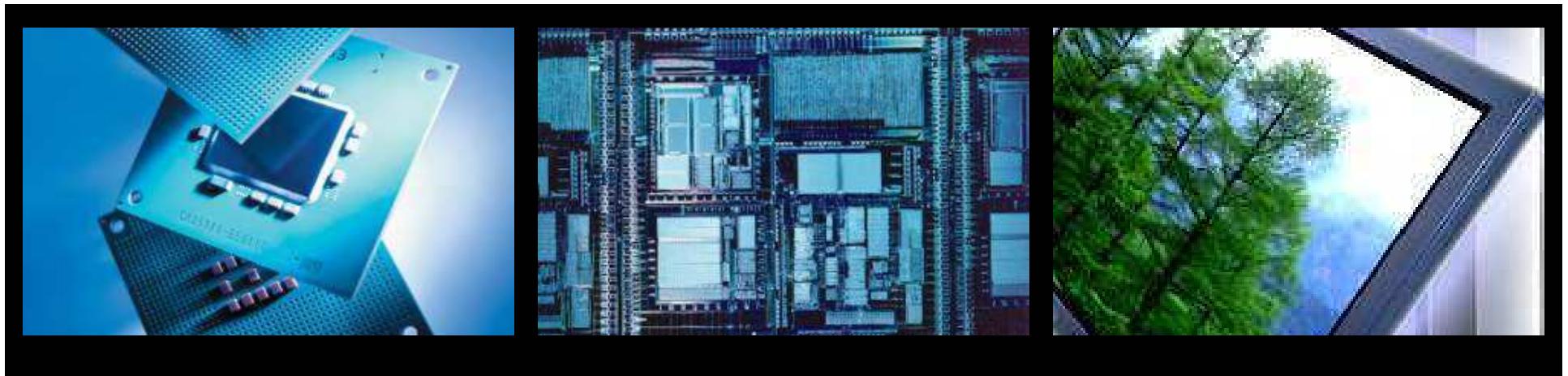




FUJITSU

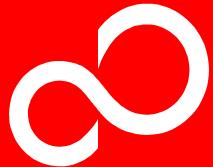
Touch Sensor Controller





Fujitsu and @lab Korea

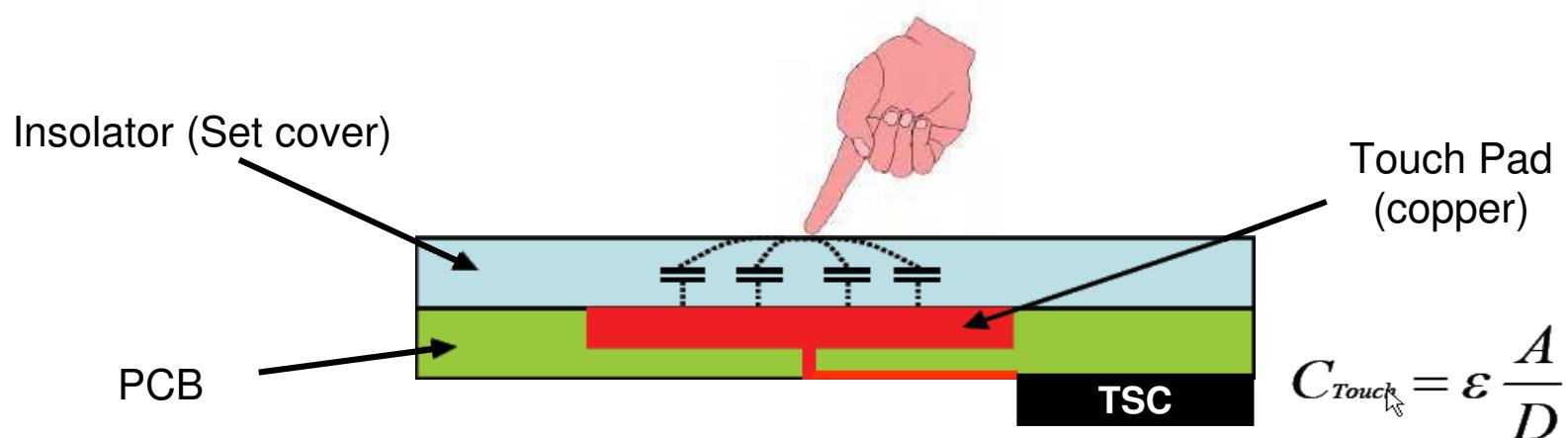
- ✓ @lab is a COT customer of Fujitsu Korea
- ✓ For digi-sensor product, Fujitsu has full worldwide cooperation with @lab
- ✓ In China, FMC has full distributor rights on promoting/selling @lab products
- ✓ In S.E.A (including TW & Australian), FMAL has full distributor rights on promoting/selling @lab products
- ✓ In North America, FMA has full distributor rights on promoting/selling @lab products
- ✓ @lab will not sell the product directly, but only through distributor channels
- ✓ Fujitsu MCU products + @lab Digi-sensor for various applicable solutions



Touch Sensing – a revolution

■ Touch Sensing – a revolution in Human Input Device

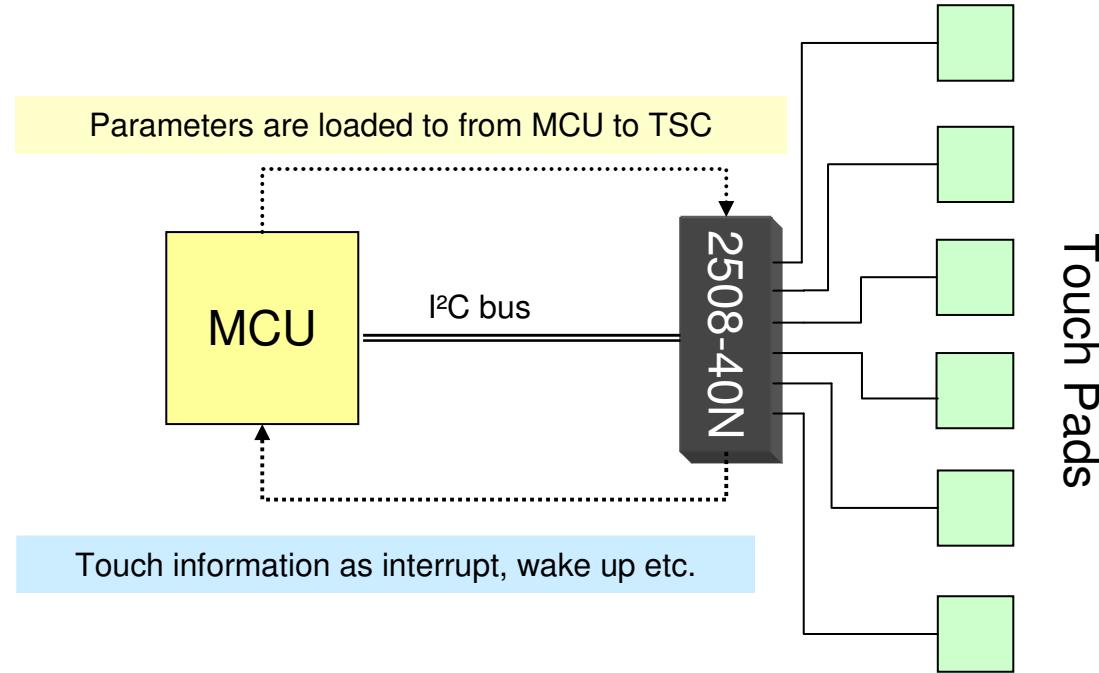
- Can replace virtually all mechanical buttons, sliders and turning knobs
- Create a simple, robust, clean und esthetic design



C_{touch} : the capacitance induced between finger and touch pad
 ϵ : the constant value of permittivity (Air=1, Glass=10, Acryl=5~10, Rubber=2~3)
 D : the thickness of the set cover
 A : the size of the touch pad



System Overview



■ Typical Applications

- Single Keys
 - Output information:
 - Which key has been touched
 - MCU no need to process the touch data
- Advanced sensing
(slide, wheel, approximation etc.)
 - Output information
 - Touch strength
 - MCU needs to process the touch data



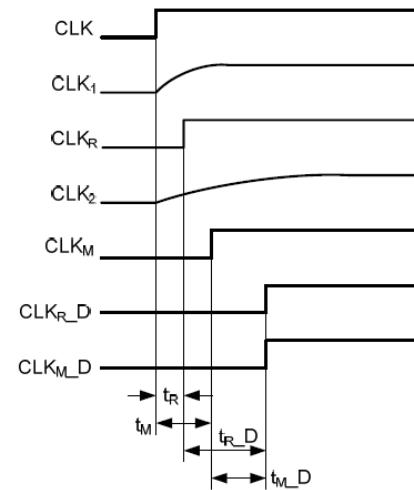
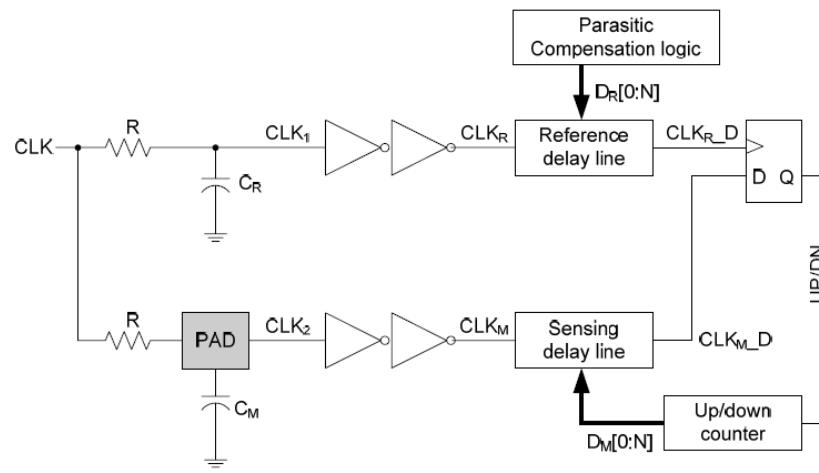
How does it work? – Main Idea

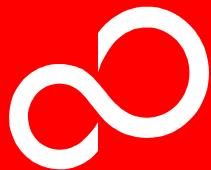
Digital Sensing

- Impedance includes capacitance, resistance, and inductance
- Impedance causes delay of capacitor charging time
- Time delay is measured → Digital domain, no AD conversion

Differential Signal

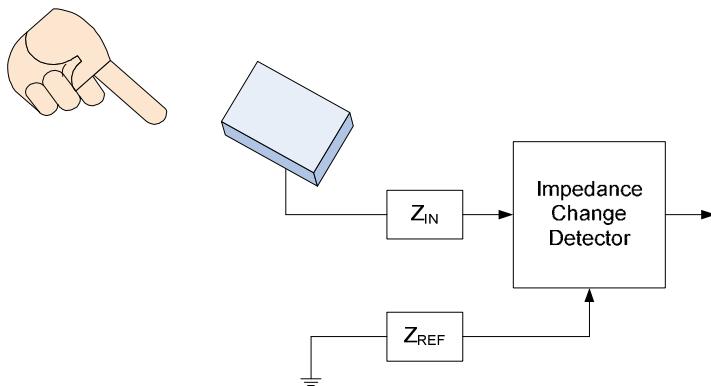
- Internal reference RC circuit → Reference time delay → can be calibrated
- Comparison between Input time delay and reference time delay
 - If input time delay is larger than reference time delay by a certain amount
→ touch event occurred
- No Ground Electrode needed for Touchpad



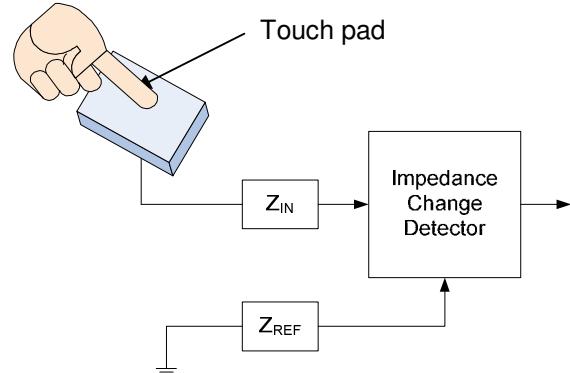


How does it work? - Touch Sensing

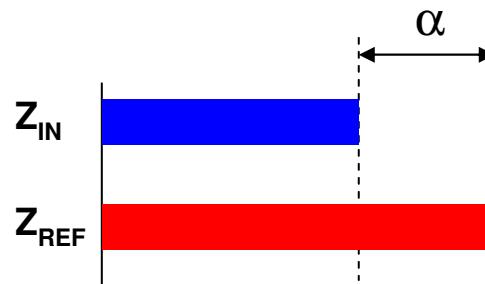
[1] Not Touched



[2] Touched



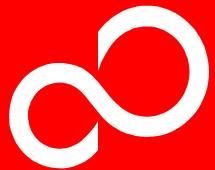
[1] $Z_{IN} < Z_{REF}$



[2] $Z_{IN} > Z_{REF}$



Consistent sensitivity of the touch pad is maintained by setting proper value of α .



Advantages

- **Extremely Fast**
- **Extremely Low Power**
- **Extremely Robust**
- **Extremely EASY to implement**



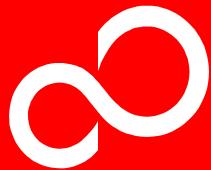
Fast and Low Power

■ Extremely FAST Response Time

- No complex signal processing needed
- Register programmable, 10 times/sec (100msec) ~ 5,000 times/sec (0.2msec)
- Allows data management, filtering, etc.

■ Extremely LOW Power Consumption

- Supply current typical
 - 120µA Active mode, 60µA Idle mode, 0.1µA Sleep mode
- Perfectly fit to portable products



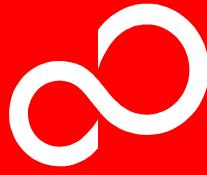
Robust and Easy Implementation

■ Extremely Robust

- Consistent sensitivity through AIC™
- Resistant to outer signal disturbances through differential signal format
- Water resistant designs possible
- ESD protected up to 8KV (HBM) / 15KV (set / air)

■ Extremely EASY to Implement

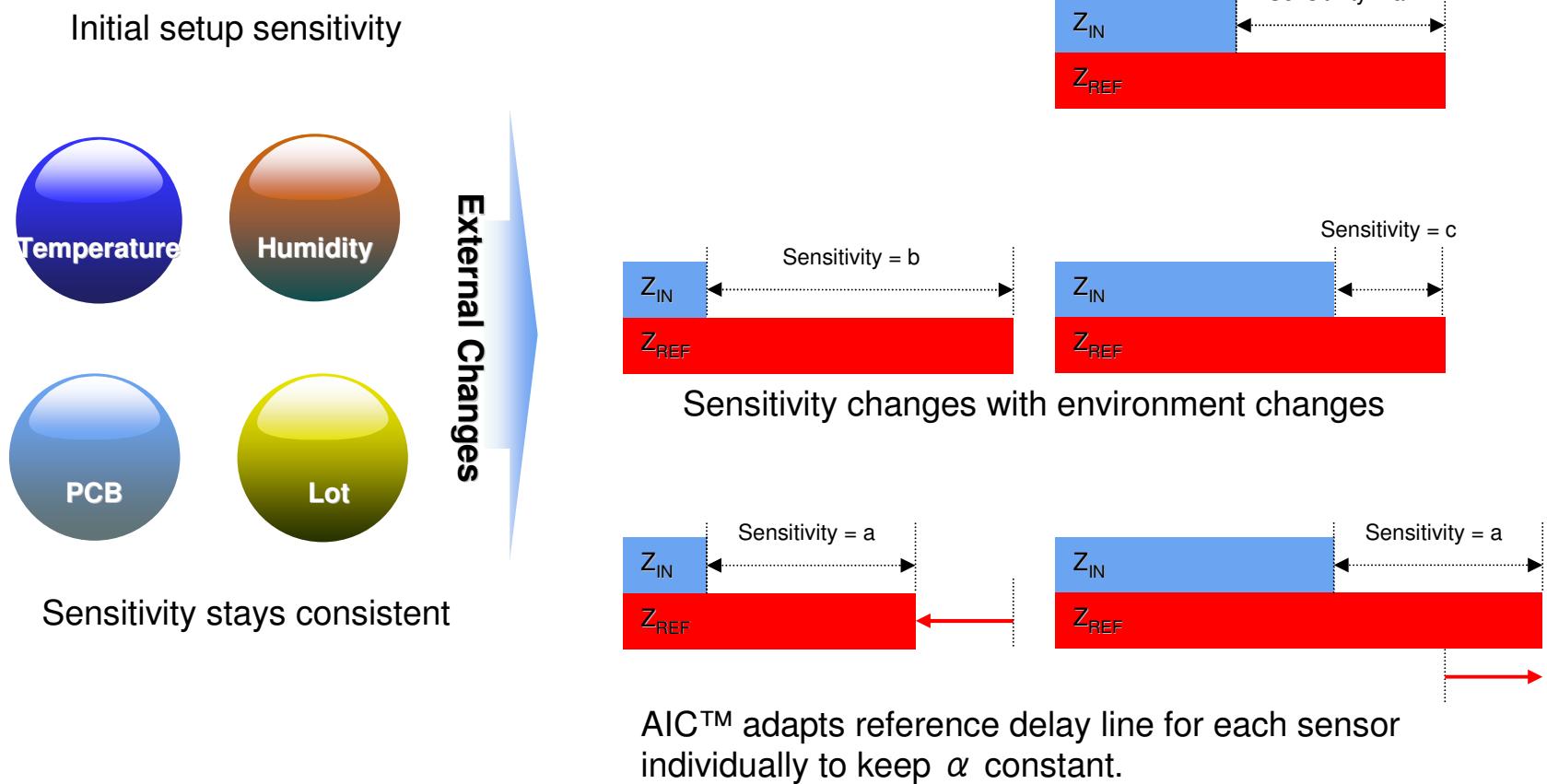
- One single electrode is sufficient for touch channel
- Advanced hardware functionality
 - AIC™ impedance calibration
 - APIS™ touch filtering
- High design flexibility
 - Host interface via I²C
 - up to 12 general-purpose IOs
 - Individual channel sensitivity
 - Touch strength output
 - TSC can be either located close to touch pads or on the main PCB
 - Touch pad can be as small as 1mm x 1mm
- Tuning Board with Tuning Viewer Program available



Automatic Impedance Calibration

■ AIC™ (Automatic Impedance Calibration)

- Maintain consistent sensitivity despite environmental changes
 - temperature, humidity, production tolerance, etc.



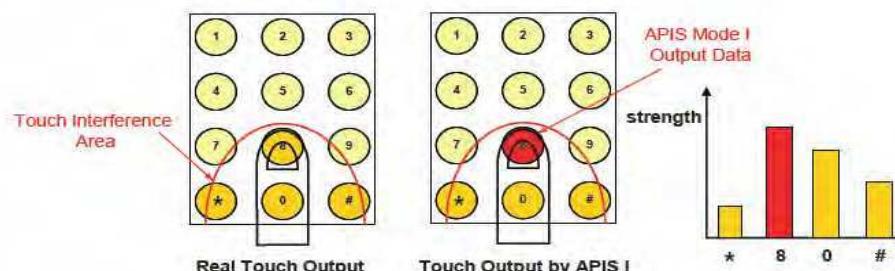


■ APIS™ (Adjacent Pattern Interference Suppression)

- Filter out unintentional touches
- Reduce Software efforts

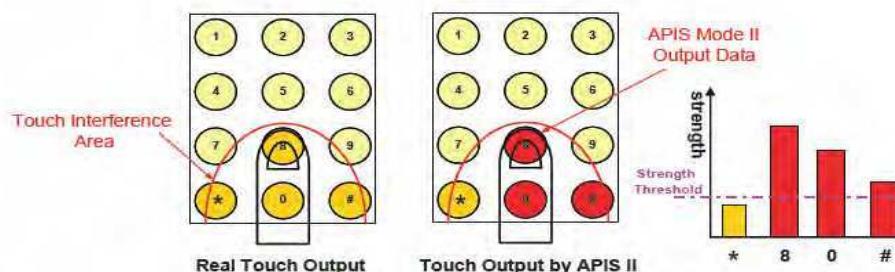
APIS™ Mode 1

Reports the strongest output only



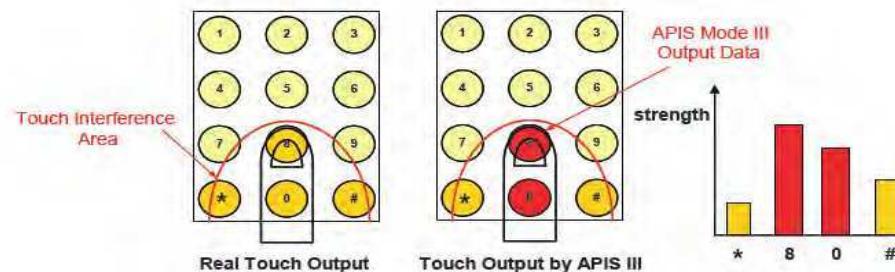
APIS™ Mode 2

Reports all outputs that exceeds predefined thresholds



APIS™ Mode 3

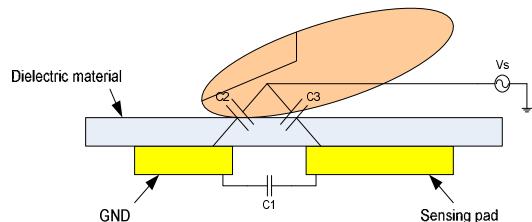
Reports two strongest outputs



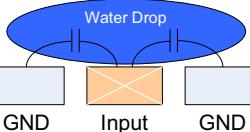
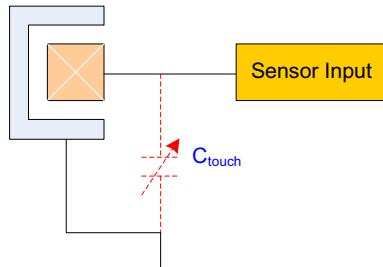
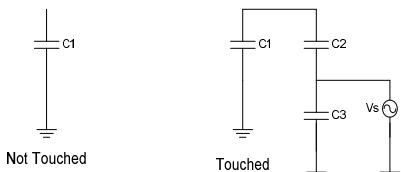


Water Resistant

Split pad



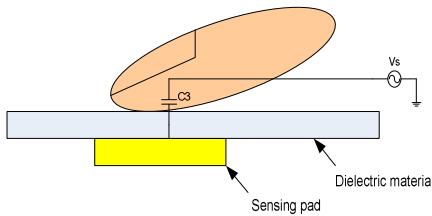
Equivalent Circuits



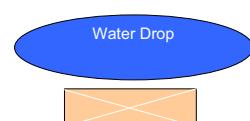
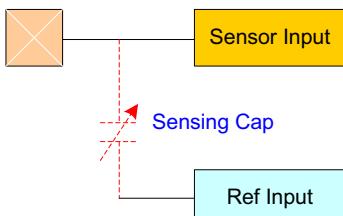
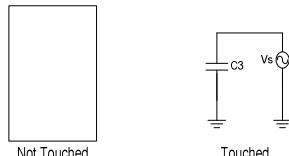
■ Split pad

- Coupling Capacity between two electrodes is measured
- Finger increases capacity coupling
- Water drop has the same effect
→ false touch detection

Single pad – 2508-40N



Equivalent Circuits

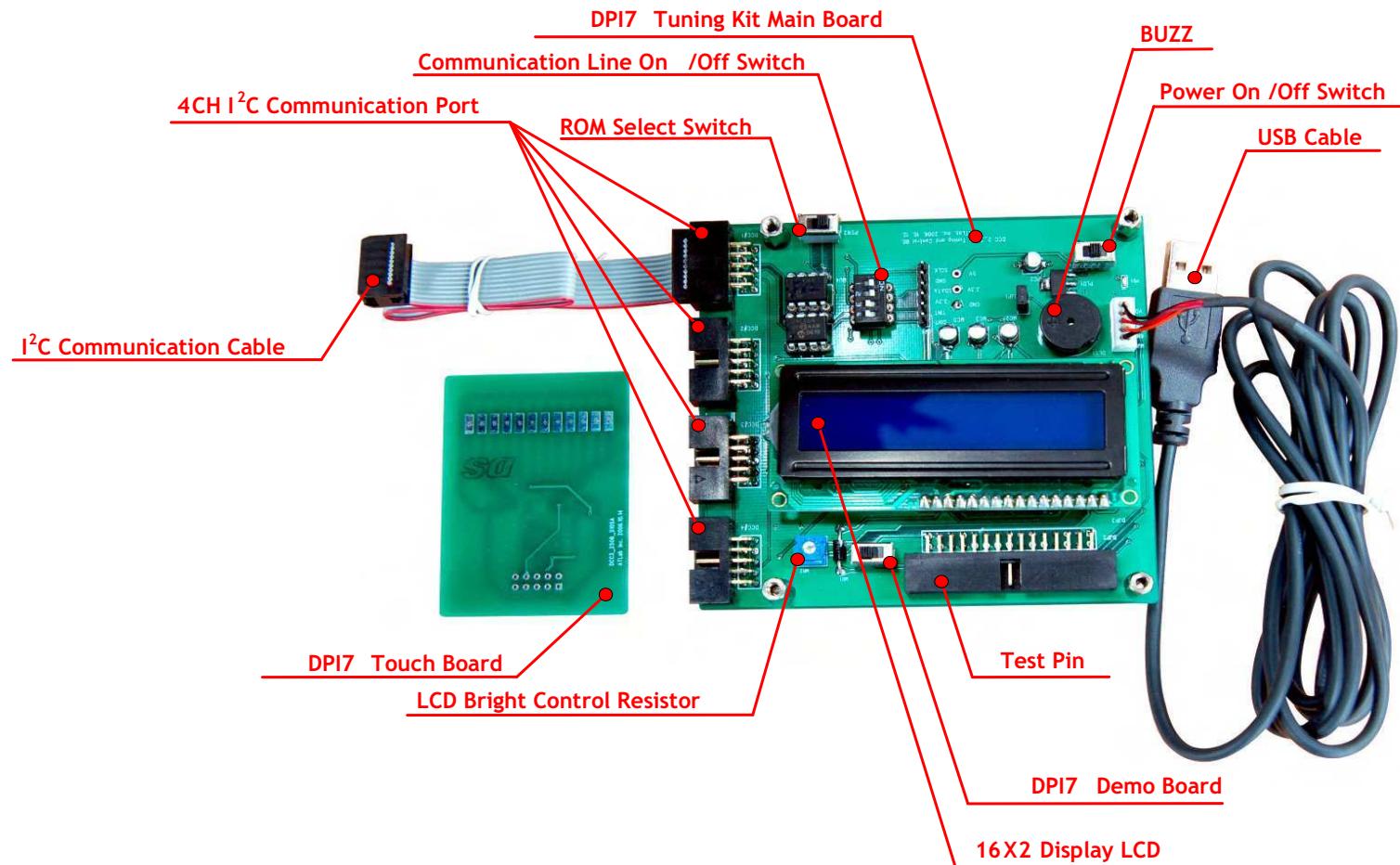


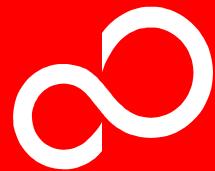
■ Single pad – 2508 - 40N

- No ground or reference electrode next to pad
- Capacity of pad is measured directly
- Water drop has nearly no effect
→ no false trigger

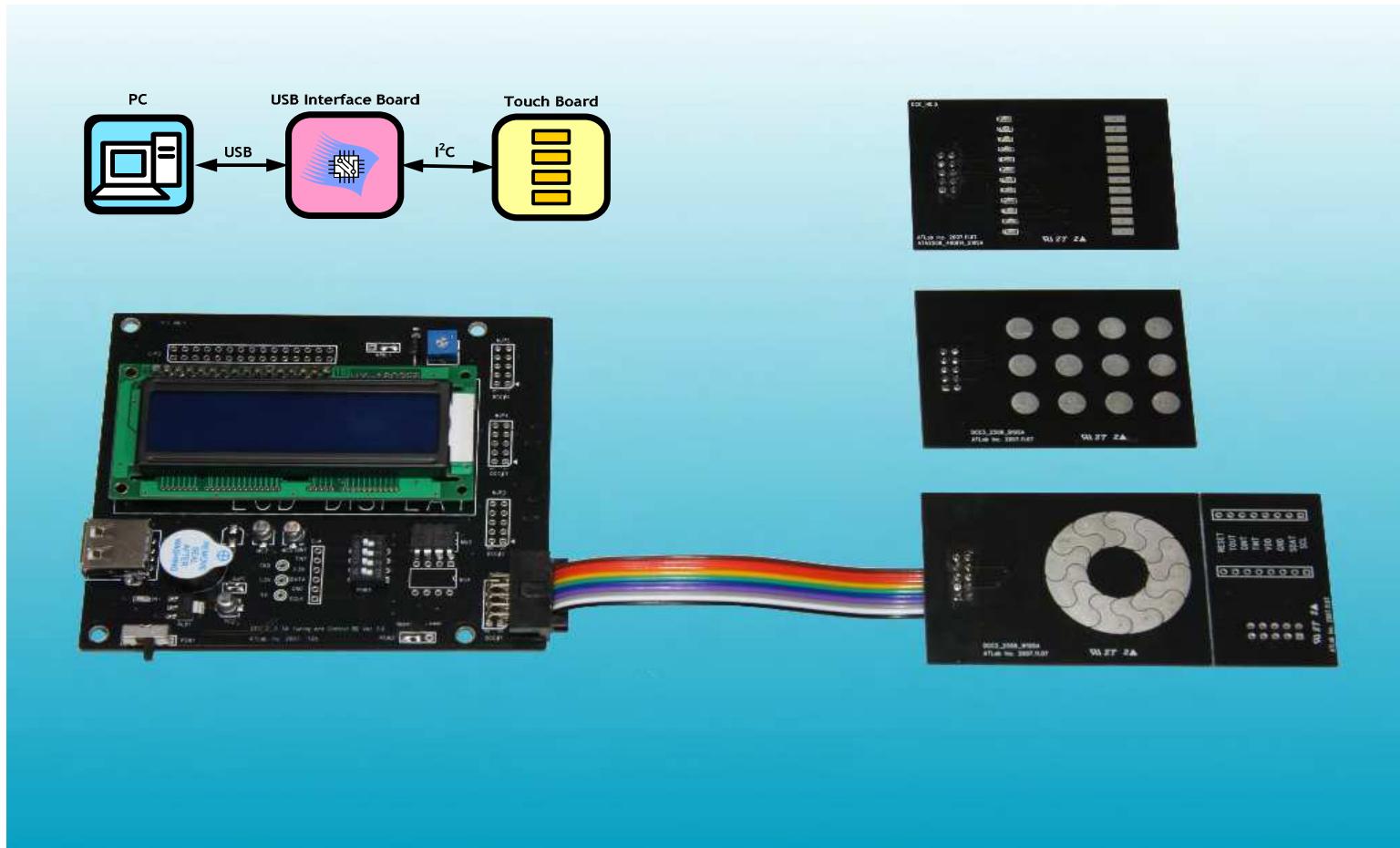


Tuning/Development Board





Development Tools



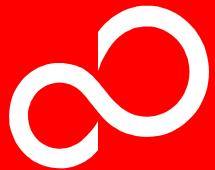


Tuning Kit

Tuning / Development Software

The screenshot displays the FMA1127 Controller Window v1.5 software interface, which includes several windows for tuning and configuration:

- AIC Tuning Window:** Shows strength values for various pins (00-11) and parameters like ALPHA(W), BETA(W), and Reference_Delay(W).
- Strength View:** A grid showing strength values for pins 00-11 across multiple rows.
- MCU Configuration Window:** Allows setting MCU Clock Speed (48MHz, 24MHz, 12MHz), MCU Interrupt Enable (INT EX0(TINT), INT EX1(GINT)), I2C Speed Control (I2C 100KHz, I2C 400KHz), I2C CHIP ID SELECTION (CHIPID1(0x58), CHIPID2(0x59), CHIPID3(0x5A), CHIPID4(0x5B), CUSTOM ID(HEX: 58)), DCC Device Selection (DCC2(AT2501), DCC3(AT2508), DCC3A(AT2509)), USB Device Selection (USB-0, USB-1, USB-2, USB-3), and USB Device Description.
- Control Register:** A window for reading and writing control registers. It lists various register names and their bit fields, with checkboxes for selecting specific bits to read or write.



Applications of Touch Sensors

Unlimited Applications ~ limited only by imagination

Touch Sensor may REPLACE virtually all MECHANICAL buttons and scrolling knobs with ELECTRONICS.



Buttons



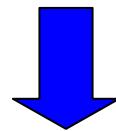
Slider



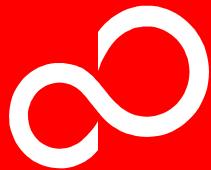
*Circular Scroll
Or Navigation*



Invisible Buttons on LCD (ITO)



Aesthetic Design and Higher Product Reliability



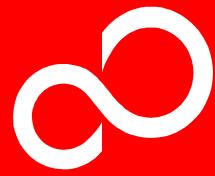
Why TSC?

■ Key Technology Features

- **Lowest Power** Consumption
 - Active (120~350uA), Idle (20uA), Sleep (< 0.1uA)
- **Resistant** to Water and Noise ~ Differential signal, No GND
- **Fastest** Response Time ~ 0.2 msec (5KHz)
- **Wider** Dynamic Range for touch
 - No hardware tuning required
- **Higher** Sensitivity
 - More sensitive to smaller changes in capacitance (time delay)

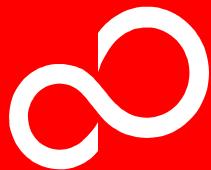
■ Commitments to Customers

- Customer requirements: FPGA proof
- Close **technical/commercial support**
 - On-site technical support, prototyping, proof of concept
 - Meet quality and delivery schedule



Technical Position

		Touch Response Time				
		Slow	Fast			
Architecture	Digital	Digisensor			<i>As small as 1mm x 1mm</i>	
	Analog					
		<i>S, C, Q, A</i>				
		Single - End		Differential		
Signal Format						



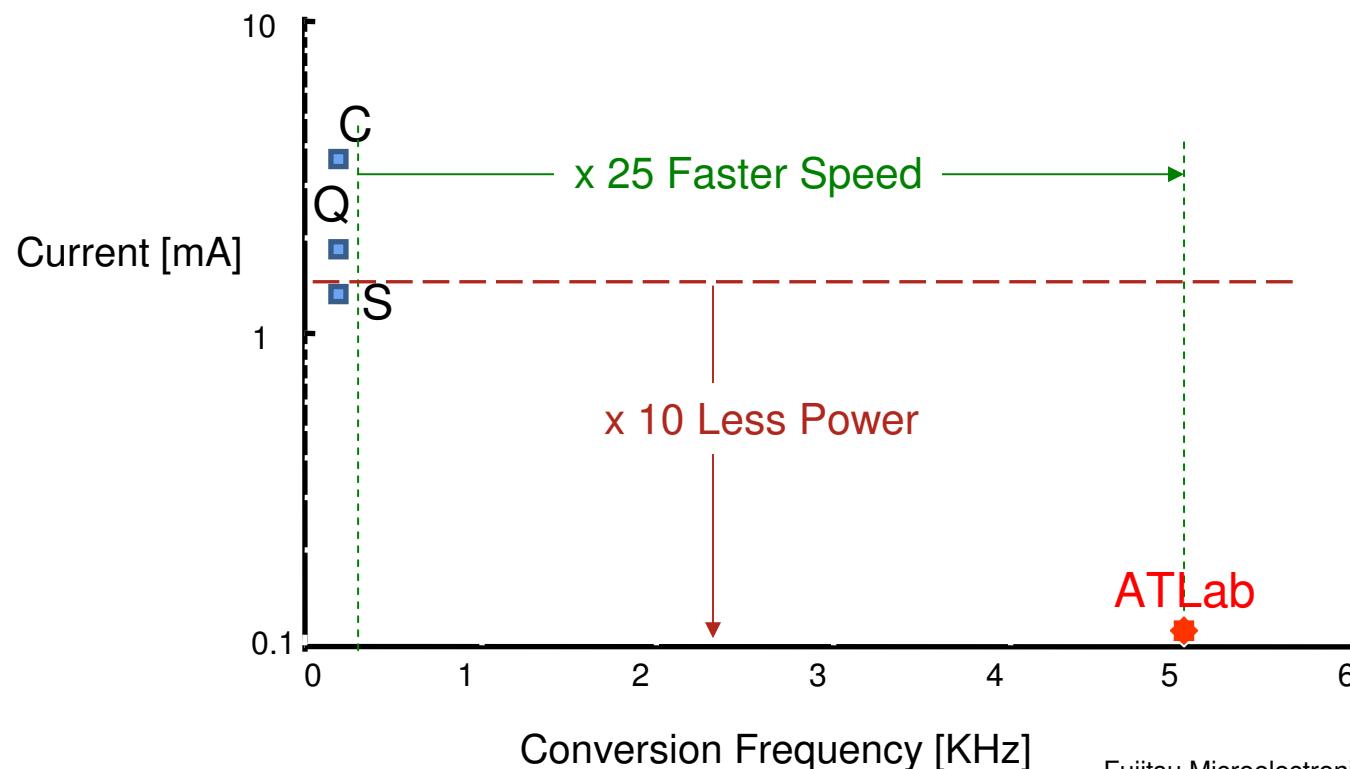
Strong Point

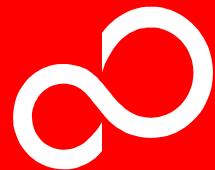
1. Consumption Current : 1/10 times comparing to competitors

- Because of not using analog technology, circuit architecture is very simple.
- Active mode : $130\mu\text{A}$, Idle mode : $70\mu\text{A}$, Sleep mode : $0.1\mu\text{A}$

2. Response Time : 25 times comparing to competitors

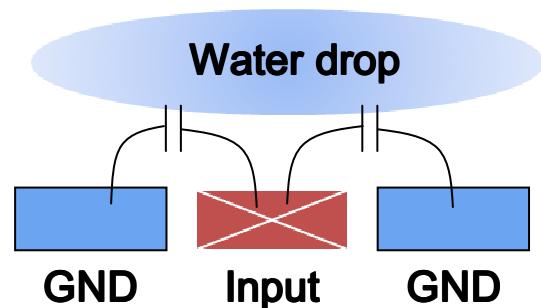
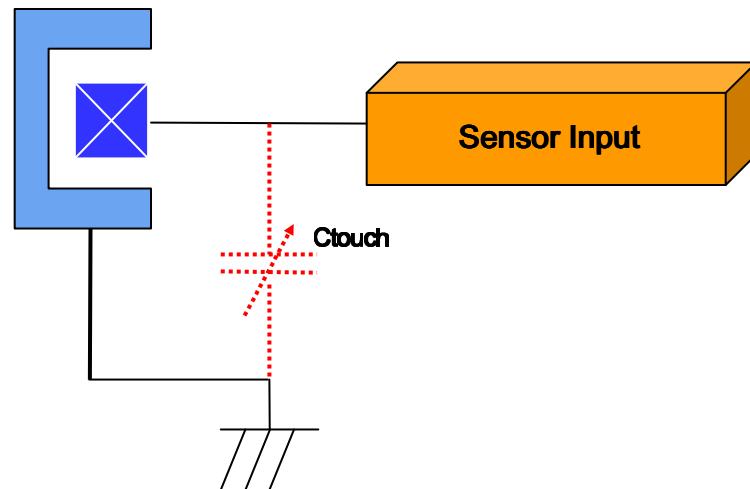
- Because it dose not need complex signal processing, can raise the data sampling rate.



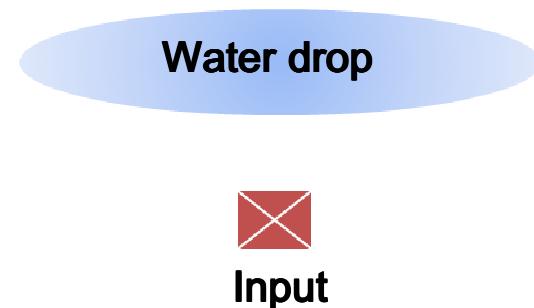
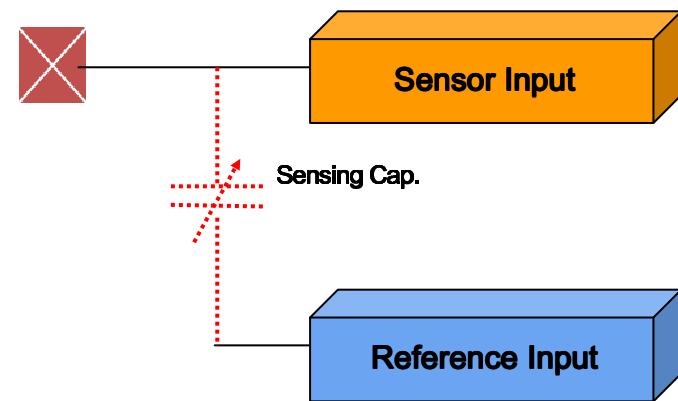


Strong Point

Single-End



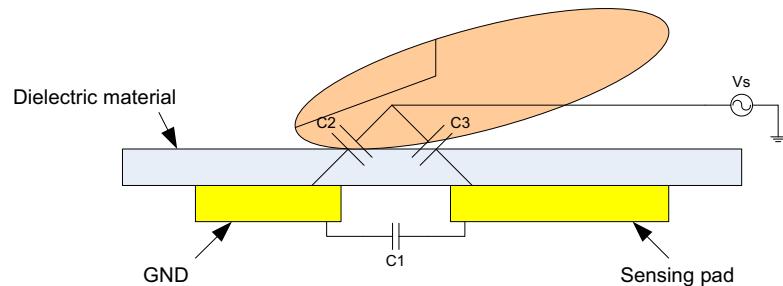
Differential



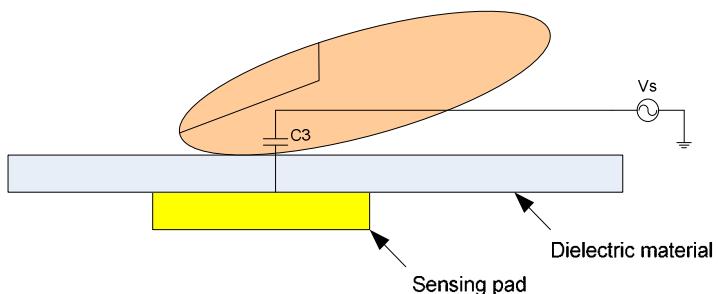


Strong Point

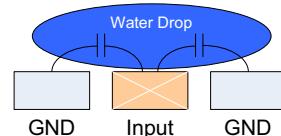
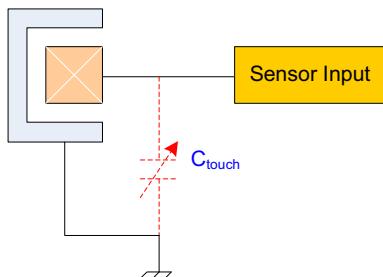
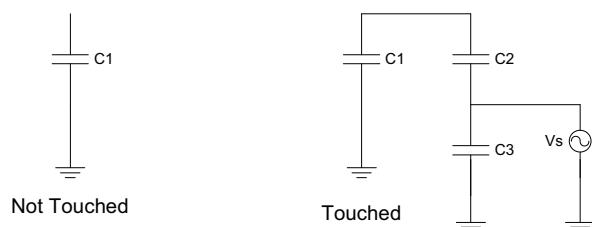
Other's Solution



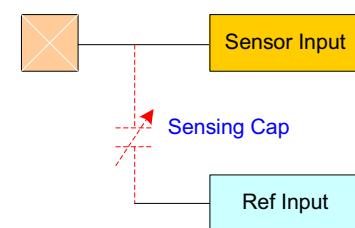
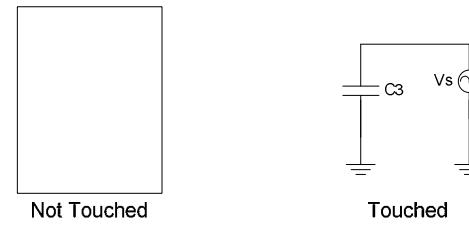
@Lab Solution

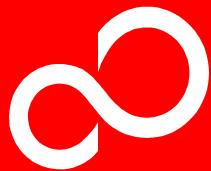


Equivalent Circuits



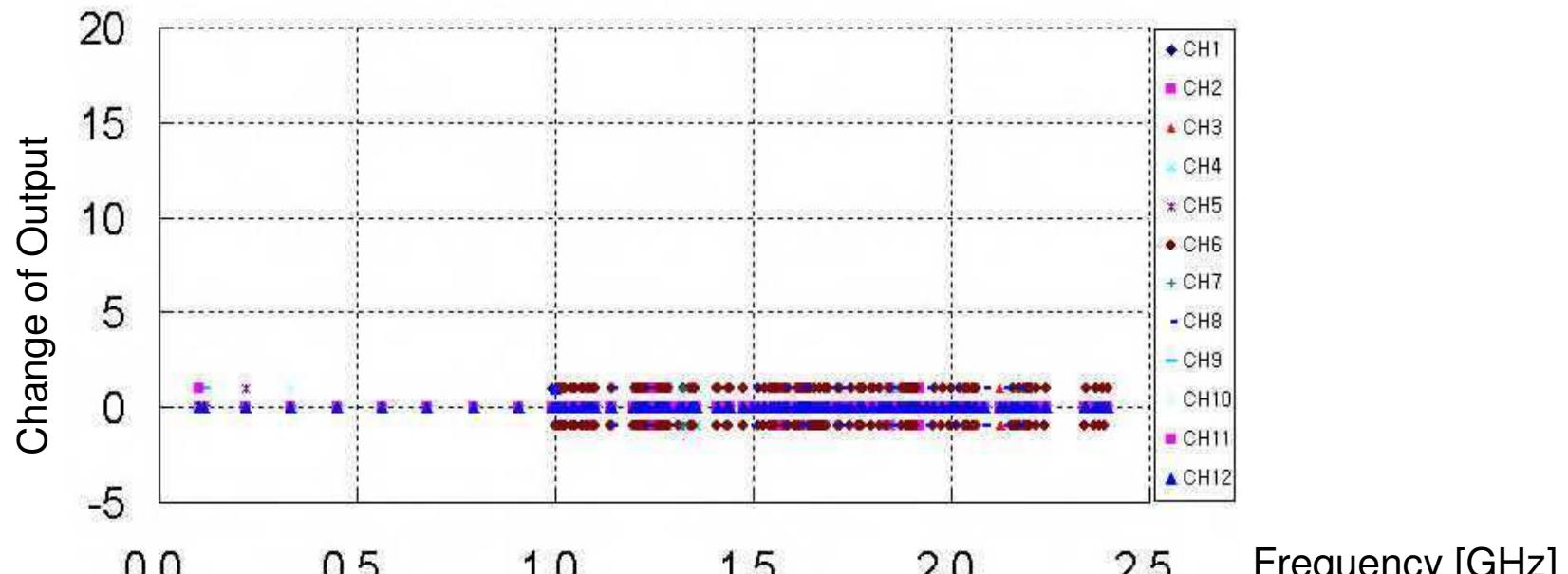
Equivalent Circuits



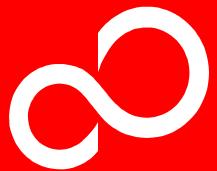


Strong Point

- Inherently Differential Architecture
 - Immune for External Noises
 - Non-interrupt Touch Operation at active RF
- Multi-level Capacitance Values

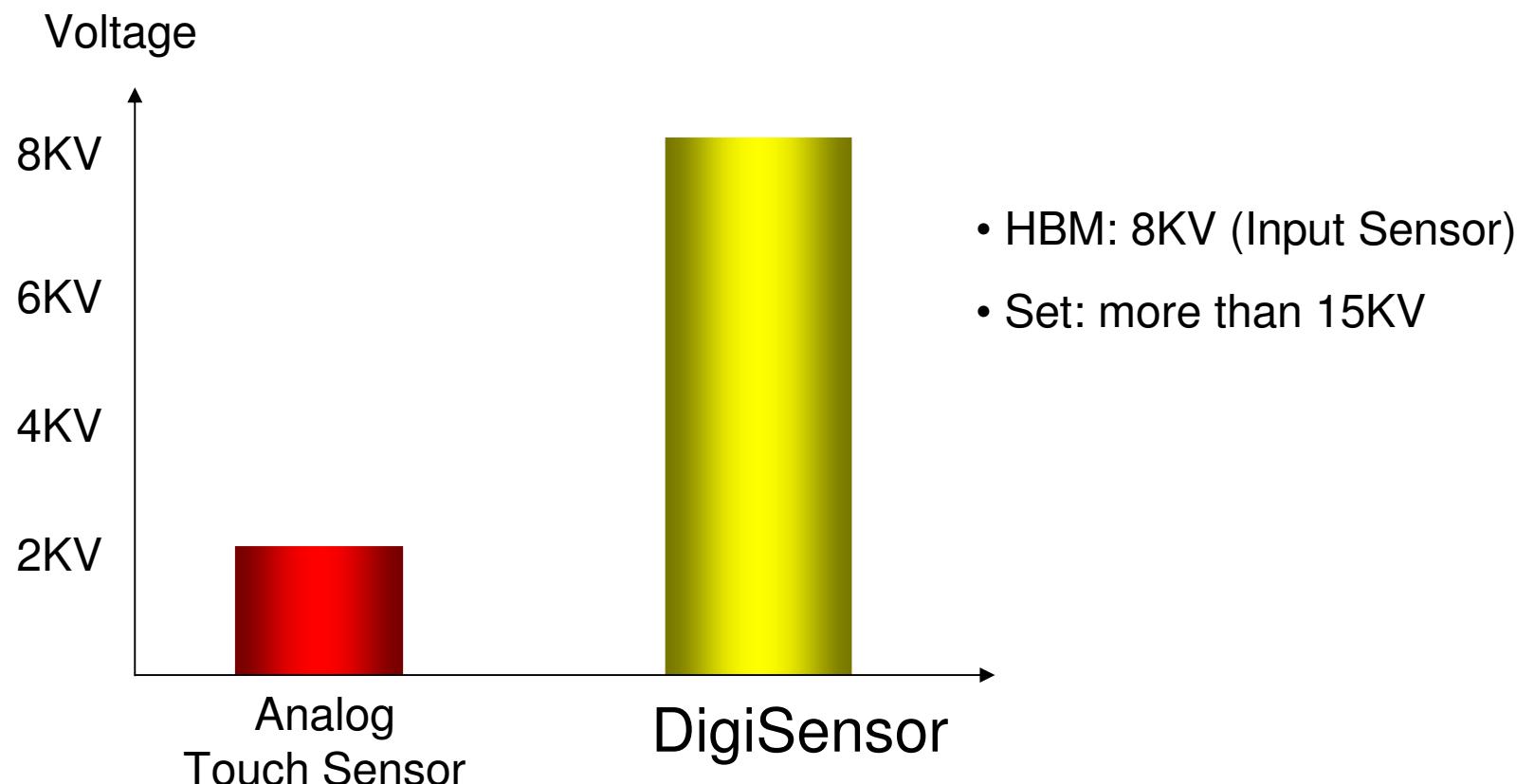


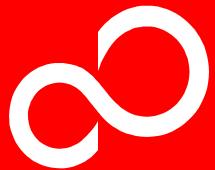
RF Signal: 3Vp-p swept from 100MHz to 2.4 GHz, Korea MIC Condition



Strong Point

Low Input Impedance → Higher ESD





Strong Point

- High Sensitivity
 - 30 fF/step now (x 5 than others), break 1 fF barrier soon.
 - Small sensing area → Better resolution
 - Extend to another applications
 - (e.g. proximity sensing, display embedded touch screen)
- Digital Advantages
 - Following Moore's Law / Insensitive to Foundry/ Technology
- Low Power & Best for Portable Electronics
 - Longer Battery Lifetime / Touch Wake-up
- Fast Sampling
 - Less Noise Aliasing / Capable for Signal Conditionings



Patent Status

Protected by 33 patents

Application/Patent No.	Patent Name		Country	Status
	Korea	USA	Registered	Public
2004-0040537	전기적 접촉센서			
11/145,332	electrical touch sensor			
200510075210.8	electrical touch sensor			
94117777	electrical touch sensor	Application/Patent No.	Patent Name	Country Status
2007190311-7	2007190311-7	portable terminal and method of working thereof		상가동 Registered
2004-0041065	화면 액정화면	2008-520317	Portable terminal and method of working thereof	Japan Application
11/113,585	apparatus of general	200680023756.1	Portable terminal and method of working thereof	China Public
200510075215.0	apparatus of general	2005-0114414	Portable terminal and method of working thereof	
94115750	apparatus of general	95130603	Portable terminal and method of working thereof	
2004-0080075	디자인서울 구체화	pressure sens	10-2006-0120487	접촉 감지장치 Korea Public
Human input appa	PCT/KR2006/003069	pressure sens	KR2007/004022	touch sensor device PCT Public
200510108278.1	Human input appa	2008-542222	pressure sens	Taiwan Application
94134925	Human input appa	12/094,074	pressure sens	Taiwan Public
2005-0007742	데이터 관리 및 디	200803799-6	pressure sens	[Touch sensor device] (Optical pointing device and data transmission method thereof) Taiwan Public
2005-0111783	2005-0111783	10-2006-0123952	센서 장치 및 이 장치의 동작 방법	Taiwan Public
95119530	apparatus and met	95143246	센서 장치 KR2007/004394	Sensor device and method of operating the same Taiwan Application
PCT/KR2006/000218	apparatus and met	2006-0041153	센서 장치	PCT Public
200680002392.3	apparatus and met	PCT/KR2007/001692	input device 2007-1447	화면액정화면 스크롤장치 및 이를 이용하는 화면액정화면 Korea Registered
11/814,505	apparatus and met	96113313	input device 10-2007-0027057	접촉센서 장치 및 이 장치의 동작 모드 전환 방법 Korea Application
2007-552063	apparatus and met	12/297,391	input device PCT/KR2008/002904	Touch Sensor Device and the Method of Switching Operation Mode Thereof Taiwan Application
200705190-7	apparatus and met	2008-556259	input device 97119393	Touch Sensor Device and the Method of Switching Operation Mode Thereof Taiwan Application
2005-0023382	전기적 접촉센서	200780010761.3	input device 10-2007-0041228	화면액정화면 스크롤장치 및 이를 이용하는 화면액정화면 Korea Registered
951052111	접촉센서 및 이	2006-00513189	input device 10-2007-0059389	접촉센서 장치 및 이 장치의 동작 방법 Korea Public
PCT/KR2006/001841	Touch sensor and d	PCT/KR2007/002567	도난예 방지 97122577	도난예 방지 및 지연시간 측정 방법 Taiwan Application
2008-515618	Touch sensor and d	96119749	electrical touch	Delay time measurement circuit and method PCT Public
02006/001841	Touch sensor and d	PCT/KR2008/003422	electrical touch	Delay time measurement circuit and method Korea Public
95120752	Touch sensor and d	200809131-6	10-2007-0064410	자동 경도 조절장치 및 이에 제어방법 PCT Public
200680020728.4	화면액정화면	12/304,446	electrical touch PCT/KR2008/001847	Automatic Intellectual Adjuster and Control Method Thereof Taiwan Application
11/917,077	Touch sensor and d	2006-0056539	97122576	자동 경도 조절장치 및 이에 제어방법 Taiwan Application
200718419-5	Touch sensor and d	KR2007/002134	touch sensor 10-2007-0011300	터치 패널 장치 및 이에 접촉위치 감지방법 Korea Public
2005-0059895	화면액정화면	96116110	touch sensor PCT/KR2008/002459	터치 패널 장치 및 이에 접촉위치 감지방법 Korea Application
95121374	Portable terminal	12/297,401	touch sensor 10-2007-00132174	시리얼 통신 시스템 및 이에 ID 부여방법 Korea Public
2006-00115848	화면액정화면	20078009643.0	touch sensor PCT/KR2008/002832	Serial Communication System and ID Grant Method thereof Taiwan Application
PCT/KR2006/002372	Portable terminal	2006-0084962	97126665	시리얼 통신 시스템 및 이에 ID 부여방법 Taiwan Application
11/994,679	화면액정화면	PCT/KR2007/002759	속감응부 10-2008-0023000	접촉센서 장치 및 이 장치의 포인팅 좌표 결정 방법 Korea Public
			Touch pad con	Touch Sensor Device and Pointing Coordinate Determination Method Thereof PCT Application
		96122771	Touch pad con	모든에서 자동 복원할 수 있는 통신 시스템 및 이에 적용 방법 Korea Public
		10-2006-0100370	10-2008-005180	모든에서 자동 복원할 수 있는 통신 시스템 및 이에 적용 방법 Korea Application
		PCT/KR2007/002760	Electronic dev	센서·센서의 통신 방법 및 센서의 절터 Korea Application
			2008-92336	근접 센서를 구비하는 휴대장치 Korea Application
			96122774	전화기에서 경지 Korea Application
			2008-98393	터치 배경 및 이를 구비하는 앤드로이드 PCT Application
			2009-104951	터치 배경 및 이를 구비하는 앤드로이드 Korea Application
			2009-111799	터치 배경 및 이를 구비하는 앤드로이드 Korea Application
			2009-124143	터치액정 표시장치 및 표시장치 제작방법 Korea Application
			2009-127410	터치액정 디스플레이 패널을 구비하는 앤드로이드 및 앤드로이드 제작방법 Korea Application



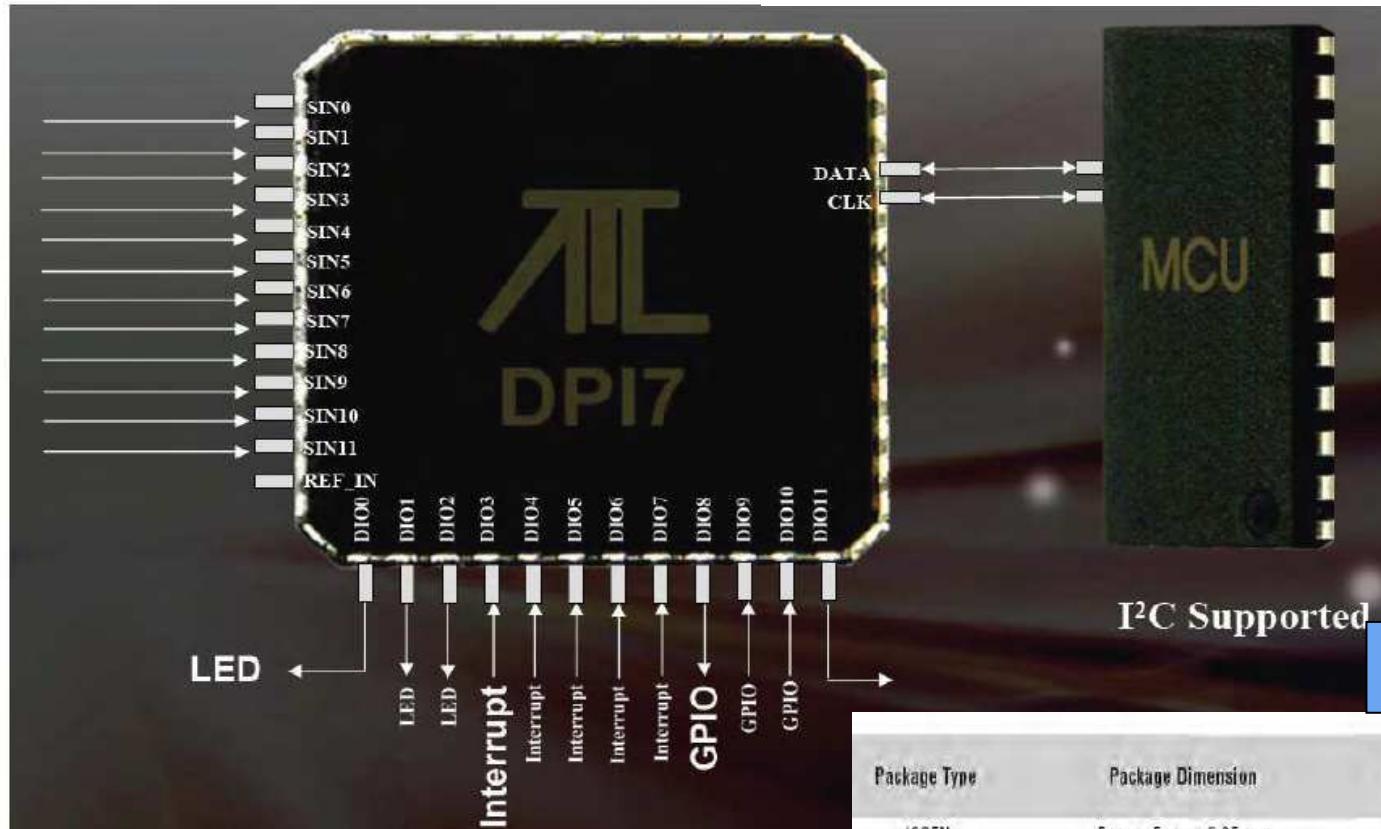
Available TSC Products

Product	ATA2508			ATA2538	
	40N/30S	32N/24S	24N/20S	24N/24S	16N/16S
No. of Ch.	12	9	6	8	6
Matrix of Ch.	<36	<20	NA	<16	NA
No. of DIO or LED	12/6	8/3	3/2	4(+8)	0(+6)
Interface	I ² C				
Operating Voltage	2.3 V ~ 5.3V				
LED Control	12/6	8/3	3/2	4(+8)	0(+6)
LED Dimming	X			O	
Package	QFN/SSOP				
Size [mm]	5X5X0.85 12.7x10.3x2.5	4X4X0.85 8.2x7.8x2	4X4X0.85 6.5x6.4x1.85	4X4X0.55 8.2x7.7x2.0	3X3X0.55



TSC Product example

General-Purpose DIOs (0.25um CMOS – Fujitsu/PSTS)



Available Packages

Package Type	Package Dimension	Pin Pitch	Number of Sensor Inputs	Number of Digital Outputs
400FN	5mm x 5mm x 0.85mm	0.4mm	12	12
320FN	4mm x 4mm x 0.9mm	0.4mm	9	8
24QFN	4mm x 4mm x 0.85mm	0.5mm	6	3
30SSOP	12.7mm x 10.3mm x 2.5mm	0.8mm	12	6
24SSOP	8.2mm x 7.8mm x 2.0mm	0.65mm	9	3
20SSOP	6.5mm x 6.4mm x 1.85mm	0.65mm	6	2



Target Applications – Home

■ Large Appliance

- Wash machine, dryer, hob, stove etc.



■ Small Appliance

- Cooker, microwave oven etc.



■ Consumer devices

- Remote control, DVD player etc.



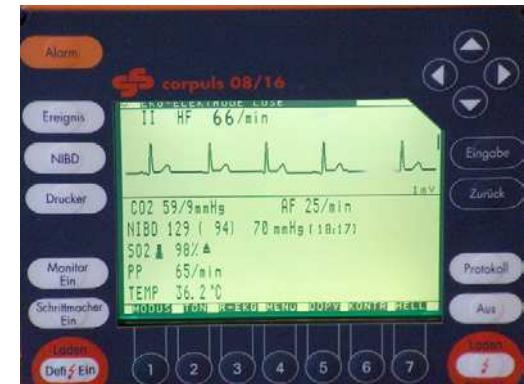


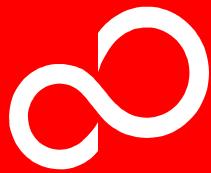
Target Applications – Industrial

■ Application examples

---- wherever robust human input device is needed

- Control panels
- Medical instruments
- Test & Measurement Equipments
- Special vehicle





Target Applications - Portable devices





Target applications - office devices

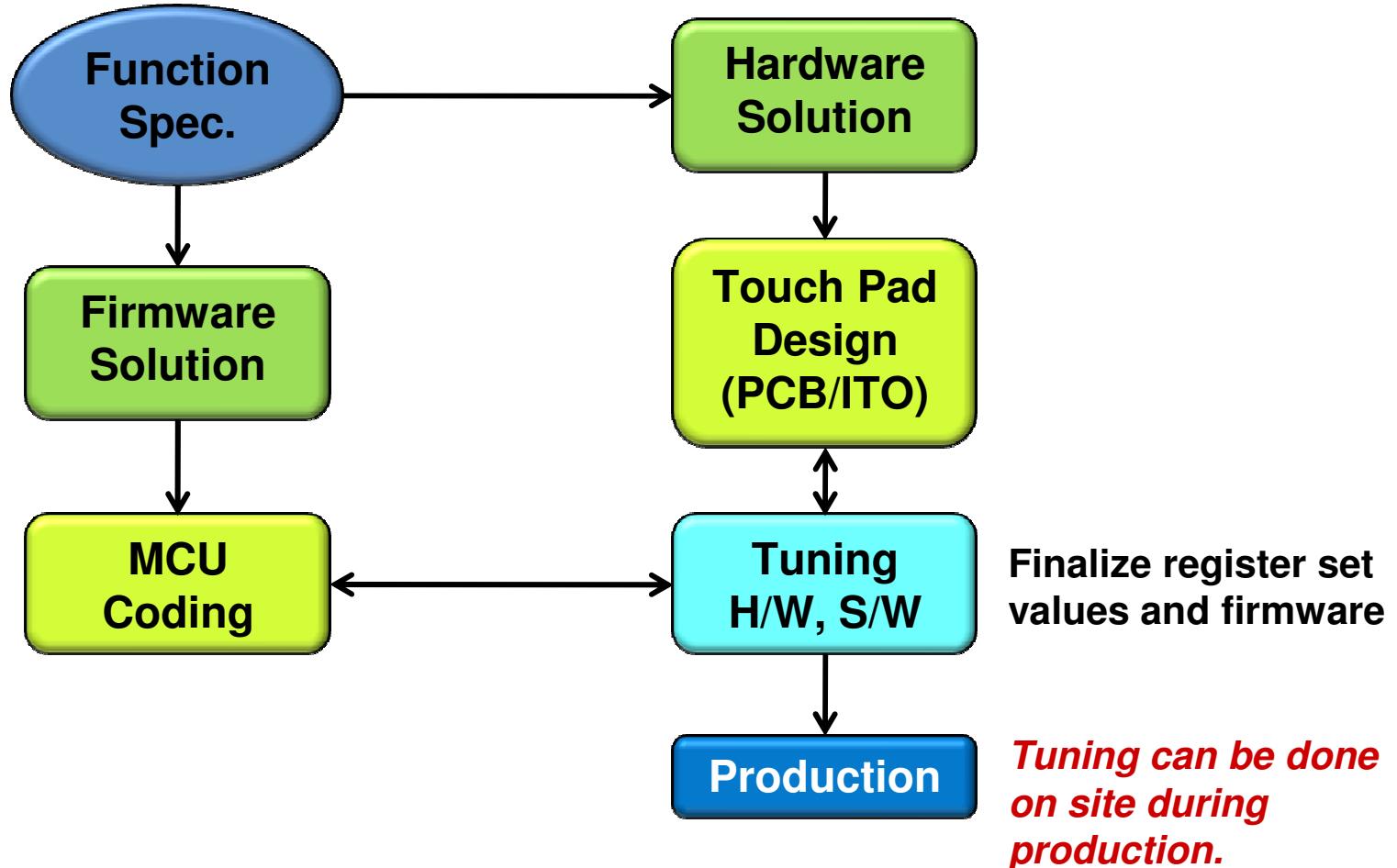


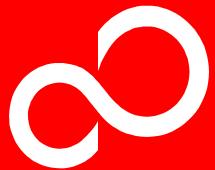
And Many More...





Application implementation



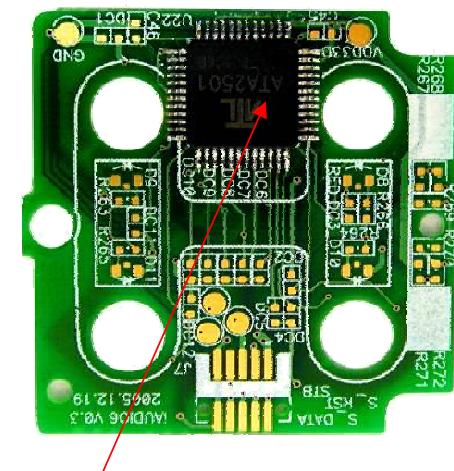
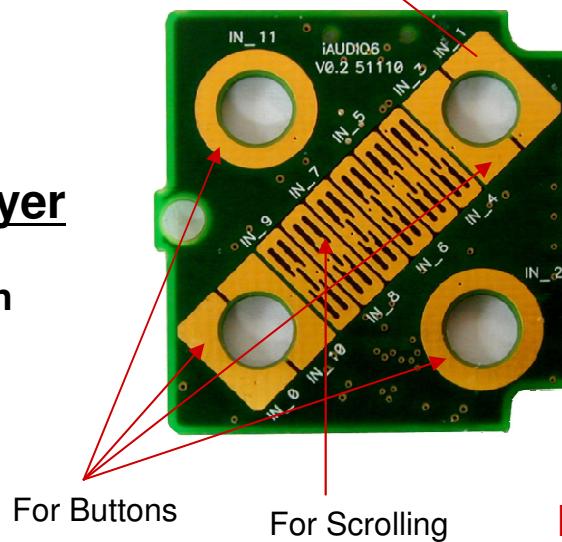


Typical Implementation example



Portable Multimedia Player

- Exhibited in CES 2006
- Currently in mass production



The Fujitsu logo is displayed in red. It consists of the word "FUJITSU" in a bold, sans-serif font. Above the letter "j", there is a small infinity symbol (∞).

FUJITSU

THE POSSIBILITIES ARE INFINITE