

Enhanced Multi-touch Capacitive Touch Screen Controller**AP389X****General Description**

The AP389X is a low-cost high-resolution single chip solution for APA capacitive touch screen. It is an 8-bit single cycle 8051 microcontroller with I²C Interface. The chip includes 8-bit successive approximation analog-to-digital converters with an I²C interface and multiplexer-switcher circuits for flexible measurement of analog signal from APA panel. An accurate switched-capacitor integrator is built-in and it can auto calibrate the pixel parameters for a wide range of capacitance on the touch screen (0.1pF to 4pF). On-chip capacitor can replace external component. This touch screen controller (TSC) with CMOS integration circuit provides an ideal choice for APA touch panel. The AP389X is specified over the temperature range of -40°C to 95°C.

The AP389X is available in QFN-7×7-56 (for AP3890) and QFN-8×8-68 (for AP3891 and AP3892) packages.

Features

- Mutual Capacitive Touch Sensing
- Dual Power Supply: 2.8V to 3.6V Operation Voltage; 1.6V to 2.0V Operation Voltage
- Up to 30/38/36 Drive Lines and 17/22/23 Sense Lines
- Dedicated Internal Two-wire Serial Control Bus I²C and UART between AP389X and Host
- Single-end Integrator with Programmable Gain Control and Offset Control
- Multiplexed Analog Digitization with Two 8-bit Resolution Odd/Even Scan SAR ADCs and Its Dedicated 2X to 8X Accumulator XSRAM Buffers

Features (Continued)

- Single Cycle 8051 CPU Core, Maximum Operating Clock up to 24MHz from IOSC (Zero Wait State); 48MHz from IOSC(With Wait State)
- 4MHz to 48MHz Internal Oscillator (IOSC)
- 64K-byte Flash ROM
- 256-byte Internal SRAM and 12032-byte XSRAM
- Extra XSRAMs for AFE:
 - ◆ 896×12-bit×2 XSRAM for 8-bit SAR ADC
 - ◆ 896×8-bit XSRAM for 8-bit Parasitital Capacitor Compensator
- Two 16-bit Timers T0/T1 and One 16-bit ECT Timer T2
- One I²C Slave Controller and One I²C Master Controller Shared with the Same Port
 - ◆ With Asynchronous I²C Slave Address Detection Logic Design
- 4 General Purpose GPIO Pins
- One External Interrupt Pin
- One UART Data Transfer Output Pin
- ISP/IAP via I²C Port
- Operation Temperature Range: -40°C to 95°C
- Package Types: QFN-7×7-56 and QFN-8×8-68
- RoHS Compliance
- Operating Mode:

Mode	Description
Power-down	No scan with power-down mode
Standard	Higher scan rate when fingers are on panel, IOSC can up to 4MHz to 48MHz

Applications

- Mobile Phones
- Personal Digital Assistants
- Smart Hand-held or Gaming Devices



Figure 1. Package Types of AP389X

Enhanced Multi-touch Capacitive Touch Screen Controller

AP389X

Pin Configuration

FN Package
(QFN-7×7-56)

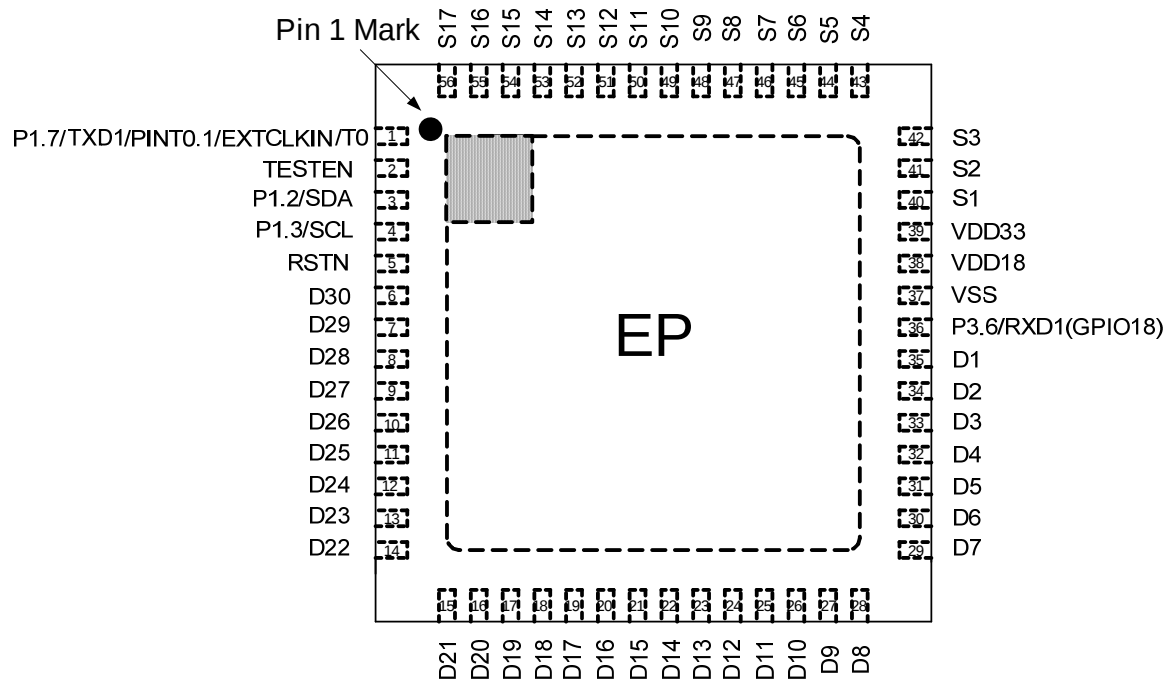


Figure 2. Pin Configuration of AP3890 (Top View)

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AP389X

Pin Configuration (Continued)

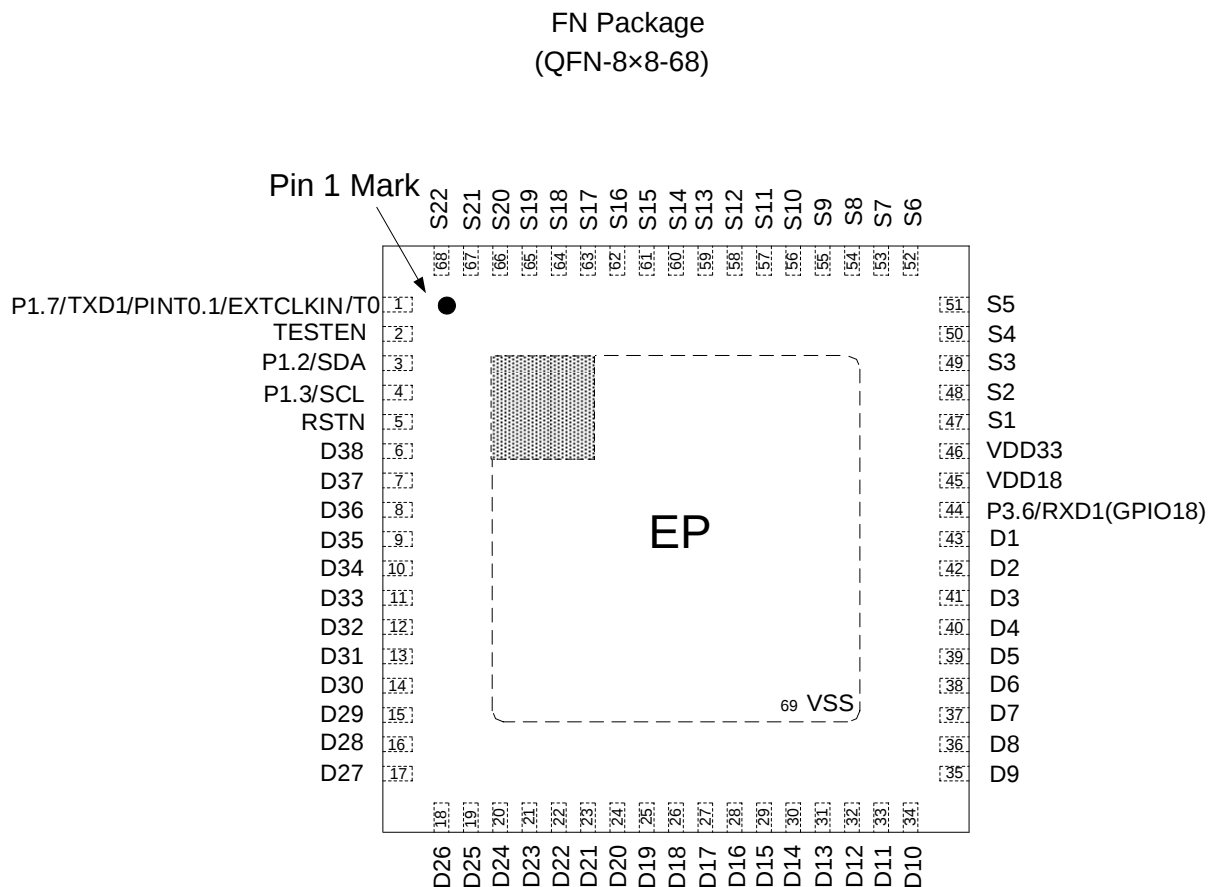


Figure 3. Pin Configuration of AP3891 (Top View)

Enhanced Multi-touch Capacitive Touch Screen Controller

AP389X

Pin Configuration (Continued)

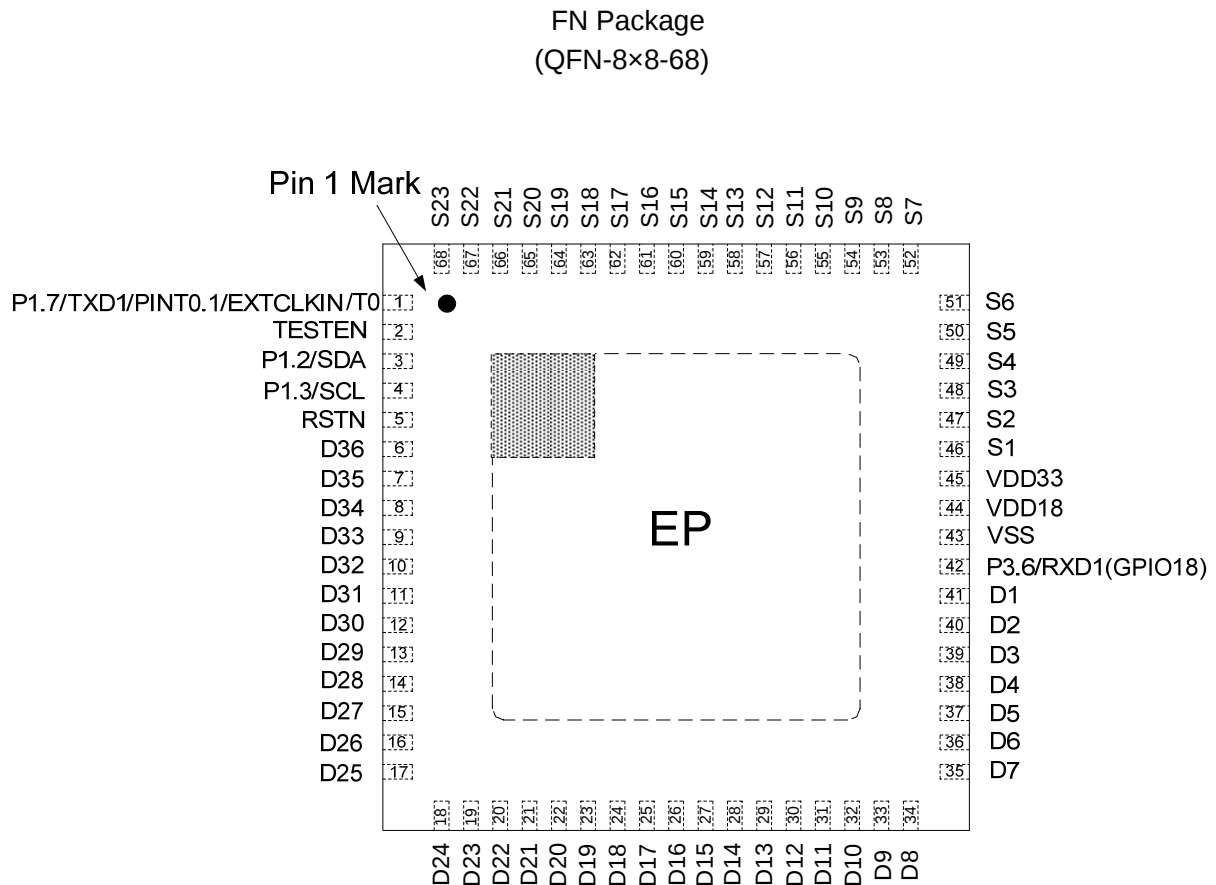


Figure 3. Pin Configuration of AP3892 (Top View)

**Enhanced Multi-touch Capacitive Touch Screen Controller****AP389X****Pin Description**

Pin Number			Pin Name	Pin Type	Pin Function
QFN-56 AP3890	QFN-68				
	AP3891	AP3892			
1	1	1	P1.7/ TXD1/ PINT0.1/ EXTCLKIN/ T0	I/O	Port 1.7 GPIO
					8051 P1.7 GPIO
					TXD1
					This pin also can be configured as TXD of UART 1
					PINT0.1
					This pin also can be configured as the expanded INTO interrupt
					External Clock Input
					External clock input source.
					T0 Timer 0 Input
					This pin also can be configured as Timer 0 input
2	2	2	TESTEN	I	Test Mode Enable High Active
					This pin has an internal weakly pull low resistor connected. If it is connected high, the chip enters into Test Mode condition
3	3	3	P1.2/SDA (open-drain)	I/O	Port 1.2 GPIO
					8051 P1.2 GPIO
					SDA
					This pin also can be configured as the SDA signal of the I2C master or I2C slave controller. In this operation mode, this pin should also be configured as bi-directional I/O with open-drain output
4	4	4	P1.3/SCL (open-drain)	I/O	Port 1.3 GPIO
					8051 P1.3 GPIO
					SCL
					This pin also can be configured as the SCL signal of the I ² C master or I ² C slave controller. In I ² C master mode, this pin should be configured as open-drain output. In I ² C slave, this pin should be configured as input only
5	5	5	RSTN	I	Reset Low Active
					Typically connect a resistor to VDD18 and a capacitor to VSS
					Low asserted and threshold at 0.5×V _{DD18} . When forced low, the chip enters into reset condition
					This pin should not be connected to any level above V _{DD18}



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Pin Description (Continued)

Pin Number			Pin Name	Pin Type	Pin Function
QFN-56 AP3890	QFN-68				
	AP3891	AP3892			
-	6, 7	-	D38, D37	O, A	D38, D37 Driving line 38 to line 37
-	8 to 13	6 to 11	D36 to D31	O, A	D36, D35, D34, D33, D32, D31 Driving line 36 to line 31
6 to 35	14 to 43	12 to 41	D30 to D1	O, A	D30, D29, D28, D27, D26, D25, D24, D23, D22, D21, D20, D19, D18, D17, D16, D15, D14, D13, D12, D11, D10, D9, D8, D7, D6, D5, D4, D3, D2, D1 Driving line 30 to line 1
36	44	42	P3.6/ RXD1 (open- drain)	I/O	Port 3.6 GPIO 8051 P3.6 GPIO This pin should be configured as open-drain output and the input range can be 1.8V to 3.3V RXD1 This pin also can be configured as RXD of UART 1
37	69	43	VSS	Power	Ground Voltage. 0V
38	45	44	VDD18	Power	Internal Regulator Output. 1.6V to 2.0V Typical decoupling capacitors of 0.1μF and 10μF should be connected between VDD18 and VSS
39	46	45	VDD33	Power	Supply Voltage. 2.8V to 3.6V A good decoupling capacitor between VDD33 and VSS is critical for good performance
40 to 56	47 to 63	46 to 62	S1 to S17	I, A	S1, S2, S3, S4, S5, S6, S7, S8, S9, S10, S11, S12, S13, S14, S15, S16, S17 Sensing line 1to line 17
-	64 to 68	63 to 67	S18 to S22	I, A	S18, S19, S20, S21, S22 Sensing line 18 to line 22
-	-	68	S23	I, A	S23 Sensing line 23

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Functional Block Diagram

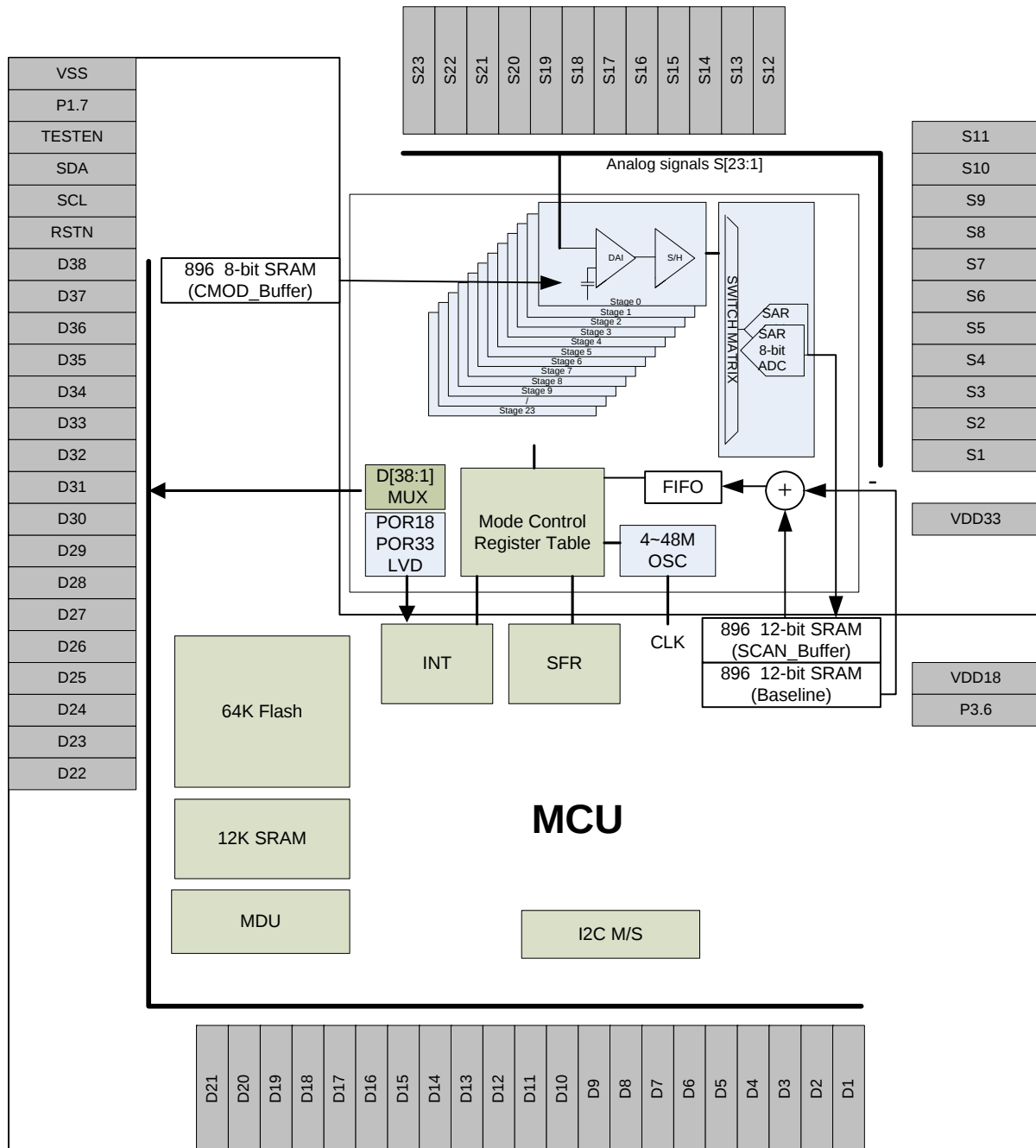
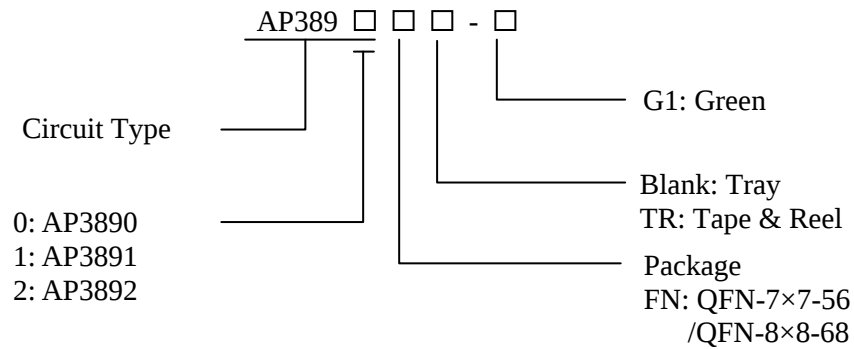


Figure 4. Main AFE I/O Pin Assignment and Whole Chip's Functional Block Diagram

**Enhanced Multi-touch Capacitive Touch Screen Controller****AP389X****Ordering Information**

Package	Temperature Range	Part Number	Marking ID	Packing Type
QFN-7x7-56	-40 to 95°C	AP3890FN-G1	AP3890FN-G1	Tray
		AP3890FNTR-G1	AP3890FN-G1	Tape & Reel
QFN-8x8-68		AP3891FN-G1	AP3891FN-G1	Tray
		AP3891FNTR-G1	AP3891FN-G1	Tape & Reel
QFN-8x8-68		AP3892FN-G1	AP3892FN-G1	Tray
		AP3892FNTR-G1	AP3892FN-G1	Tape & Reel

BCD Semiconductor's Pb-free products, as designated with "G1" in the part number, are RoHS compliant and green.

**Enhanced Multi-touch Capacitive Touch Screen Controller****AP389X****AP389X Support 7" to 13" Touch Panel, Listed Below:**

PN	TX/ RX	Multi - Touch	Package	Panel size
AP3890	30/17	10 point 100HZ	QFN-7x7-56	7" to 10"
AP3891	38/22	10 point 100HZ	QFN-8x8-68	8" to 13"
AP3892	36/23	10 point 100HZ	QFN-8x8-68	8" to 13"

Absolute Maximum Ratings (Note 1)

Parameter	Symbol	Value	Unit
Supply Voltage 1	V_{DD}	2.8 to 3.6	V
Supply Voltage 2	V_{DD18}	1.6 to 2.0	V
Analog Input Voltage (Other pins)	V_{DDA}	-0.3 to $V_{DD}+0.3$	V
Logic Input Voltage	V_{DDD}	-0.3 to $V_{DD}+0.3$	V
Power Dissipation	P_D	250	mW
Maximum Junction Temperature	T_J	100	°C
Operating Temperature	T_{OP}	-40 to 95	°C
Storage Temperature	T_{STG}	-65 to 150	°C

Note 1: Stresses greater than those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under "Recommended Operating Conditions" is not implied. Exposure to "Absolute Maximum Ratings" for extended periods may affect device reliability.

**Enhanced Multi-touch Capacitive Touch Screen Controller****AP389X****Electrical Characteristics****DA/AC Characteristics for AFE**T_A=-40°C to 95°C, V_{DD}=3.3V, I²C bus frequency=400kHz, unless otherwise noted.

Parameter	Symbol	Test Condition	Min	Typ	Max	Unit
ADC DC Accuracy						
Resolution					8	Bits
No Missing Codes		Standard/Fast	6	8		Bits
Integral Linearity Error	INL	Standard/Fast		±2		LSB
Differential Linearity Error	DNL	External V _{REF}		±1		LSB
Offset Error					±2	LSB
Gain Error					±1	LSB
Analog Input						
Full-scale Input Span			0		V _{DD}	V
Absolute Input Range			-0.2		V _{DD} +0.2	V
ADC Sampling Dynamics						
Throughput Rate			500			ksps
Reference Input						
Input Voltage Range			1.8		V _{DD}	V
Switched-capacitor Integrator						
Output Voltage Range			0.3		V _{DD} -0.3	V
Integrator Capacitor	C _{INT}			12		pF
Digital Input/Output						
Logic Family				CMOS		
Input High Voltage	V _{IH}		0.7×V _{DD}		V _{DD} +0.3	V
Input Low Voltage	V _{IL}		-0.3		0.3×V _{DD}	V
Output High Voltage	V _{OH}		0.8×V _{DD}			V
Output Low Voltage	V _{OL}				0.4	V
Input High Voltage for P3.6 (GPIO18)	V _{IH18}		0.7×V _{DD18}		V _{DD18} +0.3	V
Input Low Voltage for P3.6 (GPIO18)	V _{IL18}		-0.3		0.3×V _{DD18}	V
Output High Voltage for P3.6 (GPIO18)	V _{OH18}		0.8×V _{DD18}			V
Output Low Voltage for P3.6 (GPIO18)	V _{OL18}				0.2×V _{DD18}	V
Power Supply						
Supply Voltage	V _{DD}	Operating voltage	2.8		3.6	V
Quiescent Current		Standard mode: IOSC=4MHz to 48MHz		TBD		mA
		Power-down mode		10		μA
Temperature Range						
Specified Performance			-40		95	°C

**Enhanced Multi-touch Capacitive Touch Screen Controller****AP389X****Electrical Characteristics (Continued)****DA/AC Characteristics for AFE** $T_A = -40^{\circ}\text{C}$ to 95°C , $V_{DD} = 3.3\text{V}$, $I^2\text{C}$ bus frequency = 400kHz, unless otherwise noted.

Parameter	Symbol	Test Condition	Min	Typ	Max	Unit
3.3V-to-1.8V LDO						
Internal 1.8V Regulator Output	V_{DD18} , 15mA		1.6	1.8	2.0	V
Output Voltage Trimming Level			-2/4/6	0	2/4/6	%
Internal OSC						
Frequency			4		48	MHz
Operating Current		Operating frequency = 12MHz		50		μA
Frequency Trimming Level			-10/20/30	0	10/20/30	%

**Enhanced Multi-touch Capacitive Touch Screen Controller****AP389X****Electrical Characteristics (Continued)****DA/AC Characteristics for 8051 CPU Core, Digital GPIO pins, Digital Peripherals, and IOSC** $T_A = -40^{\circ}\text{C}$ to 95°C , $V_{DD} = 2.8\text{V}$ to 3.6V , unless otherwise noted.

Parameter	Symbol	Min	Typ	Max	Unit	Note
Power Supply Current						
Normal Mode Supply Current Using IOSC up to 48MHz	I_{DD} , normal IOSC1			25	mA	2
Normal Mode Supply Current Using IOSC=4MHz	I_{DD} , normal IOSC2		2.9		mA	2
PMM Mode Supply Current Using IOSC up to 48MHz	I_{DD} , PMM IOSC1		6		mA	2
PMM Mode Supply Current Using IOSC=4MHz	I_{DD} , PMM IOSC2		1.5		mA	2
Idle Mode Supply Current Using IOSC up to 48MHz	I_{DD} , idle IOSC1		3		mA	2
Stop Mode Supply Current Using IOSC Keeps Low	I_{DD} , stop		3		μA	2
Digital GPIO Characteristics						
Input High Voltage	V_{IH}	2		3.6	V	3
Input Low Voltage	V_{IL}	-0.3		0.8	V	3
Output High Voltage	V_{OH}	2.4			V	3
Output Low Voltage	V_{OL}			0.4	V	3
High Level Output Current @ $V_{OH}(\text{min})$	$I_{OH}(2\text{mA})$	3.0	7.87	12.9	mA	
	$I_{OH}(4\text{mA})$	7.7	15.6	25.8	mA	
Low Level Output Current @ $V_{OL}(\text{max})$	$I_{OL}(2\text{mA})$	3.4	5.4	7.4	mA	
	$I_{OL}(4\text{mA})$	6.7	10.7	14.7	mA	
Input Pull Up Resistance	R_{PU}	34		74	$k\Omega$	3
Input Pull Down Resistance	R_{PD}	29		86	$k\Omega$	3
Input Low to High Level, RSTN	V_{IH} , RSTN	0.85		0.93	V	4
Input High to Low Level, RSTN	V_{IL} , RSTN	0.63		0.71	V	4
Output Rise Time	t_{RISE}		5		ns	7
Output Fall Time	t_{FALL}		5		ns	7
Internal 3.3V-to-1.8V LDO from AFE						
Internal 1.8V Regulator Output	V_{DD18} , 15mA	1.6	1.8	2.0	V	5
Power On/Off Reset Level	V_{DD18} , Reset	80	85	90	%	6

Note 2: Does not include load current and tested under NOP loop and all peripheral disabled.

Note 3: For Digital I/O only.

Note 4: For RSTN pin only.

Note 5: Supply to internal digital and analog circuit only.

Note 6: This is measured as the percentage of steady state value of V_{DD18} .

Note 7: This is measured with 20pF load and 20% to 80% output level.

Enhanced Multi-touch Capacitive Touch Screen Controller

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Typical Application

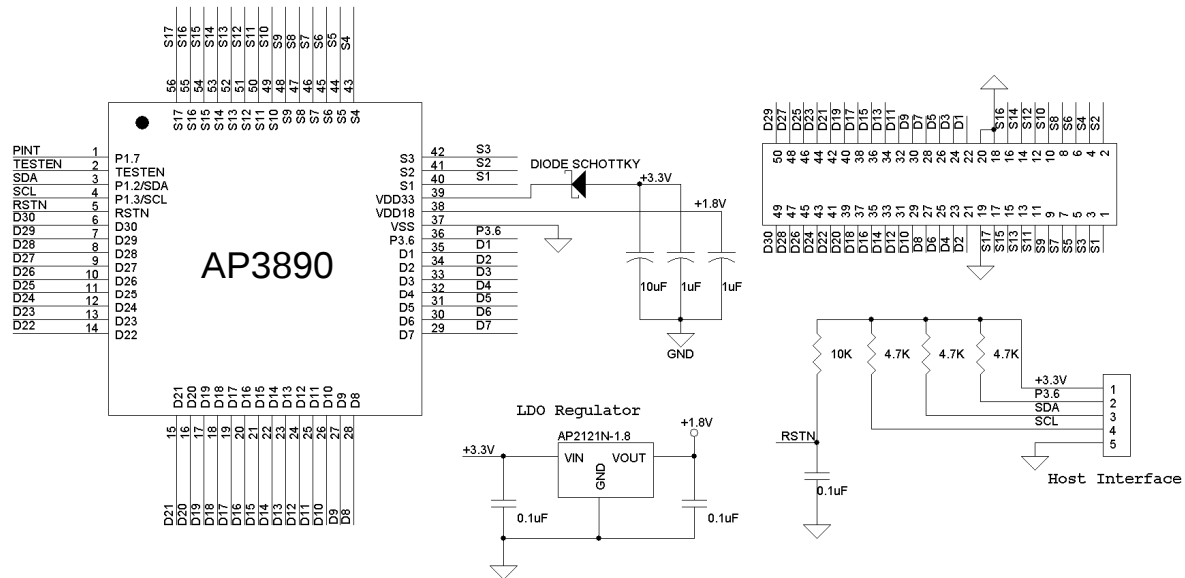


Figure 5. Typical Application Schematic of AP3890 (For QFN-7x7-56 Package)

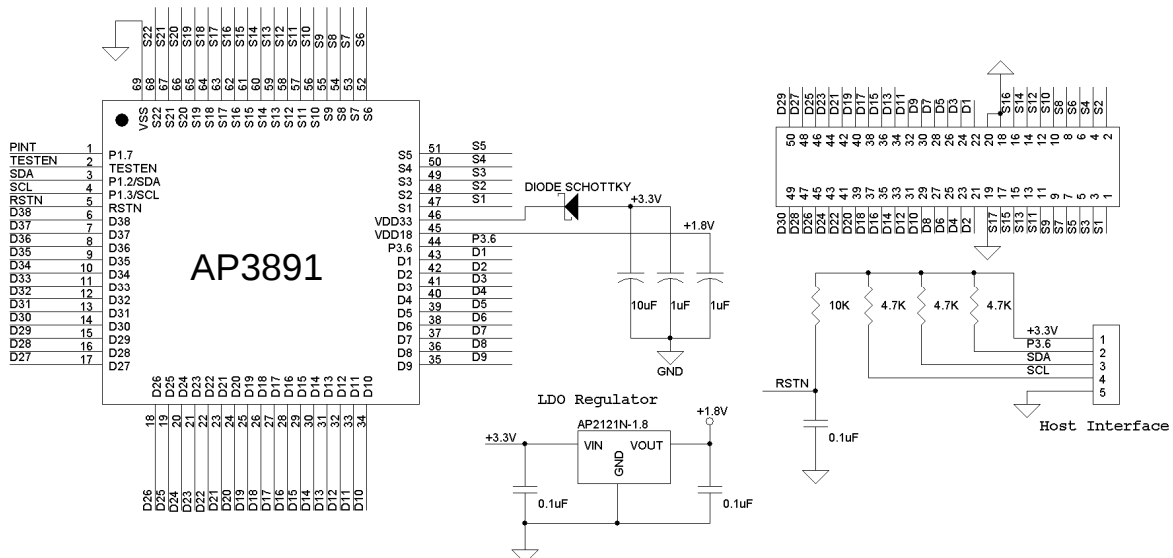


Figure 6. Typical Application Schematic of AP3891 (For QFN-8x8-68 Package)

Enhanced Multi-touch Capacitive Touch Screen Controller

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Typical Application (Continued)

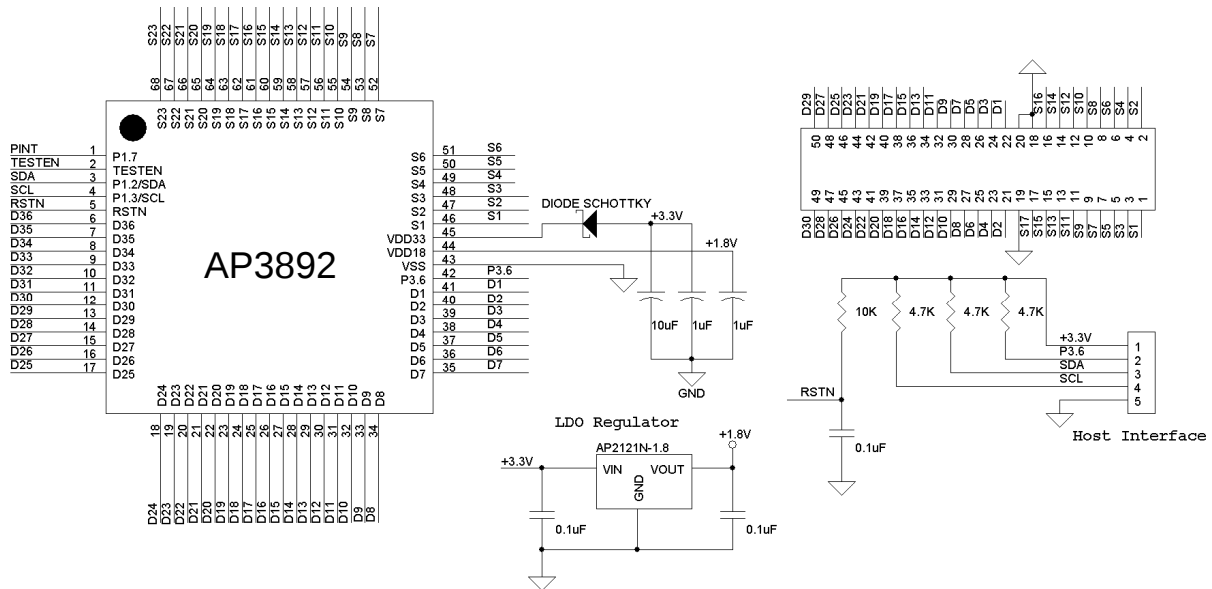
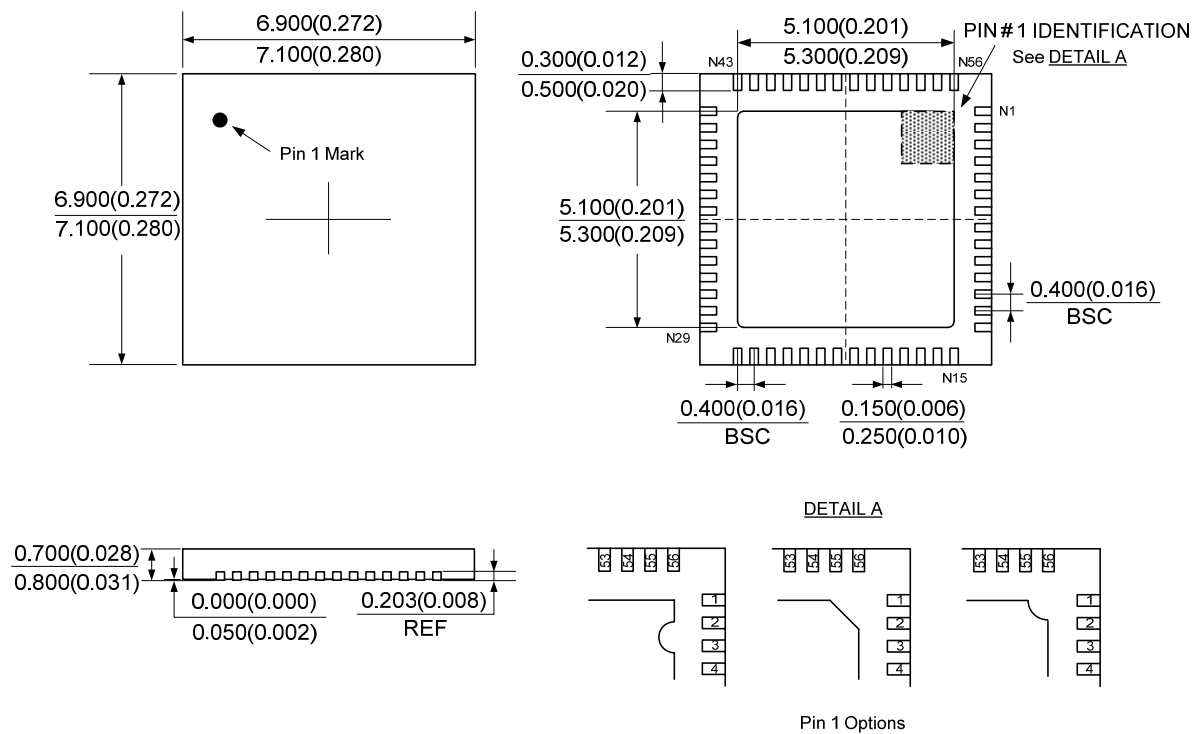


Figure 7. Typical Application Schematic of AP3892 (For QFN-8x8-68 Package)

Enhanced Multi-touch Capacitive Touch Screen Controller

AP389X

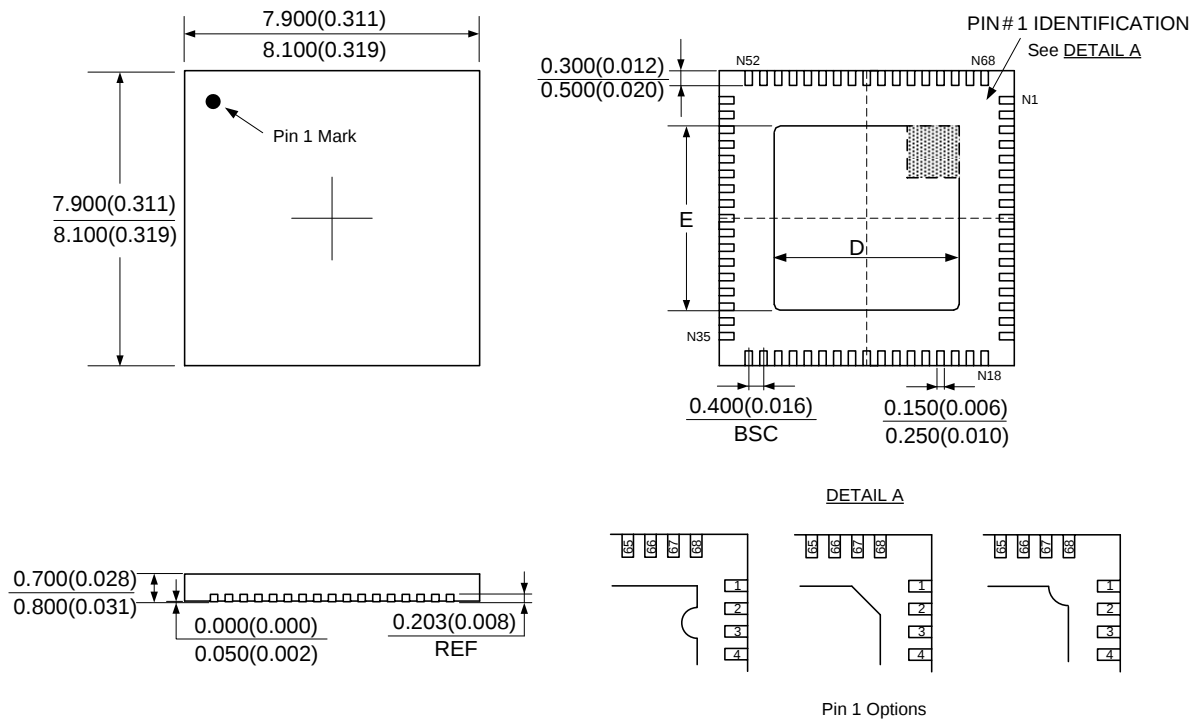
Mechanical Dimensions

QFN-7×7-56
Unit: mm(inch)


Enhanced Multi-touch Capacitive Touch Screen Controller

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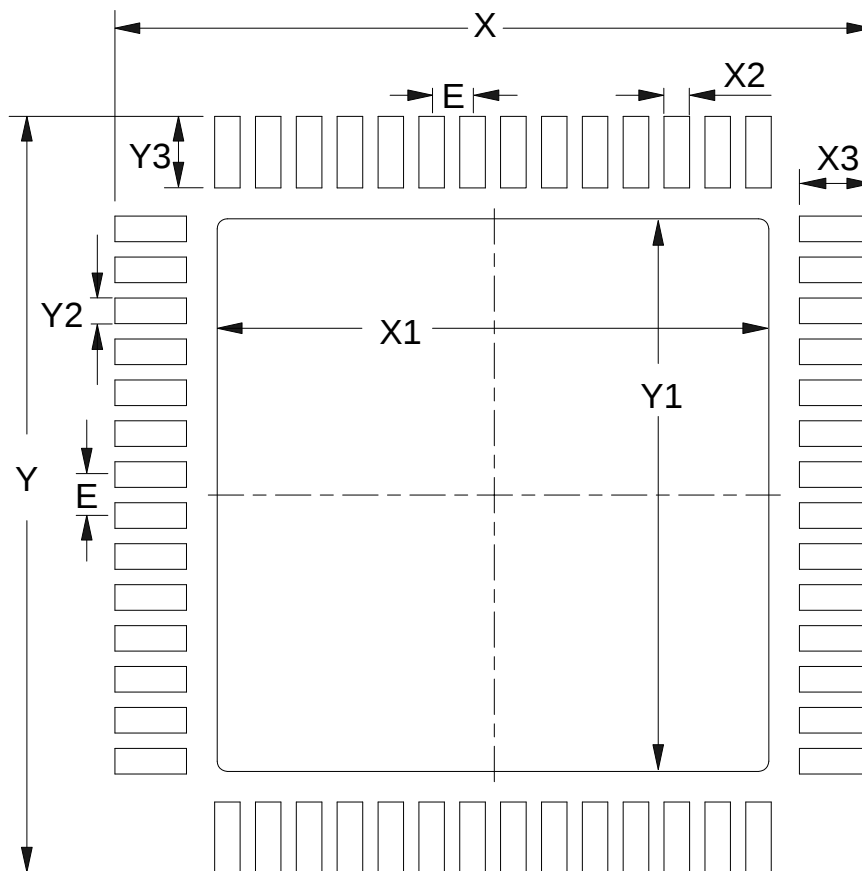
Mechanical Dimensions (Continued)

QFN-8×8-68
Unit: mm(inch)


Symbol	D				E			
	min(mm)	max(mm)	min(inch)	max(inch)	min(mm)	max(mm)	min(inch)	max(inch)
Option1	4.300	4.500	0.169	0.177	4.300	4.500	0.169	0.177
Option2	5.400	5.600	0.213	0.220	5.400	5.600	0.213	0.220
Option3	6.100	6.300	0.240	0.248	6.100	6.300	0.240	0.248

Mounting Pad Layout

QFN-7×7-56



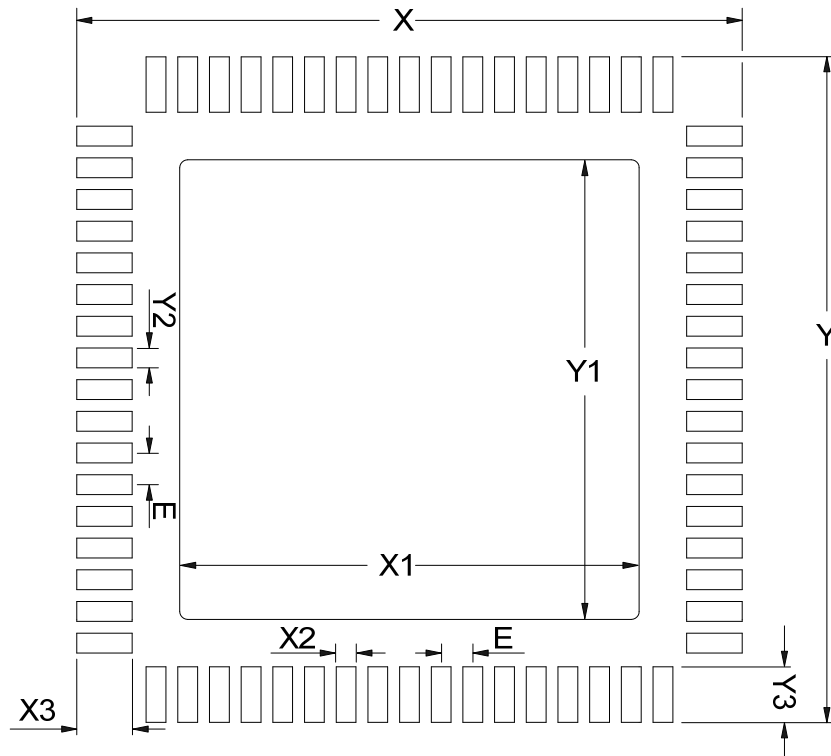
Dimensions	X=Y (mm)/(inch)	X1=Y1 (mm)/(inch)	X2=Y2 (mm)/(inch)	X3=Y3 (mm)/(inch)	E (mm)/(inch)
Value	7.400/0.291	5.400/0.213	0.250/0.010	0.700/0.028	0.400/0.016

Enhanced Multi-touch Capacitive Touch Screen Controller

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Mounting Pad Layout (Continued)

QFN-8×8-68



Dimensions	X=Y (mm)/(inch)	X1=Y1 (mm)/(inch)	X2=Y2 (mm)/(inch)	E (mm)/(inch)	X3=Y3 (mm)/(inch)
Option1	8.400/0.331	4.700/0.185	0.250/0.010	0.400/0.016	0.700/0.028
Option2	8.400/0.331	5.800/0.228	0.250/0.010	0.400/0.016	0.700/0.028
Option3	8.400/0.331	6.500/0.256	0.250/0.010	0.400/0.016	0.700/0.028



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