Preliminary Datasheet

TMA525C TrueTouch® Multi-touch All-points Touchscreen Controller

Features

- Multi-touch capacitive touchscreen controller
  - 32-bit ARM® Cortex® CPU
  - Register-configurable
  - Noise-suppression technologies for battery charger and display
    - Effective 24-V TX drive for higher signal-to-noise ratio (SNR)
    - ChargerArmor™ for charger noise immunity
    - External display synchronization
  - Water rejection and wet-finger tracking using DualSense™
  - Multi-touch glove with automatic mode switching
  - Fingernail tracking
  - Large-object rejection
  - Automatic baseline tracking to environmental changes
  - Low-power Look-for-touch mode
  - Field upgrades via bootloader
  - Android™ and Windows® Phone 10 host driver support
  - Parade Technologies™ TrueTouch® Manufacturing Test Kit (MTK)
  - Touchscreen sensor self-test and Panel ID reporting
- System performance (configuration-dependent)
  - Screen sizes up to 3.0-in. diagonal
  - 24 touchscreen I/O
    - 140 intersections (14 × 10)
  - Reports up to four fingers
  - Small-object support down to 4 mm
  - Large-object support up to 30 mm
  - Refresh rate up to 300 Hz; other rates configurable
  - TX frequency up to 500 kHz
  - Best-in-class charger noise immunity
    - Immunity up to 35V peak-to-peak (V_{PP})
    - Immunity to AT&T® Zero charger
- Power (configuration-dependent)
  - 1.71 to 1.95V or 2.0 to 5.5V digital and I/O supply
  - 2.65 to 4.7V analog supply
  - 4-mW average power
  - 5.7-µW typical deep-sleep power
- Sensor and system design (configuration-dependent)
  - Supports a variety of touchscreen sensors and stackups
    - Manhattan, Diamond, Single-Layer Independent Multi-touch (SLIM®), and Totem-pole patterns
    - Sensor-on-lens (SOL)
    - On-cell/hybrid in-cell touch-integrated display modules
    - Plastic (PET) and glass-sensor substrates
    - LCD, AMOLED, and IPS displays
    - Metal mesh
  - Single-layer flexible printed circuit (FPC) routing enabled by flexible transmit/receive (TX/RX) configurations
- Communication interface
  - I^2C slave at 100 and 400 kHz
- Package
  - 34-ball WLCSP (2.495 × 2.44 × 0.4-mm, 0.4-mm ball pitch)

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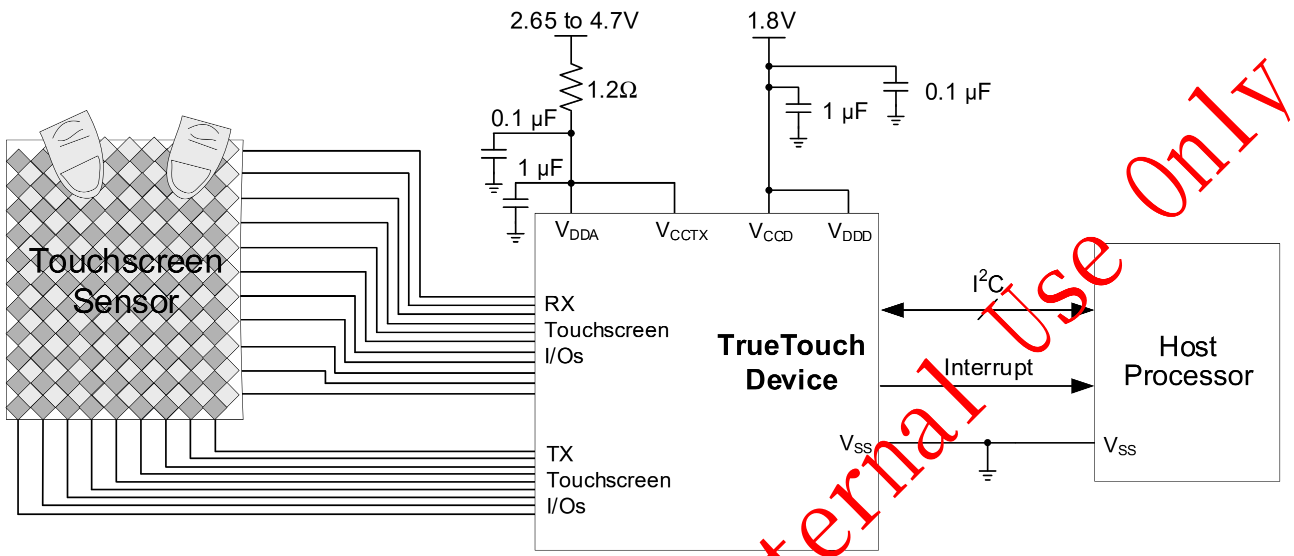
Touchscreen System Overview

Figure 1. TMA525C Typical System Diagram



TrueTouch TMA525C Overview

A capacitive touchscreen detects changes in capacitance to determine the location of one or more fingers on the touchscreen surface. A typical touchscreen system consists of a capacitive touchscreen sensor, an FPC bonded to the sensor, and the touchscreen controller mounted on the FPC. The FPC connects the touchscreen controller to the host processor. Users can interact with the displayed user interface through finger movements and gestures on the touchscreen surface.

TMA525C is a capacitive touchscreen controller with the sensing and processing technology to resolve the locations and report the positions of up to four fingers on the touchscreen. The touchscreen controller converts an array of sensor capacitances into an array of digital values, which are processed by touch-detection and position-resolution algorithms within the controller. These algorithms determine the location and signal magnitude of each finger on the touchscreen.

Parade provides:

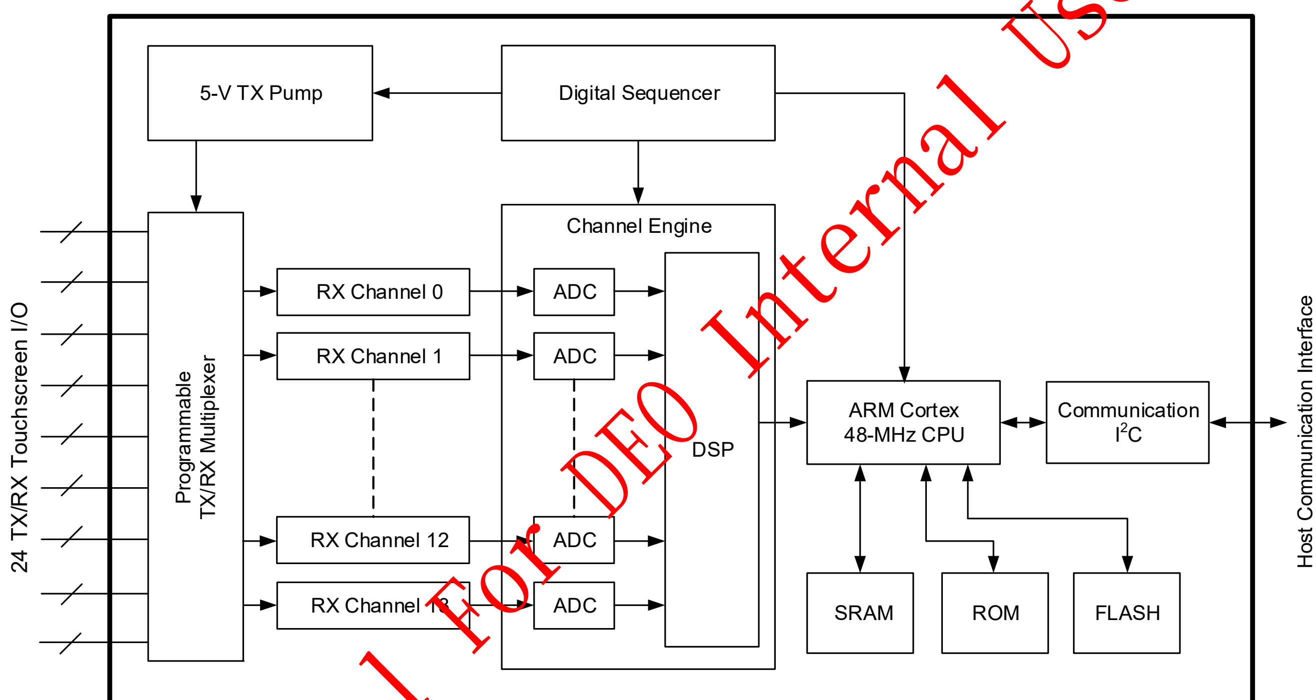
- Application firmware
- Android and Windows Phone 10 host drivers
- Design guidance for the sensor and FPC
- Touchscreen sensor MTK

The TMA525C block diagram is shown in Figure 2. This device contains a high-performance ARM 32-bit CPU with an integrated hardware multiply unit. This CPU controls all sensing and processing of measured capacitance results to allow tracking and reporting of touches. The controller is optimized for low power and fast response time, with built-in support for manufacturing test. The touchscreen controller communicates with a host through an I^2C slave interface at up to 400 kHz.

TMA525C collects the touchscreen sensor information using the touch subsystem. This touch subsystem consists of a 5-V TX pump, TX drivers, RX channels, and a programmable multiplexer. The multiplexer electrically connects the analog front end of each RX channel and TX driver to the appropriate row and column electrodes of the touchscreen sensor.

The controller TX/RX multiplexer allows flexibility of chip placement on the FPC. All ball connecting to the touchscreen sensor are programmable as either TX or RX. See the specification, *TrueTouch® Touchscreen Controller Module Design Best Practices* (001-50467), for recommended configurations. Parade reference documents are available under NDA through your local Parade sales representative. You can also direct your requests to Sales@paradetech.com.

Figure 2. TMA525C Functional Block Diagram



TrueTouch Features Overview

ChargerArmor

ChargerArmor enables touchscreens in handsets, cameras, global positioning systems (GPSs), and other mobile devices to function while connected to noisy chargers. Low-cost, third-party, and after-market battery chargers can generate high-amplitude common-mode noise that directly couples into the touchscreen sensor during a touch. This noise degrades touch performance, causing inaccurate and phantom touches. Many mobile phone vendors worked together to create the *EN62684* and *EN301489* standards, which set limits for the noise spectrum and magnitude for battery chargers. With ChargerArmor, TMA525C goes beyond these standards to operate with a broader range of chargers.

Water Rejection

Water droplets can cause false touches to be reported. However, TMA525C continues to operate in the presence of water droplets or condensation. TMA525C enables water rejection using DualSense, Parade's patented self- and mutual-capacitance sensing ability.

Wet-finger Tracking

In a touchscreen system, moisture on fingers can cause false touches to be reported and make tracking of fingers across the screen difficult. TMA525C can detect and track fingers that are wet and enable more robust functionality of the touchscreen. This includes sweaty fingers touching the screen or fingers moving across a mist-covered screen.

Glove

TMA525C detects and tracks gloved fingers. Glove support allows navigating the touchscreen without having to remove gloves or without the use of expensive conductive gloves. Tracking of gloved fingers is supported by automatic mode switching, which automatically transitions between tracking gloved fingers and other touch-tracking modes. Two-finger glove touch is supported.

Automatic Mode Switching

TMA525C supports automatic mode switching, which detects and tracks a new touch object type without requiring manual selection of the touch type from the user. Automatic mode switching allows an uninterrupted user experience when switching between a bare finger, gloved finger, fingernail, or wet finger.

Grip Suppression

TMA525C enables grip suppression for a natural user experience. While using a touchscreen device, the user can grip the device such that the gripping fingers touch the screen. This may cause a loss in touchscreen performance due to the detection of unintended fingers. Grip suppression is the ability to filter out unintended touches at the edge of the touchscreen while still supporting normal functionality in the remainder of the touchscreen. TMA525C interprets the quality and size of touches at the edge of a screen, tracks them as they move, and ensures that they do not trigger false touches while keeping the touchscreen surface responsive to touch and finger tracking. The grip suppression areas are register-configurable.

Large-object Tracking

A well-designed touchscreen system must correctly report a large finger or thumb as only a single touch. If this is not supported, a large finger can incorrectly be reported as two or more touches, hampering the user experience. When an object, such as a thumb, is pressed against the touchscreen sensor, TMA525C ensures that only one touch is reported at the object's center.

Large-object Detection and Rejection

It is important to be able to detect the presence of a large object on the touchscreen sensor. Two common examples are touching a palm on the screen when typing and pressing the side of a face on the screen when talking on a phone. TMA525C can determine the presence of a large object, such as a fist, palm, or the side of a face from the touchscreen data. This presence may either be rejected or reported to the host.

Look-for-touch

Look-for-touch is a low-power and fast-wakeup mode in which the touchscreen sensor is measured for an increase in self-capacitance. An increase in self-capacitance indicates that a touch is present. Because it is only necessary to detect a finger's presence, and not location, the sensing can be done at a much lower SNR, which requires less time and power. Look-for-touch sensing is used to implement multiple functions, including wake-on-touch and fast first-touch response.

Touchscreen System Specifications

This section specifies the touchscreen system performance delivered by TMA525C. For definitions, justification of parameters, and test methodologies, see the specification, *TrueTouch® Touchscreen Controller Performance Parameters* (001-49389)[1].

System Performance Specifications

The specifications listed in Table 1[2] and Table 2[3] are valid under these conditions: $-40°C \le T_A \le 85°C$, $1.71V \le V_{DDD} \le 1.95V$ or $2.0V \le V_{DDD} \le 5.5V$, $1.71V \le V_{CCD} \le 1.95V$, $2.65V \le V_{DDA} \le 4.7V$, unless otherwise noted. Typical values are specified at $T_A = 25°C$, $V_{DDD} = V_{CCD} = 1.8V$, core low-dropout regulator (LDO) disabled, and $V_{DDA} = 2.7V$, unless otherwise noted. Data was taken on a sensor with 4.8-mm electrode pitch.

Contact your local Parade sales representative for information on the system performance conditions to guarantee the specifications listed in Table 1. The performance conditions and specifications are valid only for sensors approved by Parade for use with TMA525C and produced by qualified Parade partners. Contact Sales@paradetech.com to discuss any deviations.

Table 1. Typical System Performance Specifications (Configuration-dependent)

Category	Conditions	Core	Units
Accuracy	4- to 6-mm diameter finger.	1	mm
	6 mm < finger diameter ≤ 12 mm.	0.5	mm
	Glove (1 mm < thick ≤ 5 mm).	2	mm
Linearity	4- to 12-mm diameter finger.	0.5	mm
	Glove (1 mm < thick ≤ 5 mm).	1	mm

Table 2. System Performance Specifications (Configuration-dependent)

Category	Description	Conditions	Min	Typ	Max	Units
Jitter	Delta in Reported X,Y Position, for Non-moving Finger	4- to 12-mm diameter finger.	–	0.5	–	mm
Refresh Rate	–	One finger on panel.	60	120	300[4]	Hz
Noise Handling	Charger Noise Immunity	10 to 500 kHz at 10-kHz steps, 50% duty cycle, no false touches, no false lift-offs, 9-mm finger, 60-Hz refresh rate.	35	–	–	V_{PP}
Response Time	Active Look-for-touch State Response Time	First finger down.	–	–	40	ms
	Wake from Deep Sleep Response Time	Time from host wake of device to first touch report.	–	–	100	ms
Power	In Active State	One finger, 60-Hz refresh rate.	–	16	–	mW
	In Active Look-for-touch State	–	–	4	–	mW
	Average Power[5]	TrueTouch device in Active state for 25% of touch activity and in Deep Sleep state for 75% of touch activity.	–	4	–	mW
	In Deep Sleep State	–	–	5.7	–	µW

Notes
1. Parade reference documents are available under NDA through your local Parade sales representative. You can also direct your requests to Sales@paradetech.com.
2. Typical, as represented by 85% of the sample data measured. Accuracy is measured at points across the entire panel at 1.1-mm intervals. Linearity is measured on lines drawn across the panel (vertically, horizontally, and diagonally) separated by 1.1 mm.
3. Typical, as represented by the average values from the specification, *TrueTouch® Touchscreen Controller Performance Parameters* (001-49389).
4. Requires setting TX pulses for mutual- and self-capacitance to 8 and no noise in the environment.
5. See "Power States Summary" on page 13 for power state transition details and refresh interval configuration for each state. Average power is the power consumed during the Active and Deep Sleep states, and is calculated using this equation: 0.25 × 16 mW + 0.75 × 0.0057 mW = 4 mW.

System Design Options

Operating System Driver Support and Register Map

Parade provides host drivers for Android and Windows Phone 10. These Parade drivers easily integrate into any product based on these operating systems. TMA525C has a standard host interface called Packet Interface Protocol (PIP), which allows device drivers to be repurposed for any devices within the TMA525C family. For full details of PIP, see *TMA445A, TT21X/31X, TT41X Technical Reference Manual (TRM)TMA445A, TT21X/31X, TT41X Technical Reference Manual (TRM)* – 001-88195[6].

TrueTouch Button/FPC Support

The TMA525C controller supports a maximum of four physical TrueTouch buttons. These buttons are sensed using mutual-capacitance scanning.

Detailed FPC development guidelines, including EMI shielding, are available in the specification, *TrueTouch® Touchscreen Controller Module Design Best Practices* (001-50467)[6].

Sensors

Parade supports the following sensor patterns:

- Single-Solid Diamond (SSD)
- Dual-Solid Diamond (DSD)
- Manhattan-3 (MH3)
- SLIM
- Totem-pole

Figure 3 through Figure 7 show examples of SSD, DSD, MH3, SLIM, and Totem-pole sensor patterns and unit cells, respectively.

Figure 3. Single-Solid Diamond Pattern and Unit Cell

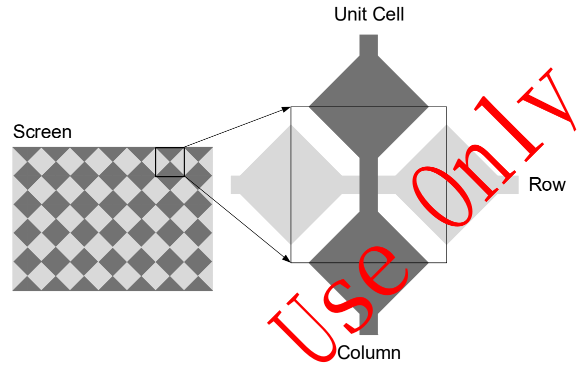


Figure 4. Dual-Solid Diamond Unit Cell

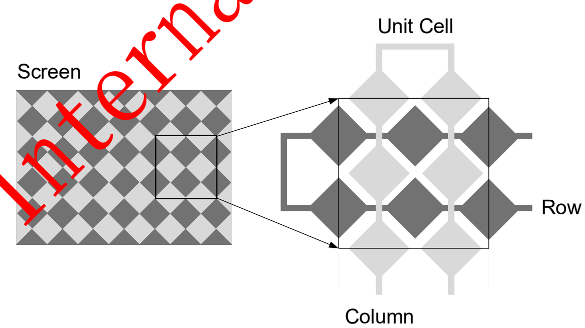
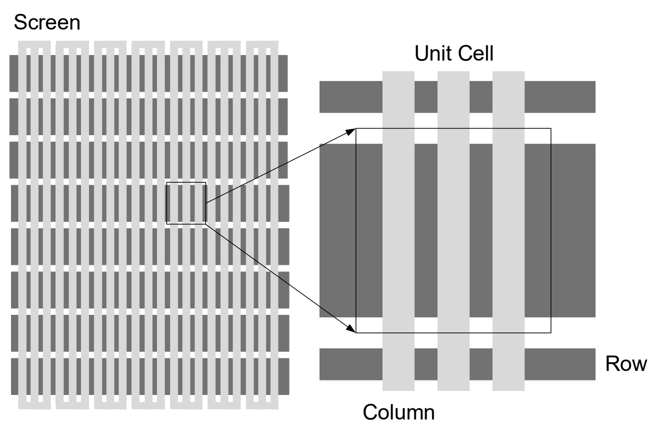


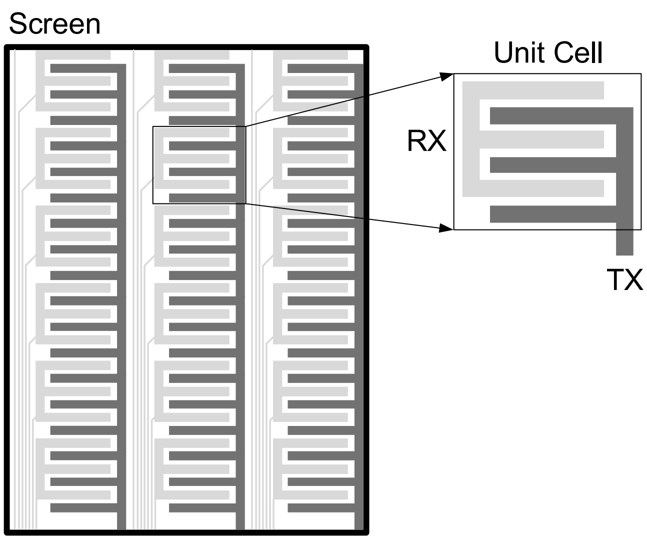
Figure 5. Manhattan-3 Pattern and Unit Cell



Note
6. Parade reference documents are available under NDA through your local Parade sales representative. You can also direct your requests to Sales@paradetech.com.

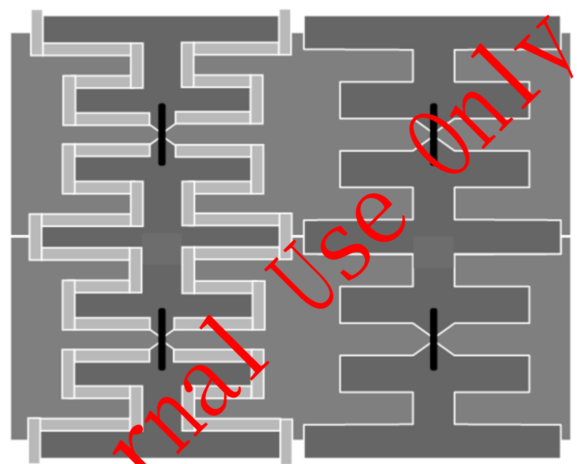
SLIM is a low-cost, single-layer sensor that supports 4-finger Multi-touch for displays up to 3-in. diagonal. This pattern has the benefits of borderless displays and an ultra-thin touchscreen stackup.

Figure 6. SLIM Pattern Unit Cell



Totem-pole is a new single-layer sensor pattern (with one bridge for each unit cell), which offers signal disparity comparable to DSD but with improved manufacturing yields.

Figure 7. Totem-Pole Pattern Unit Cell



Parade continues to develop additional patterns and materials to increase performance and decrease system cost.

The specific sensor pattern used varies based on the mechanical, electrical, optical, and cost constraints; these factors must all be considered for an optimal solution. Here are some examples:

- Overlays/lens thickness < 1 mm should not use SSD due to large signal disparity (SD)
- DCVCOM LCDs, with strong image-related noise, require an air gap, a shield layer, or a self-shielding pattern such as MH3

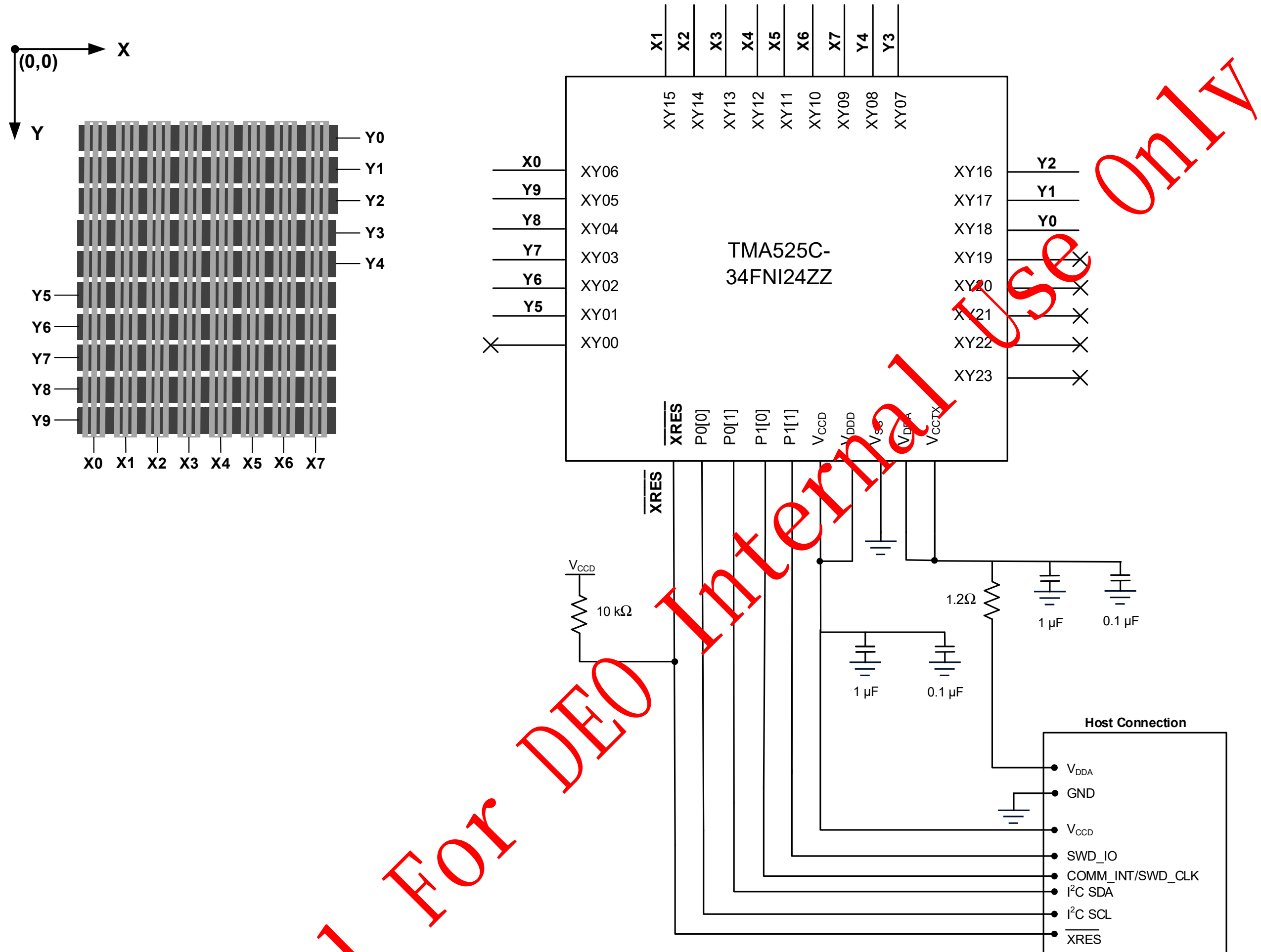
To learn more about how to design sensors using stackups and materials, see the specification, *TrueTouch® Touchscreen Controller Module Design Best Practices* (001-50467)[7].

Note

7. Parade reference documents are available under NDA through your local Parade sales representative. You can also direct your requests to Sales@paradetech.com.

Example Application Schematic

Figure 8. TMA525C-34FNI24ZZ Example Schematic (V_{CCD} = 1.8V, V_{DDA} = 2.65 to 4.7V)



Component Recommendations

V_{DDD} – Input 1.8-V, 0.1-µF high-frequency bypass capacitor[8].

V_{CCD} – Input 1.8-V, 1-µF low-frequency bypass capacitor[8].

V_{DDA} – Input 2.65 to 4.7-V, 0.1-µF high-frequency, 1-µF low-frequency bypass capacitors[8]. A 1.2-Ω, 5% tolerance resistor is required between V_{DDA} and the V_{DDA} filter capacitors to ensure safe operation under transient power conditions.

V_{CCTX} – Connect a 0.1-µF capacitor between this ball and ground.

The minimum dielectric temperature rating for all capacitors is X5R[8].

- In the FPC and PCB layouts, place capacitors near the package ball. Route interrupt, SCL, and SDA lines perpendicular to the sensor traces or isolate them from the sensor traces with ground.
- This schematic is for a 8-column (X) by 10-row (Y) panel, which supports a 2.0-in. diagonal display using electrodes with 4.3-mm pitch (XY ball assignments chosen for a center-connected device mounted at the bottom of the panel). Because the TMA525C controller supports up to 14 RX channels, it may also be center connected to the longer side of the panel and still support single-pass scanning of the panel. See *TMA445A, TT21X/31X, TT41X Technical Reference Manual (TRM)TMA445A, TT21X/31X, TT41X Technical Reference Manual (TRM)* – 001-88195[9] for ball assignment considerations and slot mapping information.
- X and Y indium tin oxide (ITO) electrodes are defined by the screen orientation, as depicted in the left half of Figure 8. X and Y refer to the column and row electrodes, respectively. The numbers begin with zero at the upper left. Touch coordinates are also reported beginning at the upper left.
- Touchscreen I/O assignments can be changed to optimize the layout. This provides FPC routing flexibility. Any XY ball can be defined as either a TX or RX touchscreen I/O to optimize performance and simplify routing of different sensors.
- COMM_INT is required for the Host connection.
- $\overline{\text{XRES}}$ is optional for Host connection but strongly recommended. If driven by a host that can tri-state its output (for example, when in a suspend or sleep state), use an external 10-kΩ pullup resistor connected to XRES. If XRES is not driven by the host, this input must be biased HIGH, either with a resistor or directly connected to V_{DDD} (with no resistor).
- Unused RX or TX ball should remain unconnected.

Notes
8. See "Voltage Coefficient" on page 11 for detailed information regarding voltage coefficient requirements for external capacitors.
9. Parade reference documents are available under NDA through your local Parade sales representative. You can also direct your requests to Sales@paradetech.com.

Power Supply Information

TMA525C contains up to five power ball: V_{DDA}, V_{DDD}, V_{CCD}, V_{CCTX}, and V_{SS}. V_{DDA} supplies power to the chip's analog circuitry, TX pump, and drivers. V_{DDD} supplies power to the digital I/Os, core LDO regulator, supply monitors, and external reset circuitry ($\overline{XRES}$). V_{CCD} supplies power to the CPU core. Whether it is configured as an input or output depends on whether a 1.71 to 1.95-V V_{DDD} supply is used.

Required External Components

The TrueTouch device requires external components for proper device operation. Quantities are dependent on the power supply configuration used.

V_{DDA}

- 1.2-Ω, 5% tolerance resistor
- 0.1-µF capacitor
- 1-µF capacitor (2.2-µF capacitor in systems with high V_{DDA} noise)

V_{DDD}

- 0.1-µF capacitor

V_{CCD}

- 1-µF capacitor when V_{CCD} and V_{DDD} are connected
- 0.1-µF capacitor when V_{CCD} and V_{DDD} are **not** connected

V_{CCTX}

- 0.1-µF capacitor (configurations with the TX pump enabled)

Voltage Coefficient

The actual capacitance of external capacitors may be reduced with higher bias voltage. Check the capacitor datasheet for the voltage coefficient. External capacitors require a dielectric with an X5R temperature rating or better. It is recommended to use an X7R dielectric or better for high-frequency 0.1-µF capacitors. Capacitors used for power supply decoupling or filtering are operated under a continuous DC-bias. Many capacitors used with DC power across them provide less than their target capacitance, and their capacitance is not constant across their working voltage range. When selecting capacitors for use with this device verify that the selected components provide the required capacitance under the specific operating conditions of temperature and voltage used in your design. While the temperature ratings of a capacitor are normally found as part of its catalog part number (for example, X7R, C0G, Y5V), the matching voltage coefficient may only be available on the component datasheet or direct from the manufacturer. Use of components that do not provide the required capacitance under the actual operating conditions may cause the device to perform to less than the datasheet specifications.

Figure 9 through Figure 11 show the available power configurations that have the TX pump enabled. Figure 12 through Figure 14 show power supply configurations with the TX pump disabled.

Figure 9. Lowest Power Consumption TX Pump Enabled

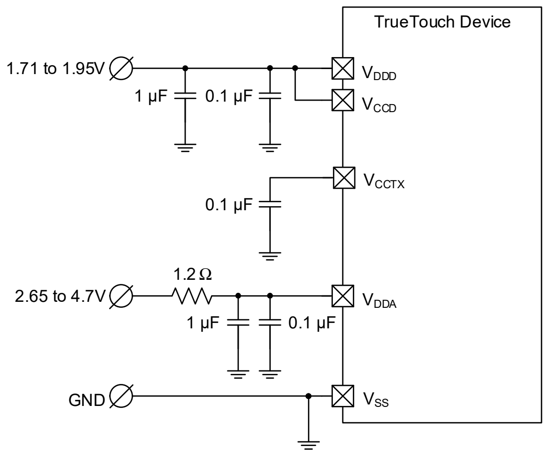


Figure 12. Lowest Power Consumption TX Pump Disabled

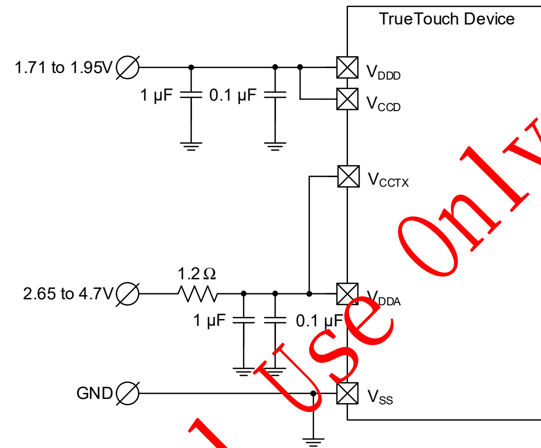


Figure 10. COM Interface > 2.0V TX Pump Enabled[10]

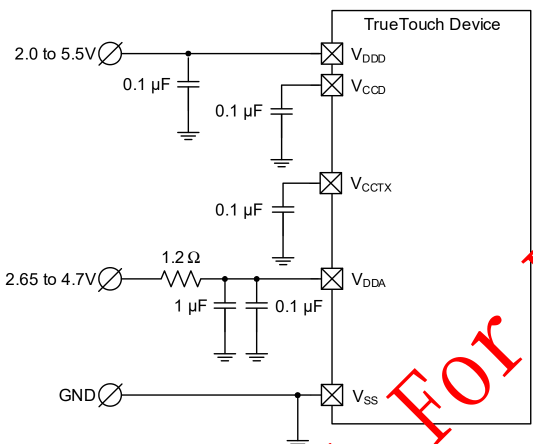


Figure 13. COM Interface > 2.0V TX Pump Disabled[10]

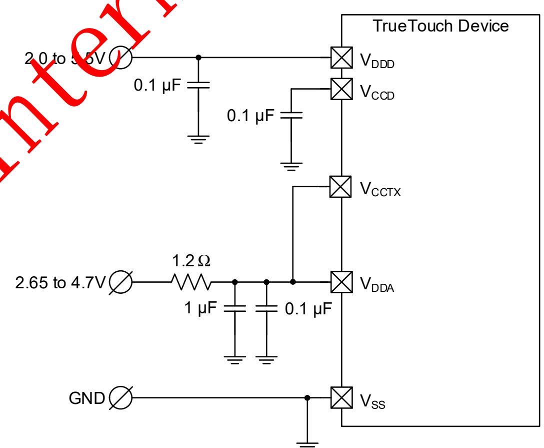


Figure 11. Single Supply TX Pump Enabled[10]

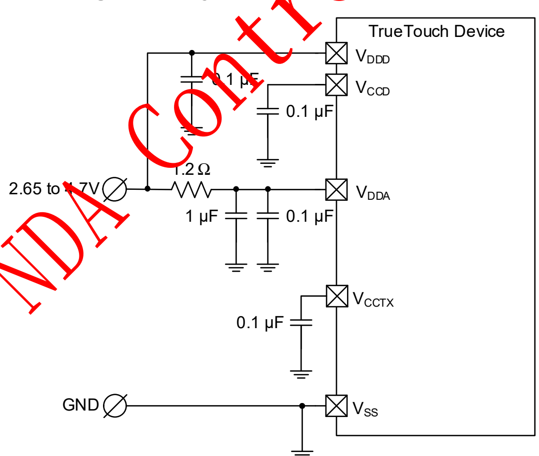
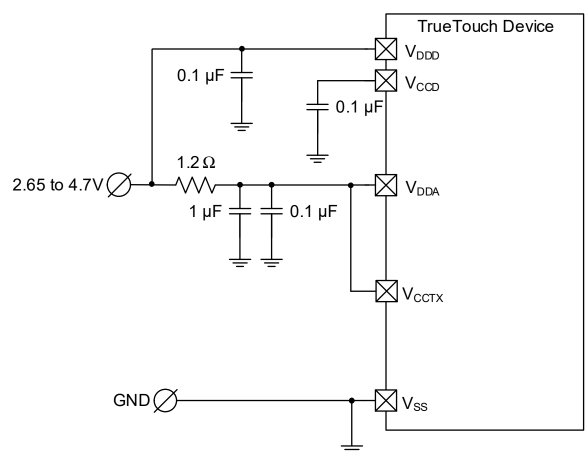


Figure 14. Single Supply TX Pump Disabled[10]



Note

10. 1.8-V communication is possible by using the 1.8-V mode for the digital inputs P0/P1, when $V_{DDD} \geq 2.0V$.

Power States Summary

The TMA525C controller has four power states, shown in Figure 15:

- Active, where the touchscreen is actively scanned to determine the presence of a touch and identify the touch coordinates
- Active Look-for-touch, where the device performs a fast self-capacitive scan to determine whether a touch exists
- Low Power, where the touchscreen is scanned for touch presence at a much slower rate
- Deep Sleep, where the touchscreen is not scanned and TMA525C is in a low-power state with no processing

The TMA525C controller automatically manages transitions between three power states (Active, Active Look-for-touch, and Low Power). The host can force transition in and out of the fourth power state (Deep Sleep). PIP allows the user to control power management and Deep Sleep; see *TMA445A, TT21X/31X, TT41X Technical Reference Manual (TRM)TMA445A, TT21X/31X, TT41X Technical Reference Manual (TRM)* – 001-88195[11].

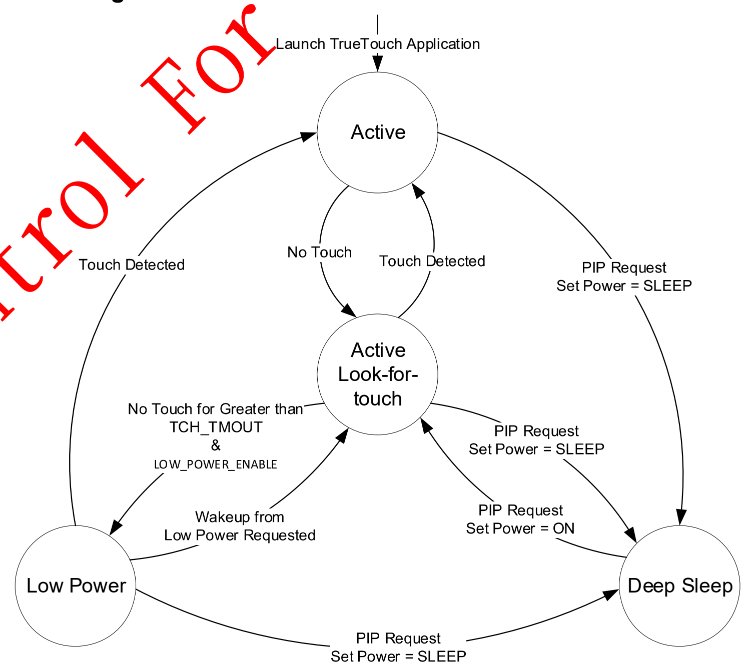
The Active state emphasizes low refresh time for accurate finger tracking, the Active Look-for-touch state allows fast first-touch response, and the Low Power state enables low power consumption during periods of no touch activity. In all three states, the TMA525C controller periodically scans the panel to determine the presence of a touch. If a touch is present, the controller either enters or remains in the Active state where it identifies the touch coordinates. These tasks occur at different rates in the three states and the detection of touches affects transitions between the states. Transition from Active to Active Look-for-touch occurs when no touch is detected.

By requesting low power to be disabled over PIP, the host can force the TMA525C controller to stay out of the Low-power state at all times for fastest response to the first touch on the panel.

The following parameters configure power states, which can be configured over PIP:

- Refresh Interval (register ACT_INTRVL) sets the minimum time between the start of subsequent touchscreen scans in the Active state.
- Active Look-for-touch Interval (register ACT_LFT_INTRVL) sets the minimum refresh time in the Active Look-for-touch state.
- Active Mode Timeout (register TCH_TMOUT) sets the period of time in which no touch is detected during the Active Look-for-touch state before transitioning to the Low-power state.
- Low-Power Interval (register LP_INTRVL) sets the time in the Low-power state between touchscreen scans.
- Deep Sleep is entered via a command from the host to move the device into the Deep Sleep state. Automatic entry into the Low Power state is enabled by setting the LOW_POWER_ENABLE parameter.

Figure 15. TMA525C Power States and Transitions



Note
11. Parade reference documents are available under NDA through your local Parade sales representative. You can also direct your requests to Sales@paradetech.com.

Ball Information

TMA525C is available in a 34-ball WLCSP package. This section lists ball names, descriptions, and mapping to the physical package. Input and output balls may have more than one possible configuration. Guidance for each configuration option is provided below:

XY – XY ball may be configured as either transmit (TX) drive or receive (RX) touchscreen I/O, allowing each design to be optimized based on the sensor pattern and layout. See the specification, *TrueTouch® Touchscreen Controller Module Design Best Practices* (001-50467), for guidelines[12]. To configure the device for lowest power, unused XY ball should remain unconnected. TX and RX ball are internally tied to V_{SS} during the Deep Sleep power state.

P1 – Unused Port 1 digital ball should remain unconnected.

SWD – Serial wire debug (SWD) is the recommended programming mode for all designs. If the SWD ball are used in the end product, shared Panel ID ball cannot be directly tied to V_{DDD} or V_{SS}. If SWD is not used on the target board, use the bootloader to upgrade firmware.

COMM_INT – The COMM_INT ball may be configured to use the internal pullup/pulldown resistor. If an external component is used, use the same value specified for R_{INT} in Table 9. The COMM_INT ball may be shared with the SWDCLK ball on the target board.

I²C – The I²C ball require external pullup/pulldown resistors. Consult the *UM10204 I²C-Bus Specification and User Manual* for minimum and maximum resistor values.

External Reset ($\overline{XRES}$) – If the $\overline{XRES}$ ball is unused, it must be connected to V_{DDD}, either directly or through a pullup resistor.

SWDIO/SWDCLK – Serial wire debug (SWD) is the recommended programming mode for all designs.

Panel ID – The Panel ID ball allows TMA525C to automatically report to which panel it is connected when two panel vendors are used. The Panel ID ball is sensed after device reset (or power-up), and the 1-bit value is stored in the System Information registers. The Panel ID ball is available on P1[1]. Use the bootloader to upgrade firmware if the Panel ID ball is used. An unused Panel ID ball is configured as a high-Z output. See *TMA445A, TT21X/31X, TT41X Technical Reference Manual (TRM)TMA445A, TT21X/31X, TT41X Technical Reference Manual (TRM)* – 001-88195 for configuration details[12].

Ball Configuration – Multiple ball configurations are supported using TrueTouch Host Emulator (TTHE) software. Balls are configured using the TTHE Pin Configuration Wizard.

Shared Panel ID Balls – If additional Panel ID ball are needed, external components may be added to allow sharing the Panel ID ball with SWD. If Panel ID ball are shared with another function, the ball must be pulled up or down with a 10 kΩ to 100 kΩ resistor. Panel ID ball shared with SWD ball must be high-Z when SWD is performed by the host controller from the time $\overline{XRES}$ is deasserted until the first COMM_INT. If SWD is performed from an external programmer, the host must not drive any of the Panel ID ball during programming.

Do Not Use (DNU) – DNU balls must remain unconnected to ensure proper device operation.

Note
12. Parade reference documents are available under NDA through your local Parade sales representative. You can also direct your requests to Sales@paradetech.com.

Table 3. 34-ball WLCSP, 24-Touchscreen I/O TMA525C-34FNI24ZZ[13]

Ball No.	Name	Digital	Analog	Description	Ball No.	Name	Digital	Analog	Description
A6	XY06	–	I/O	TX Drive or RX Touchscreen I/O	C3	XY15	–	I/O	TX Drive or RX Touchscreen I/O
C5	XY05	–	I/O	TX Drive or RX Touchscreen I/O	A2	XY14	–	I/O	TX Drive or RX Touchscreen I/O
B6	XY04	–	I/O	TX Drive or RX Touchscreen I/O	B3	XY13	–	I/O	TX Drive or RX Touchscreen I/O
D4	XY03	–	I/O	TX Drive or RX Touchscreen I/O	A3	XY12	–	I/O	TX Drive or RX Touchscreen I/O
C6	XY02	–	I/O	TX Drive or RX Touchscreen I/O	C4	XY11	–	I/O	TX Drive or RX Touchscreen I/O
D5	XY01	–	I/O	TX Drive or RX Touchscreen I/O	A4	XY10	–	I/O	TX Drive or RX Touchscreen I/O
D6	XY00	–	I/O	TX Drive or RX Touchscreen I/O	B4	XY09	–	I/O	TX Drive or RX Touchscreen I/O
F5	$\overline{XRES}$	I	–	External Active LOW Reset	A5	XY08	–	I/O	TX Drive or RX Touchscreen I/O
F6	P0[0]	I/O	–	I^2C SCL	B5	XY07	–	I/O	TX Drive or RX Touchscreen I/O
E6	P0[1]	I/O	–	I^2C SDA					
F4	P1[0]	I/O	–	COMM_INT / SWDCLK					
E5	P1[1]	I/O	–	SWDIO / Panel ID					
E4	V_{CCD}	Power		Digital Core Power Supply I/O					
E3	V_{DDD}	Power		Digital Power Supply Input					
E2	V_{SS}	Power		Ground					
F1	V_{DDA}	Power		Analog Power Supply Input					
E1	V_{CCTX}	Power		TX Pump Reservoir and Filter Capacitor Connection Point					
D2	XY23	–	I/O	TX Drive or RX Touchscreen I/O					
D1	XY22	–	I/O	TX Drive or RX Touchscreen I/O					
D3	XY21	–	I/O	TX Drive or RX Touchscreen I/O					
C1	XY20	–	I/O	TX Drive or RX Touchscreen I/O					
C2	XY19	–	I/O	TX Drive or RX Touchscreen I/O					
B1	XY18	–	I/O	TX Drive or RX Touchscreen I/O					
B2	XY17	–	I/O	TX Drive or RX Touchscreen I/O					
A1	XY16	–	I/O	TX Drive or RX Touchscreen I/O					

Ball Grid Map (Bottom View)

6	5	4	3	2	1	
XY 06	XY 08	XY 10	XY 12	XY 14	XY 16	A
XY 04	XY 07	XY 09	XY 13	XY 17	XY 18	B
XY 02	XY 05	XY 11	XY 15	XY 19	XY 20	C
XY 00	XY 01	XY 03	XY 21	XY 23	XY 22	D
P0 [1]	P1 [1]	V_{CCD}	V_{DDD}	V_{SS}	V_{CCTX}	E
P0 [0]	$\overline{XRES}$	P1 [0]			V_{DDA}	F

Note
13. See "Ball Information" on page 14 for details regarding ball configuration.

Electrical Specifications

This section lists TMA525C DC and AC electrical specifications.

Absolute Maximum Ratings

Table 4. Absolute Maximum Ratings

Symbol	Description	Conditions	Min	Typ	Max	Units
T_{STG}	Storage Temperature	–	–55	25	100[13]	°C
V_{DDD}	Digital Supply Voltage	–	V_{SS} – 0.5	–	6	V
V_{DDA}	Analog Supply Voltage	–	V_{SS} – 0.5	–	6	V
V_{CCTX}	TX Supply	–	V_{SS} – 0.5	–	6	V
V_{DDDR}[14]	Digital (V_{DDD}) Supply Ripple Voltage	Amplitude of AC riding on DC (V_{PP}), DC to 20 MHz.	–	–	100	mV
V_{DDAR}[14]	Analog (V_{DDA}) Supply Ripple Frequency (TX Pump Enabled)	Amplitude of AC riding on DC (V_{PP}), DC to 20 MHz.	–	–	100	mV
	Analog (V_{DDA}) Supply Ripple Frequency (TX Pump Disabled)	Amplitude of AC riding on DC (V_{PP}), 150 kHz to 20 MHz. A maximum of 15mV is supported for DC to 150 kHz, +dB/decade for >150 kHz (80 kHz when a 2.2 µF capacitor is used in place of a 1 µF capacitor), measured at the input pin to external components.	–	–	100	mV
V_{CCD}	Core Supply Voltage	–	V_{SS} – 0.5	–	2.3	V
V_{TX}	Touchscreen I/O Voltage (HIGH State)	–	V_{CCTX}–0.5	–	V_{CCTX}	V
V_{GPIO}	Port 0 Ball Voltage	Driver is enabled.	V_{SS} – 0.5	–	6	V
	Port 0 Ball Voltage	Driver is disabled.	V_{SS} – 0.5	–	7	V
	Port 1/$\overline{XRES}$ Ball Voltage	–	V_{SS} – 0.5	–	V_{DDD} + 0.5	V
I_{IO}	Current into I/O Ball	–	–25	–	50	mA
ESD_{CDM}	Electrostatic Discharge Voltage	Charge device model.	1500	–	–	V
ESD_{HBM}	Electrostatic Discharge Voltage	Human body model.	5000	–	–	V

Operating Temperature

Table 5. Operating Temperature

Symbol	Description	Conditions	Min	Typ	Max	Units
T_A	Ambient Temperature	–	–40	–	85	°C

Note

14. Analog supply ripple specifications are valid for the supply presented to the external resistor (shown in Figure 9 on page 12), not at the device V_{DDA} ball.

Flash Specifications

The following specifications are valid under these conditions: –40°C ≤ T_A ≤ 85°C, 1.71V ≤ V_{DDD} ≤ 1.95V or 2.0V ≤ V_{DDD} ≤ 5.5V, 1.71V ≤ V_{CCD} ≤ 1.95V, and 2.65V ≤ V_{DDA} ≤ 4.7V. Typical values are specified at T_A = 25°C, V_{DDD} = V_{CCD} = 1.8V, core LDO disabled, and V_{DDA} = 2.7V.

Table 6. Flash Specifications

Symbol	Description	Conditions	Min	Typ	Max	Units
$Flash_{ENPB}$	Flash Write Endurance	Erase/write cycles per block.	10,000	–	–	cycles
$Flash_{DR}$	Flash Data Retention	Following maximum Flash write cycles ($Flash_{ENPB}$), T_A ≤ 55°C.	20[15]	–	–	years
		Following maximum Flash write cycles ($Flash_{ENPB}$), T_J ≤ 85°C.	10[15]	–	–	years

Chip-level DC Specifications

The following specifications are valid under these conditions: –40°C ≤ T_A ≤ 85°C, 1.71V ≤ V_{DDD} ≤ 1.95V or 2.0V ≤ V_{DDD} ≤ 5.5V, 1.71V ≤ V_{CCD} ≤ 1.95V, and 2.65V ≤ V_{DDA} ≤ 4.7V. Typical values are specified at T_A = 25°C, V_{DDD} = V_{CCD} = 1.8V, core LDO disabled, and V_{DDA} = 2.7V.

Table 7. Chip-Level DC Specifications

Symbol	Description	Conditions	Min	Typ	Max	Units
V_{DDD}	Digital Supply Voltage	Core LDO is enabled (V_{CCD} output).	2.0	–	5.5	V
		Core LDO is disabled (V_{CCD} input)[16].	1.71	1.8	1.95	V
V_{CCD}	Digital Core Supply Voltage	Core LDO is enabled (V_{CCD} output).	–	1.8	–	V
		Core LDO is disabled (V_{CCD} input)[16].	1.71	1.8	1.95	V
V_{DDA}[16]	Analog Supply Voltage	TX pump is enabled.	2.65	–	4.7	V
V_{CCTX}	V_{CCTX} Supply Operating Voltage Range	Input to external low-pass filter, TX Pump Disabled configuration.	3.0	–	5.5	V
V_{TX}	Touchscreen I/O Voltage (HIGH State)	TX pump is enabled.	V_{CCTX} – 0.5	–	V_{CCTX}	V
PSA_{RAMP}	V_{DDA} Ramp Up	–	–	–	100	mV/µs
I_{DDD_ACT}	V_{DDD} Active Current	–	–	15	30	mA
I_{DDA_ACT}	V_{DDA} Active Current	–	–	9	12	mA
I_{DDD_DS}	V_{DDD} Deep Sleep Current	–	–	1.65	–	µA
I_{DDA_DS}	V_{DDA} Deep Sleep Current	–	–	1	–	µA
I_{DDD_XR}	V_{DDD} Current, $\overline{XRES}$ = LOW	–	–	2	–	µA
I_{DDA_XR}	V_{DDA} Current, $\overline{XRES}$ = LOW	–	–	25	–	µA
I_{DDD_P}	V_{DDD} Flash Programming and Flash Verify Current	–	–	5	25	mA

Notes

15. Storing programmed devices at or above the ambient temperature specified by $Flash_{DR}$ may reduce flash data retention time.
16. These minimum and maximum limits are absolute limits, inclusive of noise. For proper operation, V_{DDA} or V_{DDD} with combined noise cannot go below or above the specified minimum and maximum limits.

I/O Port 0 (P0[0:1]) DC Specifications

The following specifications are valid under these conditions: $-40°C \leq T_A \leq 85°C$, $1.71V \leq V_{DDD} \leq 1.95V$ or $2.0V \leq V_{DDD} \leq 5.5V$, $1.71V \leq V_{CCD} \leq 1.95V$, and $2.65V \leq V_{DDA} \leq 4.7V$. Typical values are specified at $T_A = 25°C$, $V_{DDD} = V_{CCD} = 1.8V$, core LDO disabled, and $V_{DDA} = 2.7V$.

Table 8. I/O Port 0 (P0[0:1]) DC Specifications

Symbol	Description	Conditions	Min	Typ	Max	Units
V_{IH}	Input High Voltage	CMOS mode.	$0.7 \times V_{DDD}$	–	–	V
		1.8-V mode, V_{EXT} = 1.8V, V_{DDD} = 1.8, 3.0, 3.3, 5.0V.	$0.7 \times V_{EXT}$	–	–	V
V_{IL}	Input Low Voltage	CMOS mode.	–	–	$0.3 \times V_{DDD}$	V
		1.8-V mode, V_{EXT} = 1.8V, V_{DDD} = 1.8, 3.0, 3.3, 5.0V.	–	–	$0.3 \times V_{EXT}$	V
V_{OH}	High-Output Voltage	Reference to V_{DDD}, I_{OH} = 1 mA, V_{DDD} = 1.8V.	$V_{DDD} - 0.5$	–	–	V
		Reference to V_{DDD}, I_{OH} = 4 mA, V_{DDD} = 3.0V.	$V_{DDD} - 0.6$	–	–	V
V_{OL}	Low-Output Voltage	$V_{DDD} \geq 1.71V$, I_{OL} = 10 mA.	–	–	0.6	V
		$V_{DDD} \geq 1.71V$, I_{OL} = 3 mA.	–	–	0.4	
V_H	Input Hysteresis Voltage	–	$0.1 \times V_{DDD}$	–	–	V
T_{RISE_OV}	Output Rise Time Fast-Strong	25-pF load, 10 to 90% V_{DDD} = 3.3V.	2	–	12	ns
	Output Rise Time Slow-Strong	25-pF load, 10 to 90% V_{DDD} = 3.3V.	10	–	60	ns
T_{FALL_OV}	Output Fall Time Fast-Strong	25-pF load, 10 to 90% V_{DDD} = 3.3V.	1.5	–	12	ns
	Output Fall Time Slow-Strong	25-pF load, 10 to 90% V_{DDD} = 3.3V.	10	–	60	ns
I_{IL}[17]	Input Leakage Current (Absolute Value)	T_A = 25°C, V_{DDD} = 3.0V.	–	–	14	nA
		T_A = 25°C, V_{DDD} = 0.0V.	–	–	10	µA
C_{IN}	Input Ball Capacitance	Package- and ball-dependent T_A = 25°C.	–	–	7	pF
C_{OUT}	Output Ball Capacitance	Package- and ball-dependent T_A = 25°C.	–	–	7	pF
R_{INT}	Internal Pullup/Pulldown Resistance	Ball configured for internal pullup or pulldown.	3.5	5.6	8.5	kΩ

Note
17. Gang tested with all I/Os to 1 µA.

I/O Port 1 (P1[0:3]) and $\overline{\text{XRES}}$ DC Specifications

The following specifications are valid under these conditions: –40°C ≤ T_A ≤ 85°C, 1.71V ≤ V_{DDD} ≤ 1.95V or 2.0V ≤ V_{DDD} ≤ 5.5V, 1.71V ≤ V_{CCD} ≤ 1.95V, and 2.65V ≤ V_{DDA} ≤ 4.7V. Typical values are specified at T_A = 25°C, V_{DDD} = V_{CCD} = 1.8V, core LDO disabled, and V_{DDA} = 2.7V.

Table 9. I/O Port 1 (P1[0:3]) and $\overline{\text{XRES}}$ DC Specifications

Symbol	Description	Conditions	Min	Typ	Max	Units
V_{IH}	Input Voltage High Threshold, 1.8V ≤ V_{DDD} ≤ 5.5V	1.8-V configuration.	1.26	–	–	V
		CMOS configuration.	0.7 × V_{DDD}	–	–	V
		$\overline{\text{XRES}}$.	1.35	–	–	V
V_{IL}	Input Voltage Low Threshold, 1.8V ≤ V_{DDD} ≤ 5.5V	1.8-V configuration.	–	–	0.54	V
		CMOS configuration.	–	–	0.3 × V_{DDD}	V
		$\overline{\text{XRES}}$.	–	–	0.45	V
V_{OH}	High-output Voltage	I_{OH} = 4 mA, V_{DDD} = 3.0V.	V_{DDD} – 0.6	–	–	V
		I_{OH} = 1 mA, V_{DDD} = 1.8V.	V_{DDD} – 0.5	–	–	V
V_{OL}	Low-output Voltage	I_{OL} = 8 mA, V_{DDD} = 3.3V.	–	–	0.6	V
		I_{OL} = 4 mA, V_{DDD} = 1.8V.	–	–	0.6	V
V_H	Input Hysteresis Voltage	–	0.1 × V_{DDD}	–	–	V
T_{RISE_G}	Output Rise Time Fast-Strong	25-pF load, 10 to 90% V_{DDD} = 3.3V.	2	–	12	ns
	Output Rise Time Slow-Strong	25-pF load, 10 to 90% V_{DDD} = 3.3V.	–	–	60	ns
T_{FALL_G}	Output Fall Time Fast-Strong	25-pF load, 10 to 90% V_{DDD} = 3.3V.	2	–	12	ns
	Output Fall Time Slow-Strong	25-pF load, 10 to 90% V_{DDD} = 3.3V.	–	–	60	ns
I_{IL}[17]	Input Leakage Current (Absolute Value)	–	–	–	2	nA
C_{IN}	Input Ball Capacitance	Package- and ball-dependent T_A = 25°C.	–	–	7	pF
C_{OUT}	Output Ball Capacitance	Package- and ball-dependent T_A = 25°C.	–	–	7	pF
R_{INT}[18]	Internal Pullup/Pulldown Resistance	Ball configured for internal pullup or pulldown.	3.5	5.6	8.5	kΩ

Note

18. $\overline{\text{XRES}}$ is input only with no internal pullup or pulldown resistor.

SWD Interface AC Specifications

The following specifications are valid under these conditions: –40°C ≤ T_A ≤ 85°C, 1.71V ≤ V_{DDD} ≤ 1.95V or 2.0V ≤ V_{DDD} ≤ 5.5V, 1.71V ≤ V_{CCD} ≤ 1.95V, and 2.65V ≤ V_{DDA} ≤ 4.7V. Typical values are specified at T_A = 25°C, V_{DDD} = V_{CCD} = 1.8V, core LDO disabled, and V_{DDA} = 2.7V.

Table 10. SWD Interface AC Specifications

Symbol	Description	Conditions	Min	Typ	Max	Units
f_{SWDCLK}	SWDCLK Frequency	3.3V ≤ V_{DDD} ≤ 5V.	–	–	14	MHz
		1.71V ≤ V_{DDD} < 3.3V.	–	–	8	MHz
T_{SWDI_SETUP}	SWDIO Input Setup before SWDCLK HIGH	T = 1 / f_{SWDCLK}.	T / 4	–	–	ns
T_{SWDI_HOLD}	SWDIO Input Hold after SWDCLK HIGH	T = 1 / f_{SWDCLK}.	T / 4	–	–	ns
T_{SWDO_VALID}	SWDCLK HIGH to SWDIO Output valid	T = 1 / f_{SWDCLK}.	–		T / 2	ns
T_{SWDO_HOLD}	SWDIO Output Hold after SWDCLK HIGH	T = 1 / f_{SWDCLK}.	1	–	–	ns

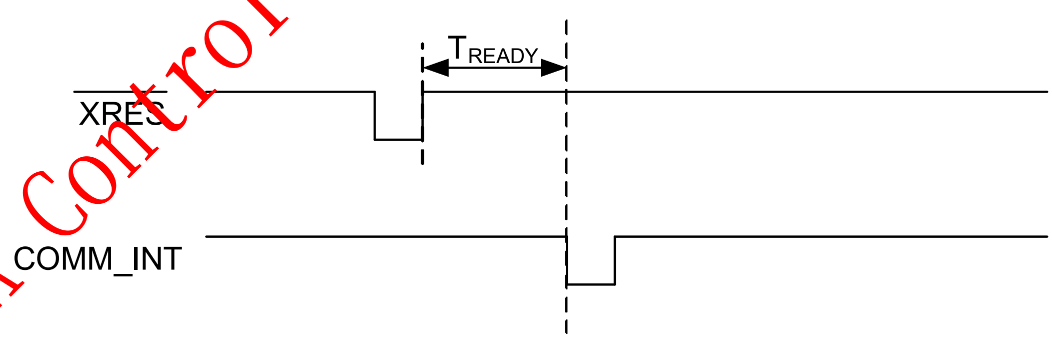
Chip-level AC Specifications

The following specifications are valid under these conditions: –40°C ≤ T_A ≤ 85°C, 1.71V ≤ V_{DDD} ≤ 1.95V or 2.0V ≤ V_{DDD} ≤ 5.5V, 1.71V ≤ V_{CCD} ≤ 1.95V, and 2.65V ≤ V_{DDA} ≤ 4.7V. Typical values are specified at T_A = 25°C, V_{DDD} = V_{CCD} = 1.8V, core LDO disabled, and V_{DDA} = 2.7V.

Table 11. Chip-level AC Specifications

Symbol	Description	Conditions	Min	Typ	Max	Units
T_{XRST}	External Reset ($\overline{XRES}$) Pulse Width	After V_{DDD} is valid.	10	–	–	µs
T_{READY}	Time from $\overline{XRES}$ Deassertion to COMM_INT	–	–	–	10	ms
T_{CAL}	Calibration Routine Execution Time	–	–	–	1100	ms

Figure 16. COMM_INT Timing Diagram



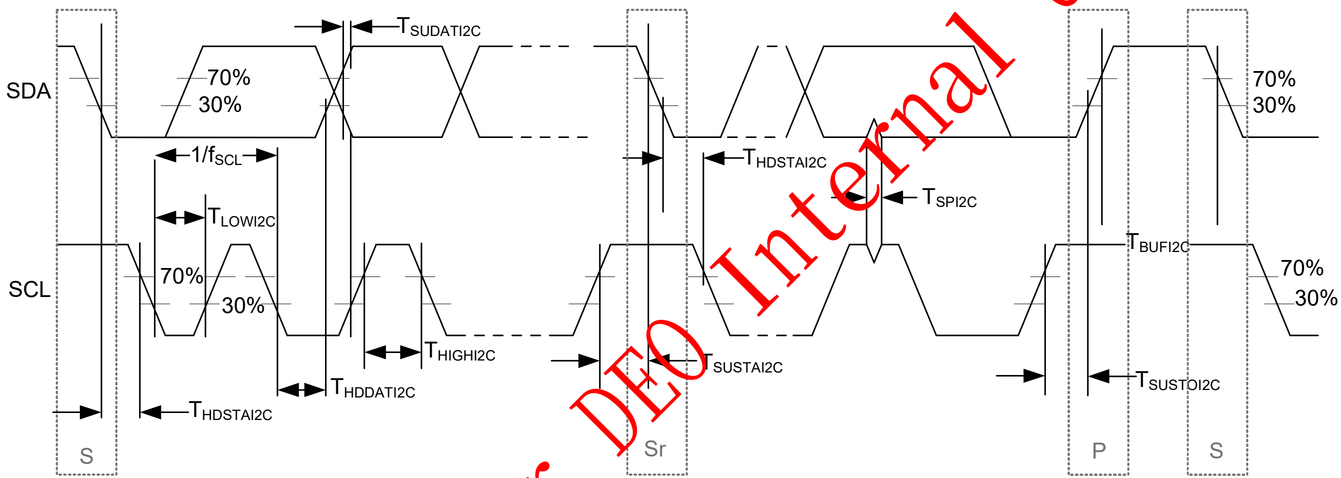
I²C Specifications

The specifications listed in Table 12 are valid under these conditions: $-40°C \le T_A \le 85°C$, $1.71V \le V_{DDD} \le 1.95V$ or $2.0V \le V_{DDD} \le 5.5V$, $1.71V \le V_{CCD} \le 1.95V$, and $2.65V \le V_{DDA} \le 4.7V$. Typical values are specified at $T_A = 25°C$, $V_{DDD} = V_{CCD} = 1.8V$, core LDO disabled, and $V_{DDA} = 2.7V$. TMA525C does not require a clock-stretch capable host, but is fully compatible with systems that perform clock stretching.

To ensure proper I²C functionality in extreme bus conditions, see the application note, *Using TMA4/5XX I²C in Systems With Slow Clock Edges* (001-81514)[19].

Important Note: The P0[0] and P0[1] ball have I/O cells optimized for use on multi-drop buses. When the TrueTouch device is powered off, the ball drivers do not load the attached bus, such that other devices attached to them may continue to communicate. During the V_{DDD} power-up and power-down transitions, the P0[0] and P0[1] drivers may be momentarily enabled. To ensure error-free communication during these power transitions, the host should suspend communication with other devices on the shared communication bus.

Figure 17. I²C Bus Timing Diagram for Fast/Standard Mode



Legend
S: I²C Start Condition
Sr: I²C Repeat Start Condition
P: I²C Stop Condition

Note
19. Extreme bus conditions are considered to be a combination of the following conditions: High-capacitive bus load, slow SCL fall time, and fast SDA rise/fall time. Parade reference documents are available under NDA through your local Parade sales representative. You can also direct your requests to Sales@paradetech.com.

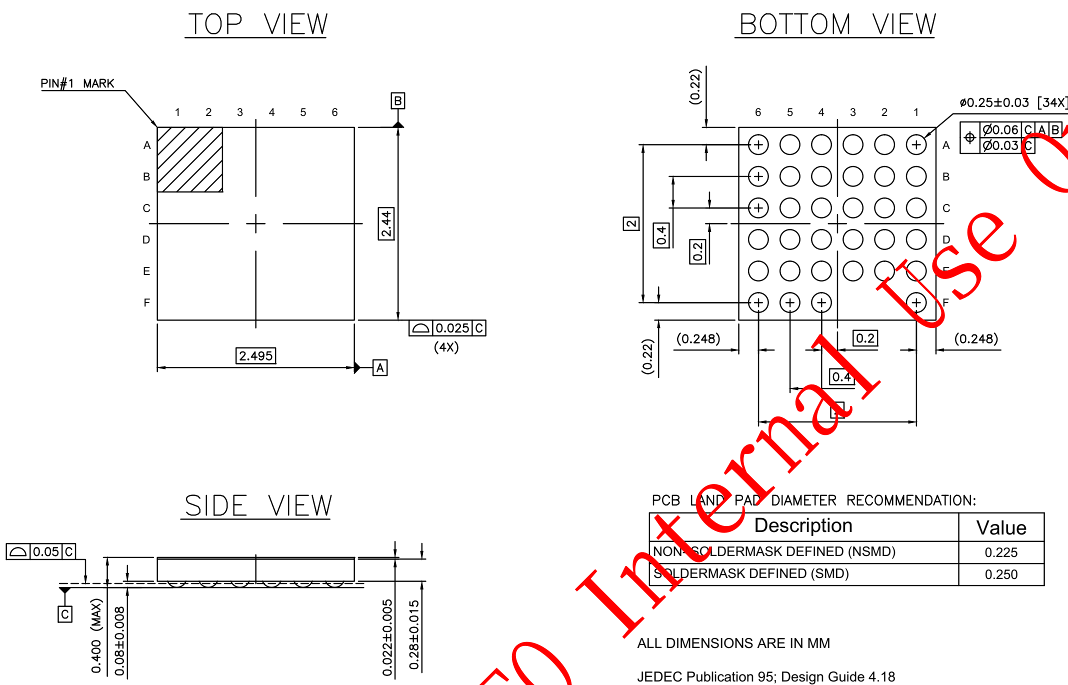
Table 12. I^2C SDA and SCL Line AC and DC Characteristics

Symbol	Description	Standard Mode		Fast Mode		Units
		Min	Max	Min	Max	
f_{SCLI2C}	SCL Clock Frequency	0	100	0	400	kHz
$T_{HDSTAI2C}$	Hold Time (Repeated) START Condition (First Clock Pulse Is Generated after this Period)	4	–	0.6	–	µs
T_{LOWI2C}	SCL Clock LOW Period	4.7	–	1.3	–	µs
$T_{HIGHI2C}$	SCL Clock HIGH Period	4	–	0.6	–	µs
$T_{SUSTAI2C}$	Repeated START Condition Setup Time	4.7	–	0.6	–	µs
$T_{HDDATI2C}$	Data Hold Time	0	–	0	–	µs
$T_{SUDATI2C}$	Data Setup Time	250	–	100	–	ns
$T_{VDDATI2C}$	Data Valid Time	–	3.45	–	0.9	µs
$T_{VDACKI2C}$	Data Acknowledge Time	–	3.45	–	0.9	µs
$T_{SUSTOI2C}$	Setup Time for STOP Condition	4	–	0.6	–	µs
V_{HH}	Input Hysteresis High Voltage, 1.71V ≤ V_{DDD} ≤ 1.95V or 2.0V ≤ V_{DDD} ≤ 5.5V	0.1 × V_{DDD}	–	0.1 × V_{DDD}	–	V
T_{BUFI2C}	Bus Free Time between STOP and START Condition	4.7	–	1.3	–	µs
T_{SPI2C}	Pulse Width of Spikes Suppressed by Input Filter	–	–	50	–	ns
C_{BUS}	SDA or SCL Capacitance Load	–	400	–	400	pF
V_{IL_I2C}	Input Low Voltage	–0.5	0.3 × V_{DDD}	–0.5	0.3 × V_{DDD}	V
V_{IH_I2C}	Input High Voltage	0.7 × V_{DDD}	–	0.7 × V_{DDD}	–	V
$V_{OL\_I2C\_L}$	Output Low Voltage (V_{DDD} ≤ 2-V, 3-mA Sink)	–	0.2 × V_{DDD}	–	0.2 × V_{DDD}	V
$V_{OL\_I2C\_H}$	Output Low Voltage (V_{DDD} > 2-V, 3-mA Sink)	–	0.4	–	0.4	V
I_{OL_I2C}	Output Low Current V_{OL} = 0.4V	–	3	–	3	mA
	Output Low Current V_{OL} = 0.6V	–	–	–	6	mA
V_{H_I2C}	Input Hysteresis	0.1 × V_{DDD}	–	0.1 × V_{DDD}	–	mV

Packaging Information

This section shows the TMA525C device packaging specifications.

Figure 18. 34-ball WLCSP (2.495 × 2.44 × 0.4-mm)



Important Note

For information on the thermal conditions, PCB layout, SMT guidelines, and preferred dimensions for mounting the package, see the application note, *AN69061 - Design, Manufacturing, and Handling Guidelines for Parade Wafer Level Chip Scale Packages* (001-69061).[20]

Thermal Impedance and Moisture Sensitivity

Table 13. Thermal Impedance and Moisture Sensitivity

Package	Typical θ_{JA}	Moisture Sensitivity Level
34-Ball WLCSP	43°C/W	1

Solder Reflow Specifications

The following table lists the maximum solder reflow peak temperatures. Thermal ramp rate during preheat should be 3°C/s or lower.

Table 14. Solder Reflow Specifications

Package	Maximum Peak Temperature	Time at Maximum Temperature
34-Ball WLCSP	260°C	30 seconds

Note
20. Parade reference documents are available under NDA through your local Parade sales representative. You can also direct your requests to Sales@paradetech.com.

Ordering Information

Table 15 lists the TMA525C TrueTouch Multi-touch all-points touchscreen controller ordering information. For information on other TrueTouch families, visit http://www.paradetech.com/products/products-overview/.

Table 15. Device Ordering Information[21]

Device Part Number		Features				Package
Segmentation	Part Number	# of Touch-screen I/O	$35V_{PP}$ ChargerArmor	DualSense	Glove	
Custom	TMA525C-34FNI24ZZ(T)	24	✔	✔	✔	34-Ball WLCSP

Ordering Code Definitions

TMA 525C - 34FN I 24 ZZ (T)

T: Tape and Reel

Features: ZZ = Custom Development

Number of Touchscreen I/Os (##): 24

Temperature Range: I = Industrial

Package (34FN): 34-ball WLCSP package

Part Number: 525C

Family Code: TMA = Multi-touch All-points Controller

Note

21. All devices have the following base features: ChargerArmor, TrueTouch Buttons, Large-object Detection and Rejection, and Grip Suppression.

Reference Documents

Parade has created a collection of documents to support the design of TrueTouch touchscreen controllers. The following list will guide you in identifying the proper document for your task.

- PCB/FPC Schematic and Layout Design
- ITO Panel Design
- Driver Development
- Manufacturing (MFG)
- System Performance Evaluation

Parade's TrueTouch technology is Parade confidential information and is protected through a Non-Disclosure Agreement (NDA). These documents are not publicly available on the Parade website. Contact your local Parade office to request any of these documents pursuant to the aforementioned NDA. You can also direct your requests to Sales@paradetech.com. For a complete list of product documentation, see *TMA445A, TT21X/31X, TT41X Technical Reference Manual (TRM)TMA445A, TT21X/31X, TT41X Technical Reference Manual (TRM)* – 001-88195.

Table 16. Reference Specifications

Document Number	Document Title	Description	PCB FPC	ITO Panel	Driver	MFG	System
Product Specifications							
001-88195	*TMA445A, TT21X/31X, TT41X Technical Reference Manual (TRM)*	Contains detailed information on communication protocol, modes and registers, power states, and instructions on getting started with supporting tools.	✔	✔	✔		✔
Solution Specifications							
001-49389	*TrueTouch® Touchscreen Controller Performance Parameters*	Contains Parade touchscreen performance parameter definitions, justification for parameters, and parameter test methodologies.		✔			✔
001-50467	*TrueTouch® Touchscreen Controller Module Design Best Practices*	System-level design guide for building a capacitive touchscreen module, covering topics such as touchscreen traces, shielding, mechanical design, FPC/PCB design, and LCD considerations.	✔	✔			
001-69061	*Design, Manufacturing, and Handling Guidelines for Parade Wafer-level Chip Scale Packages (WLCSP) - AN69061*	Describes the design guidelines to be followed for using WLCSP packages from Parade.	✔				
001-81514	*Using TMA4/5XX I^{2}C in Systems With Slow Clock Edges*	Discusses how to ensure proper I^{2}C functionality in extreme bus conditions[22].	✔				
001-83948	*TrueTouch® Host Emulator Guide*	Describes the TrueTouch® Host Emulator Software.					✔
001-63571	*TK3295-MTK TrueTouch® Manufacturing Test Kit User Guide*	Describes the TK3295-MTK Manufacturing Test Kit.				✔	
001-81891	*TrueTouch® Driver for Android (TTDA) User Guide*	Contains information on the Android TrueTouch host driver.			✔		
001-85104	*TrueTouch® Driver for WinPhone (TTDW) User Guide*	Contains information on the Windows Phone host driver.			✔		
External Specifications – These specifications are not created by Parade or owned by Parade, but directions on how to acquire or access them can be provided upon request by contacting Sales@paradetech.com.							
UM10204	*I^{2}C-Bus Specification and User Manual*		✔				✔
EN301489	*Electromagnetic Compatibility and Radio Spectrum Matters (ERM); ElectroMagnetic Compatibility (EMC) Standard for Radio Equipment and Services Part-1: Common Technical Requirements*		✔				✔
EN62684	Interoperability specifications of common external power supply (EPS) for use with data-enabled mobile telephones.		✔				✔
JEP95	*JEDEC Publication 95, Design Guide 4.18.*		✔				

Note

22. Extreme bus conditions are considered to be a combination of the following conditions: High-capacitive bus load, slow SCL fall time, and fast SDA rise/fall time.

Document Conventions

Units of Measure

Table 17. Units of Measure

Symbol	Unit of Measure
°C	degrees Celsius
μA	microampere
μF	microfarad
μs	microsecond
μW	microwatt
Ω	ohm
Hz	hertz
kΩ	kilo-ohm
kHz	kilohertz
mA	milliampere
mm	millimeter
ms	millisecond
mV	millivolt
mW	milliwatt
MHz	megahertz
nA	nanoampere
ns	nanosecond
pF	picofarad
s	second

Port Nomenclature

Px[y] describes a particular bit "y" available within an I/O port "x." For example, P1[2] reads "Port 1, bit 2."

Bit Field Nomenclature

Px[y:z] describes a particular range of bits "y to z" within an I/O port named "Px." For example, P1[0:3] refers to bits 0 through 3 within an I/O port named P1.

Acronyms, Abbreviations, and Initialisms

Table 18. Acronyms, Abbreviations, and Initialisms Used in This Document

Acronym	Description
CPU	central processing unit
DSD	dual-solid diamond pattern (Figure 4)
EMI	electromagnetic interference
ESD	electrostatic discharge
FPC	flexible printed circuit
GPS	global positioning system
I^2C	inter-integrated circuit
I/O	input/output
ITO	indium tin oxide
LCD	liquid crystal display
LDO	low-dropout regulator
MH3	Manhattan-3 pattern (Figure 5)
MTK	manufacturing test kit
PCB	printed circuit board
PET	polyethylene terephthalate
PIP	packet interface protocol
RF	radio frequency
SCL	serial I^2C clock
SD	signal disparity
SDA	serial I^2C data
SLIM	single-layer independent Multi-touch (Figure 6)
SMT	surface mount technology
SNR	signal-to-noise ratio
SOL	sensor-on-lens
SSD	single-solid diamond pattern (Figure 3)
SWD	serial wire debug
SWDCLK	serial wire debug clock
SWDIO	serial wire debug input/output
TRM	technical reference manual
TTHE	TrueTouch® host emulator
V_{PP}	volts peak-to-peak

Glossary

accuracy	Maximum position error across the touchscreen, measured in millimeters, along a straight line between the actual finger position and the reported finger position. Accuracy is measured across the core and full panel. See the specification, *TrueTouch® Touchscreen Controller Performance Parameters* (001-49389)[23], for more information.
All-points	Parade brand name for TrueTouch® devices capable of tracking the motion of multiple fingers.
AMOLED/OLED	Type of display using Active Matrix (AM) Organic Light Emitting Diodes (OLED).
channel	Analog circuitry responsible for measuring capacitance. Contains RX and TX sections and a multiplexer to connect the touchscreen I/Os to the RX and TX sections. Fourteen parallel channels are available for capacitance sensing.
capacitance conversion	Process of measuring the capacitance of an electrode connected to a ball (self capacitance) or the capacitance between a pair of electrodes connected to different ball (mutual capacitance). The result is a number that can be processed by the channel engine and CPU.
core	That portion of the touchscreen, responsive to touch, less a perimeter area whose width is the larger of 3.5 mm or half the width of the finger (for example, less a perimeter band 4.5-mm wide for a 9-mm finger).
core LDO	Low-dropout regulator that sources power to the digital core when enabled. Input to the LDO is V_{DDD}. LDO output is connected to V_{CCD}. When the core LDO is disabled, power must be externally applied to V_{CCD}.
DCVCOM	Type of liquid crystal display (LCD) in which the common electrode (VCOM) is driven by DC voltage.
DualSense	Parade's patented self plus mutual capacitance sensing.
FPC	Flexible printed circuit. Pattern of conductive traces bonded on a thin, flexible substrate.
linearity	Deviation of the position data from a best-fit straight line across the touchscreen, measured in millimeters. Linearity is measured across the core and full panel. See the specification, *TrueTouch® Touchscreen Controller Performance Parameters* (001-49389)[23], for more information.
mutual capacitance	Capacitance between two touchscreen electrodes.
refresh rate	Frequency at which consecutive frames of touchscreen data are made available in a data buffer while a finger is present on the touchscreen. See the specification, *TrueTouch® Touchscreen Controller Performance Parameters* (001-49389)[23], for more information.
RX	Receive. Touchscreen electrode or touchscreen controller I/O, mapped or switched to a charge-sensing circuit within the controller (known as a receive channel).
scan	Conversion of all sensor capacitances to digital values.
self-capacitance	Capacitance between a touchscreen electrode and ground.
signal-to-noise ratio (SNR)	Ratio between a capacitive finger signal and system noise.
signal disparity (SD)	Ratio of maximum measured signal when the touchscreen is grounded and maximum measured signal when the touchscreen is isolated from ground.
stackup	Layers of materials, in defined assembly order, that make up a touchscreen sensor.
touchscreen I/O	Ball that can be multiplexed to RX or TX.
TX	Transmit. Touchscreen electrode or touchscreen controller I/O, mapped or switched to a charge-forcing circuit within the controller. This charge forcing circuit drives a periodic waveform onto one or more touchscreen electrodes, which are coupled through mutual capacitance to adjacent receive electrodes.

Note
23. Parade reference documents are available under NDA through your local Parade sales representative. You can also direct your requests to Sales@paradetech.com.

Document History

Document Title: TMA525C TrueTouch® Multi-touch All-points Touchscreen Controller Datasheet				
Revision	**ECN**	**Orig. of Change**	**Submission Date**	**Description of Change**
3	–	Chitiz.Mathema	01/10/2018	TX pump-related content – Added globally. Included updates to Figure 2 and Figure 9 through Figure 11, adding Figure 12 through Figure 14, and renumbering all subsequent figures. Chip-level AC Specifications – Added missing V_{DDD} information. Table 4 – Corrected ESD_{HBM} condition. Footnote 8 – Corrected cross-reference.
2	–	Yi.Hang. Wang	05/11/2017	Figure 8 – Corrected XY16 through XY23 ball labels.
1	–	Yi.Hang. Wang	04/10/2017	Required External Components – Clarified V_{DDA} 2.2 µF capacitor information. Figure 1 – Changed “Interrupt/Wake” with double-ended arrow to “Interrupt” with right arrow only. Figure 8 – Replaced. Table 4 – Added V_{CCTX} and $\overline{XRES}$ information. Table 7 – Added V_{CCTX} and V_{TX} information. Table 8 and Table 9 – Removed temperature condition from V_H entries. Table 12 – Added “and DC” to caption, and changed $V_{OL\_I2C\_L}$, $V_{OL\_I2C\_H}$, and I_{OL_I2C} information. Clarified Android and Windows Phone driver type (host). Updated TRM document name. Corrected miscellaneous typos.
0	–	Chitiz.Mathema	02/14/2017	Initial release preliminary Parade datasheet.