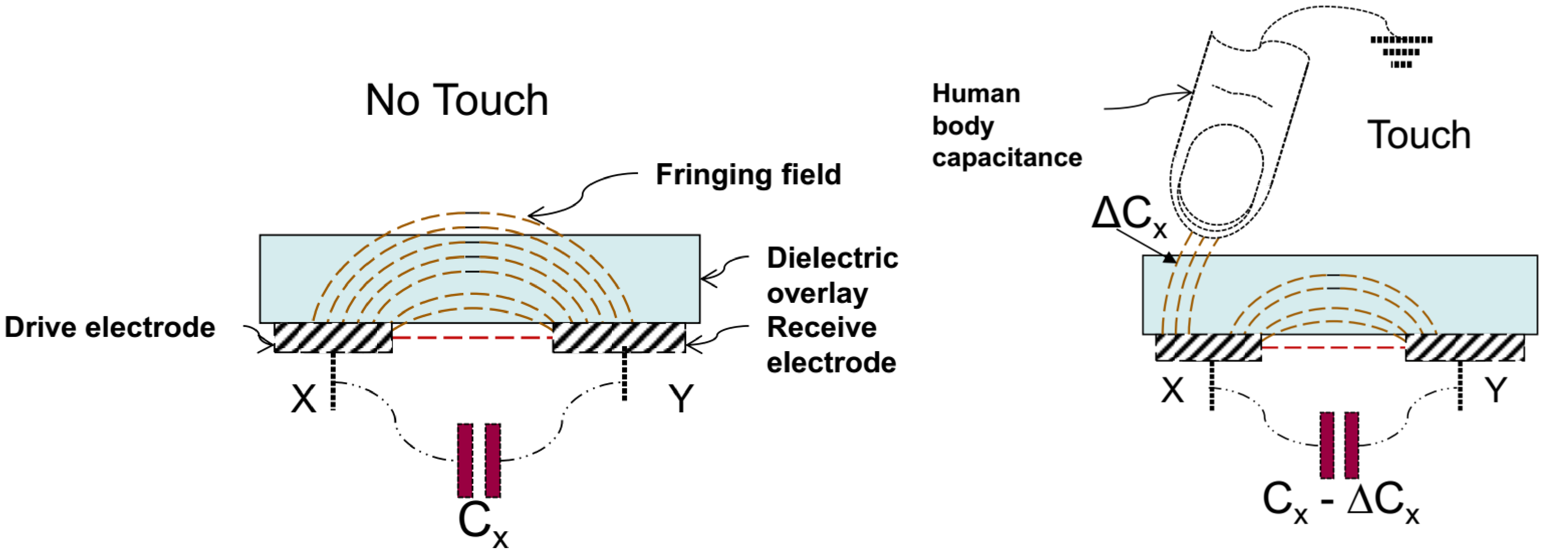
- Two capacitive touch buttons available for user feedback
- Can be used to feedback on sealed devices
- Numerous pad sizes and configurations possible

- LPC845 features used:
  - Capacitive touch

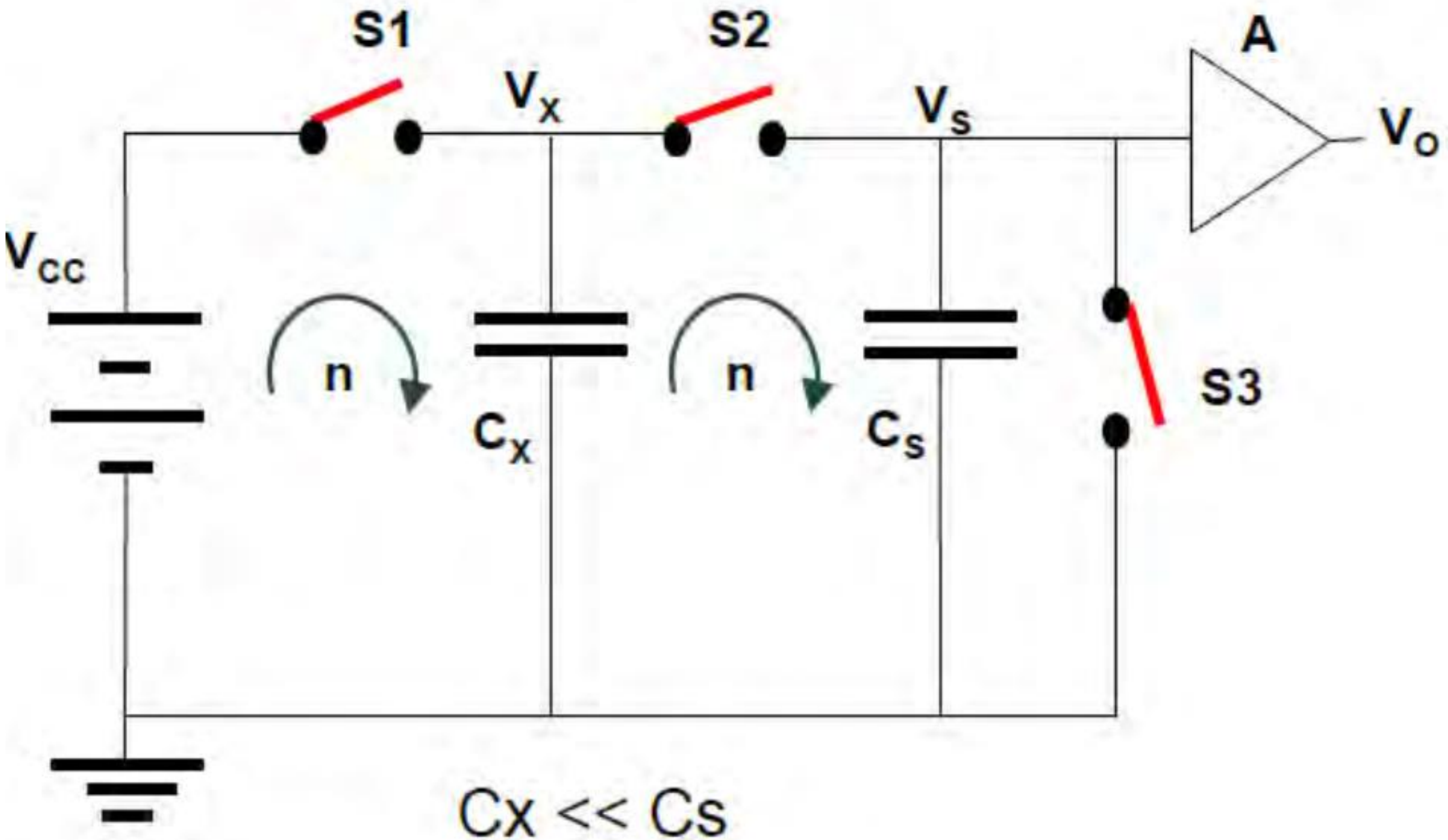
Capacitive Touch versus GPIO

	Capacitive Touch		GPIO/Tact Buttons
Pros	• Can be used in sealed devices, behind glass or plastic (medical, complex UIs) • Button shape is highly configurable • Extremely low cost (essentially free)	Pros	• Easy to implement, very low overhead • Physical feedback (tangible click and contact) • Wide range of makes and models • Responsive even under repetitive use
Cons	• ISR++: Heavier workload to process events, filter and continuously auto-calibrate • Can struggle with multiple repetitive taps in short duration	Cons	• Additional assembly and part cost • Sourcing/Availability issues for non-standard footprints • Can wear out over time, prone to physical failure

Mutual capacitance Touch Sensor



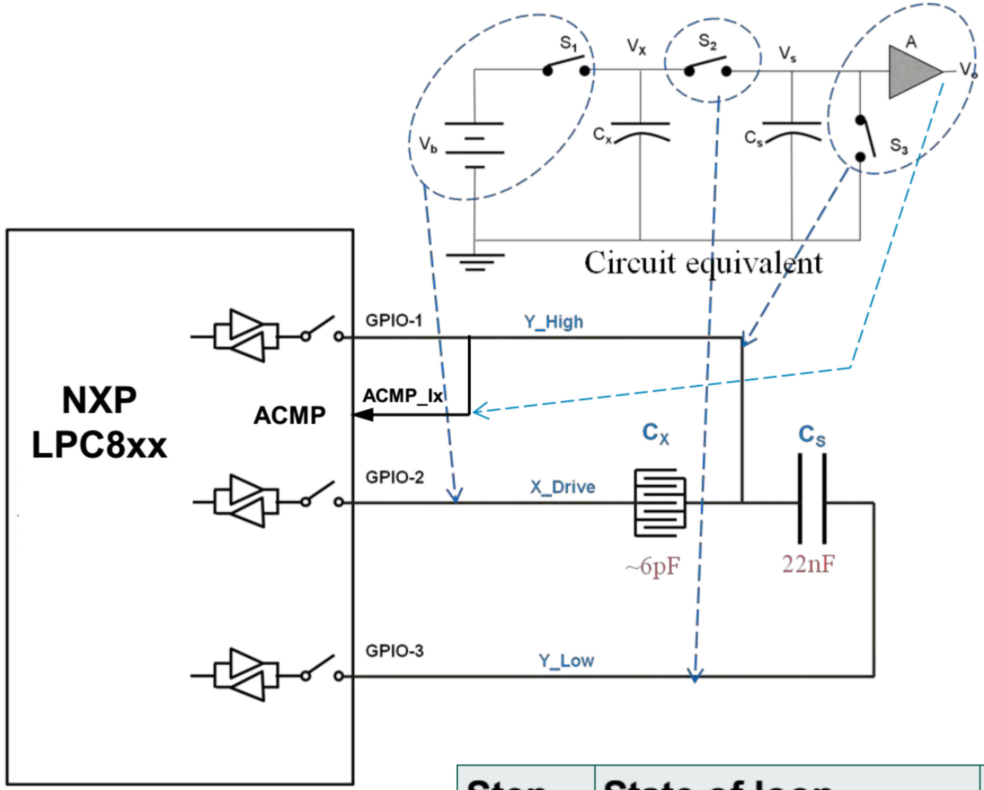
Touch Sensing Mechanism



Cx << Cs

n charge cycles

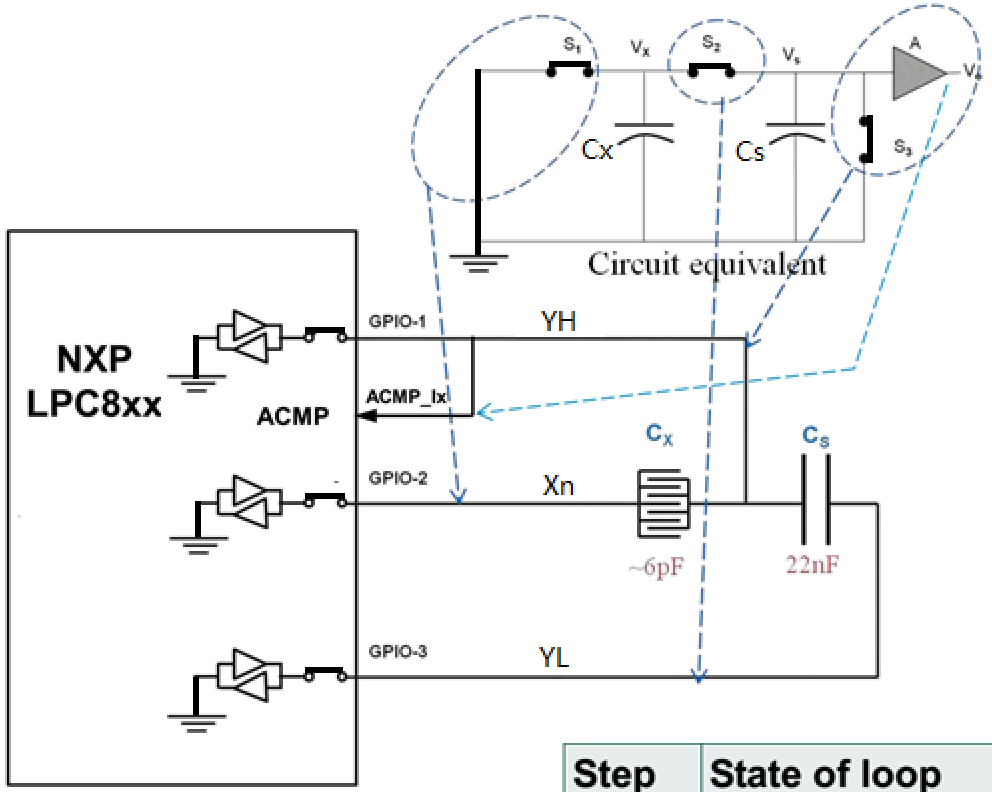
Touch Sensing Circuit



- The LPC845 capacitive touch interface implements a state machine with 4 steps:
  - 0. Reset
  - 1. Charge Cx
  - 2. Transfer charge to Cs
  - 3. Measure voltage
- Repeat steps 0 thru 2 until the ACMP (or YH port pin) reaches threshold or the block times out (too many iterations). Upon completion, returns to Step 0 before any new measurements will be taken.

Step	State of loop	Active X	YH	YL	ACMP	Other X
0	Reset / Draining Cap	L	L	L	Don't care	L
1	Charge X	H	H	High-Z	Input	High-Z
2	Transfer charge to Y	H	High-Z	L	Input	High-Z
3	Measure Voltage	L	High-Z	High-Z	Input	High-Z

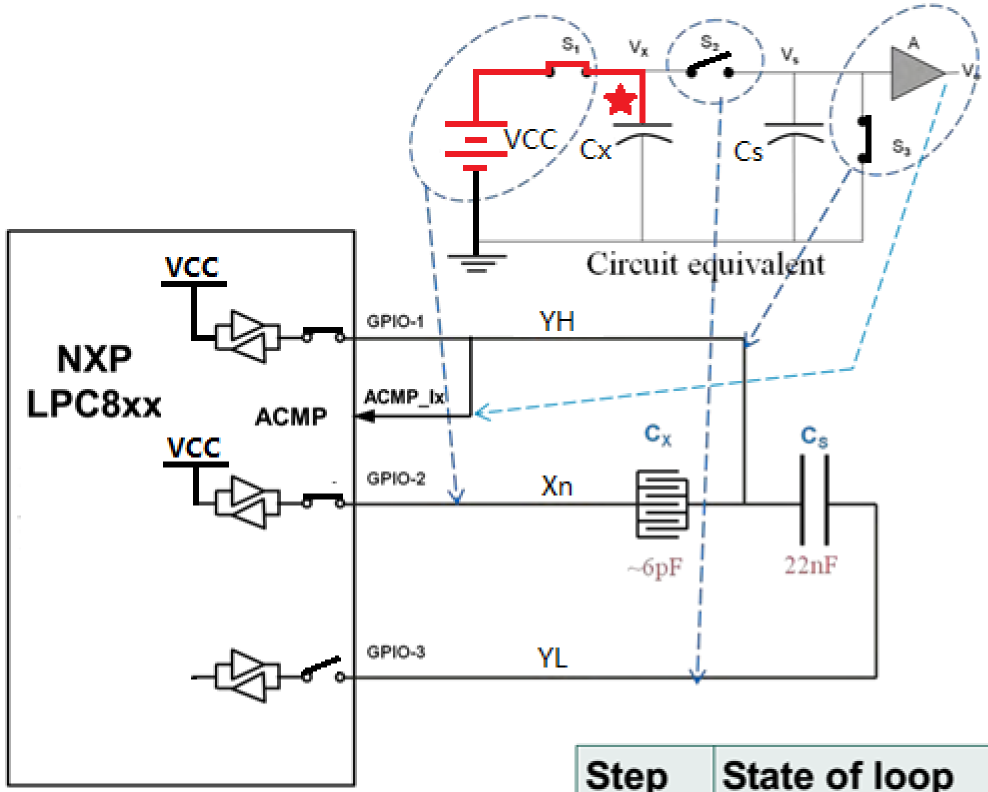
Touch Sensing Circuit



- Step 0: Reset
- Step 1: Charge X
- Step 2: Transfer charge to Y
- Step 3: Measure Voltage

Step	State of loop	Active X	YH	YL	ACMP
0	Reset / Draining Cap	L	L	L	Don't care

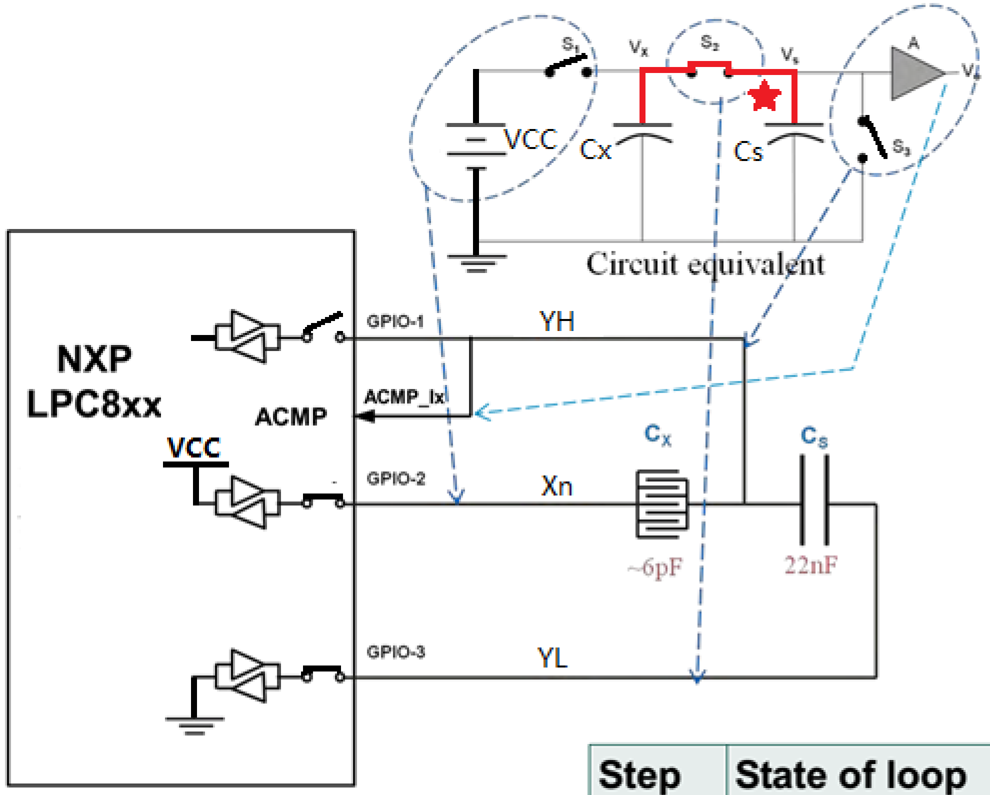
Touch Sensing Circuit



- Step 0: Reset
- Step 1: Charge X
- Step 2: Transfer charge to Y
- Step 3: Measure Voltage

Step	State of loop	Active X	YH	YL	ACMP
1	Charge X	H	H	High-Z	Input

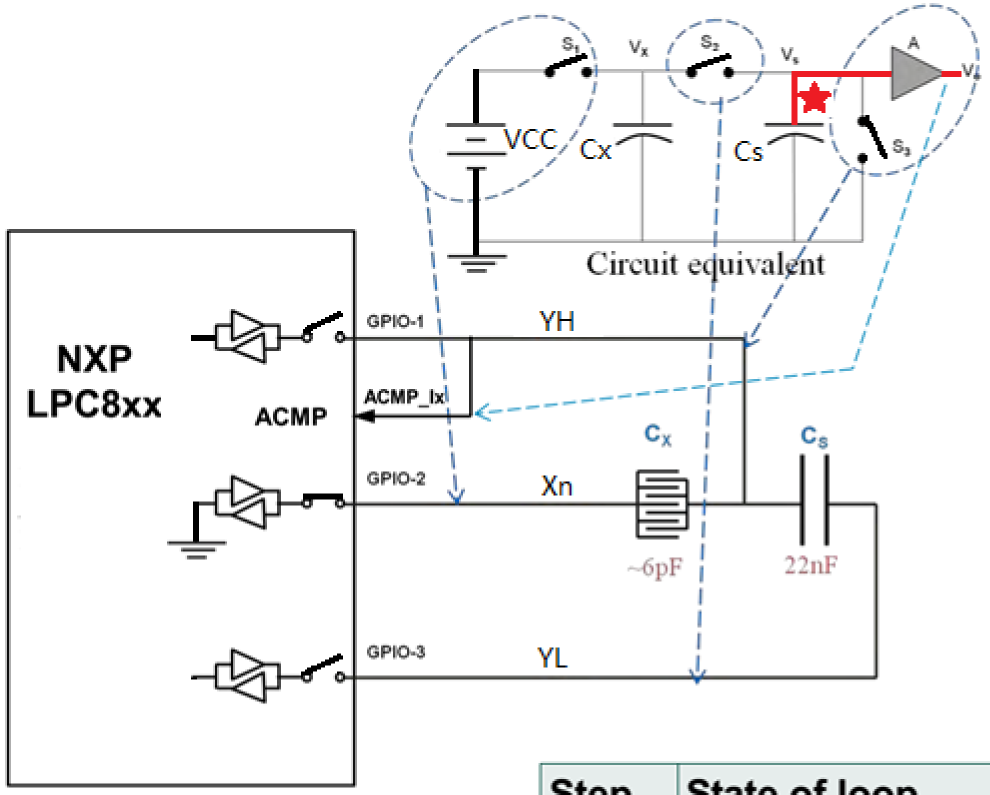
Touch Sensing Circuit



- Step 0: Reset
- Step 1: Charge X
- Step 2: Transfer charge to Y
- Step 3: Measure Voltage

Step	State of loop	Active X	YH	YL	ACMP
2	Transfer charge to Y	H	High-Z	L	Input

Touch Sensing Circuit

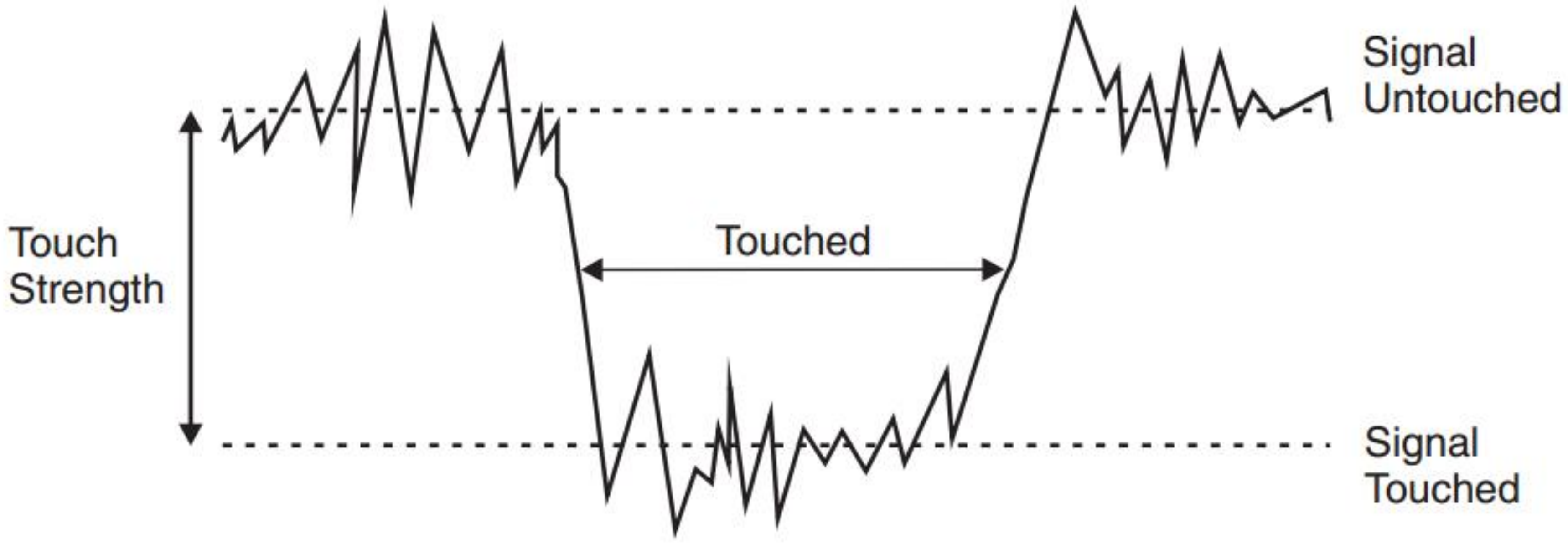


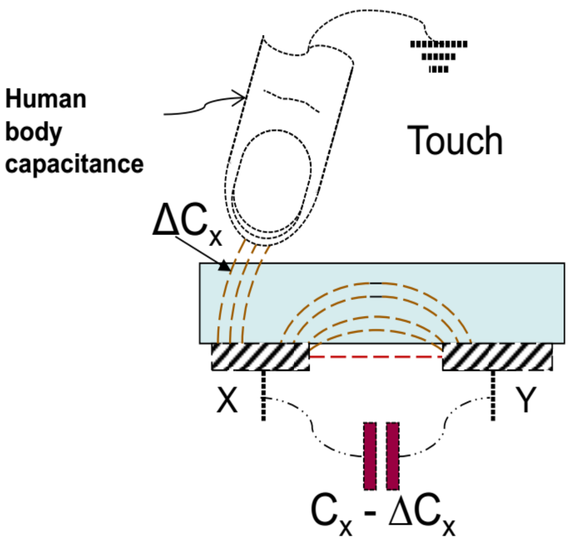
- Step 0: Reset
- Step 1: Charge X
- Step 2: Transfer charge to Y
- Step 3: Measure Voltage

Step	State of loop	Active X	YH	YL	ACMP
3	Measure Voltage	L	High-Z	High-Z[2]	Input

Sensing the Touch Value

- Once the sensor is touched, the Cx’s capacitance is changed; accordingly, the count of Cx charge cycles change
- The count of Cx charge cycles can then be used to evaluate the capacitance of Cx





Other platform features of note

- LPC11U35 is used to implement a CMSIS-DAP debug probe and UART bridge
- Hardware features available for future enhancement:
  - LPC845 FAIM: automatic, power-up time configuration of I/Os
  - Micro SD card slot
  - Capacitive touch buttons
  - NTAG I2C antenna connection
  - ADC voltage range control

In the final webinar of this series

- Part III - Take advantage of the rich ecosystem of enablement for LPC84x MCUs

  November 9th

  – How SAKEE was developed
    - MCUXpresso IDE and Code Bundles: live walk through of getting started
    - Starting from the LPCXpresso boards to develop SAKEE
    - SAKEE code structure highlights

Where to find out more

- Visit Developer Resources > Reference Designs > LPC845 Based Swiss Army Knife Multi-tester
  - Direct URL: http://www.nxp.com/pages/:LPC845-Multi-Tester
- Kevin's Github (software) : www.github.com/microbuilder/LPC84x_SAKEE
- More information on LPC84x: https://www.nxp.com/lpc84x
- MCUXpresso IDE: https://www.nxp.com/mcuxpresso

Thanks for watching!

SECURE CONNECTIONS
FOR A SMARTER WORLD