DP83TG721x-Q1 1000BASE-T1 Automotive Ethernet PHY with Advanced TSN and AVB

1 Features

- IEEE802.3bp 1000BASE-T1 compliant
- OA TC10 compliant, <20µA sleep current
  - Local and remote wake up and wake forwarding
- Advanced TSN
  - IEEE 1588v2/802.1AS Time Synchronization
  - Hardware time-stamping with integrated phase correction
  - Highly accurate 1pps signal (±15ns)
- Audio Clocking
  - AVB IEEE 1722 media clock generation capability
  - Phase synchronized wall clock output: 1KHz to 50MHz
  - I2S & TDM8 SCLK/FSYNC/MCLK clock generation
- Open Alliance TC12 Interoperability and EMC compliant
  - OA EMC compliant
  - SAE J2962-3 EMC Compliant
- Integrated LPF on MDI pins
- MAC Interfaces: MII, RMII, RGMII, and SGMII
- Supported I/O voltages: 3.3V, 2.5V, and 1.8V
- Pin compatible with TI's 100BASE-T1 PHYs and 1000BASE-T1 PHYs
  - Single board design for 100BASE-T1 and 1000BASE-T1 with required BOM change
- Diagnostic tool kit
  - Temperature, Voltage, ESD monitor
  - Data throughput calculator : Inbuilt MAC packet generator, counter and error checker
  - Signal Quality Indicator
  - TDR based open and short cable fault detection
  - CQI for cable degradation monitoring
  - Loopback modes
- AEC-Q100 Qualified
  - IEC61000-4-2 ESD : ±8kV contact discharge

2 Applications

- Telematics control unit (TCU, TBOX)
- AVB
- ADAS: LIDAR, RADAR, Front Camera
- Zonal, Gateway, and body control

3 Description

The DP83TG721-Q1 is an IEEE 802.3bp and Open Alliance compliant automotive 1000Base-T1 Ethernet physical layer transceiver. The DP83TG721-Q1 provides all physical layer functions needed to transmit and receive data over unshielded/shielded single twisted-pair cables. The device provides xMII flexibility with support for RGMII and SGMII MAC interfaces.

DP83TG721-Q1 supports OA TC10 low power sleep feature (with wake forwarding) to reduce system power consumption when communication is not required. This device offers the Diagnostic Tool Kit, with an extensive list of real-time monitoring tools, debug tools and test modes.

DP83TG721-Q1 integrates IEEE 1588v2/802.1AS hardware time stamping & fractional PLL enabling highly accurate time synchronization. The fractional PLL enables frequency/phase synchronization of the Wall Clock eliminating need for external VCXO and generating wide range of time synchronized frequencies needed for Audio, Video and other ADAS applications.

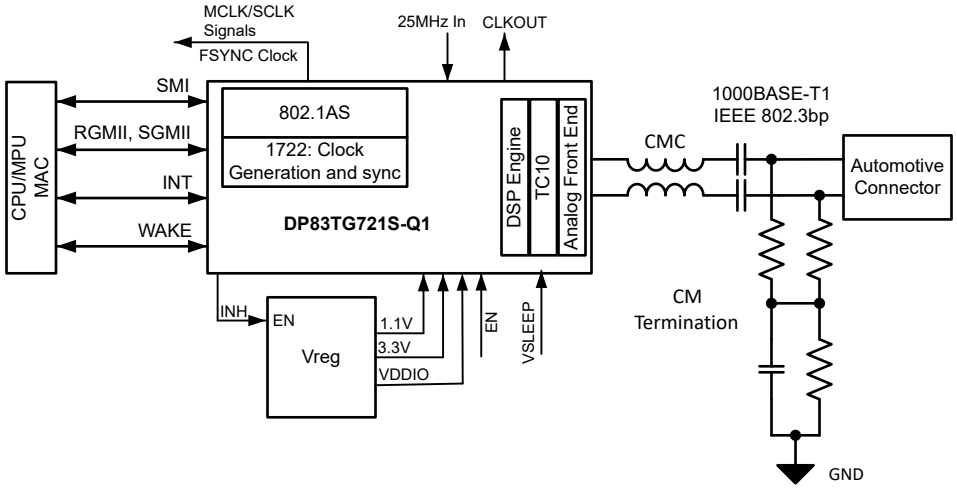
DP83TG721-Q1 also integrates IEEE 1722 CRF decode to generate Media Clock (wall clock synchronized) for AVB & other Audio standards. The DP83TG721-Q1 is also capable of generating FSYNC/SCLK (wall clock synchronized) for I2S/TDM8 interface needed for audio applications.

The DP83TG721-Q1 is compatible to TI's 100BASE-T1 PHYs and 1000BASE-T1 PHYs enabling design scalability with single board for both speeds.

Device Information

PART NUMBER	PACKAGE (1)	BODY SIZE (NOM) (2)
DP83TG721R-Q1	VQFN (36)	6.00mm × 6.00mm
DP83TG721S-Q1	VQFN (36)	6.00mm × 6.00mm

(1) For all available packages, see the orderable addendum at the end of the data sheet.
(2) The package size (length × width) is a nominal value and includes pins, where applicable.



Simplified Schematic

4 Device Comparison Table

PART NUMBER	RGMII SUPPORT	SGMII SUPPORT	OPERATING TEMPERATURE
DP83TG721R-Q1	Yes	No	–40°C to 125°C
DP83TG721S-Q1	Yes	Yes	–40°C to 125°C

5 Application Information

The DP83TG721-Q1 is a single-port 1Gbps Automotive Ethernet PHY. The DP83TG721-Q1 supports IEEE 802.3bp and allows for connections to an Ethernet MAC through RGMII or SGMII. When using the device for Ethernet applications, it is necessary to meet certain requirements for normal operation. The following subsections are intended to assist in appropriate component selection and required connections.

5.1 Time Synchronization

The DP83TG721-Q1 integrates IEEE 1588v2/802.1AS timestamping and other additional hardware engine to offer sub 15 nanosecond synchronization accuracy.

The DP83TG721-Q1 is also capable of providing a wide range of high quality time synchronized clock (1KHz to 50MHz) and generate synchronous patterns on GPIO's. This enables the DP83TG721-Q1 to achieve system level synchronization for ADAS sensor data synchronization, Corner Radar Chirp synchronization, 1 pps signal for GPS, LIDAR, V2x, etc.

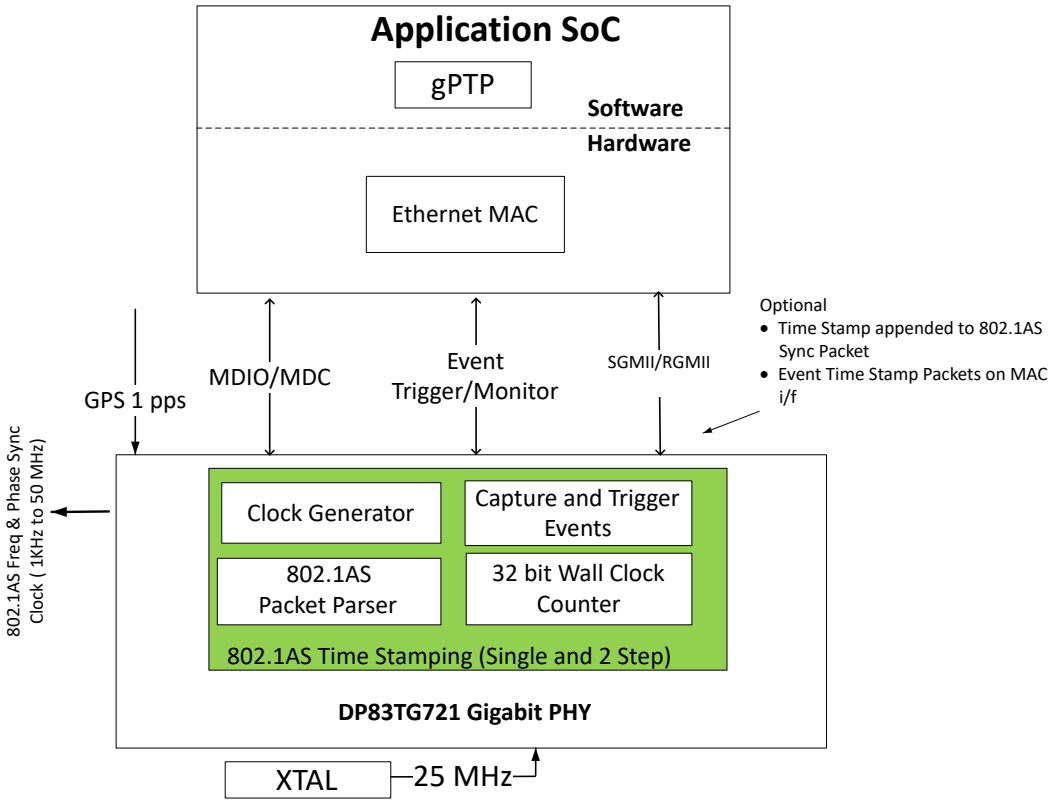


Figure 5-1. DP83TG721-Q1 802.1AS Time Synchronization Architecture

5.2 Integrated Audio Over Ethernet

DP83TG721-Q1 offers audio clocking solutions for AVB (Audio Video Bridging) and other audio transports protocols (IES676, IEEE 1733 RTP, Dante) by:

- Generating IEEE 1722 Media Clock with embedded CRF packet decode
- Synchronized clocks (FSYNC, BCLK, MCLK) for Audio interface I2S and TDMx

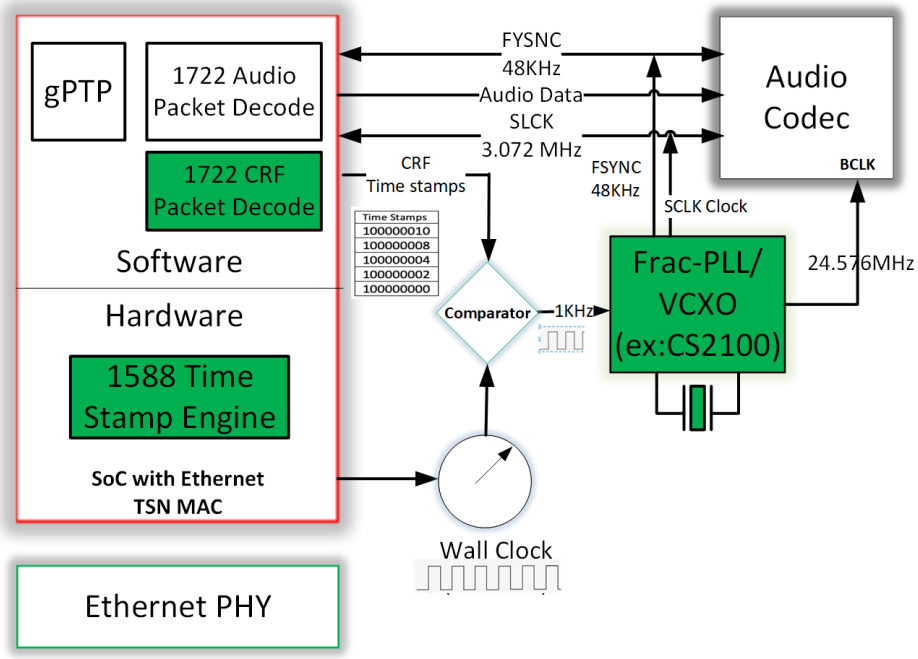


Figure 5-2. Typical Audio Over Ethernet Architecture

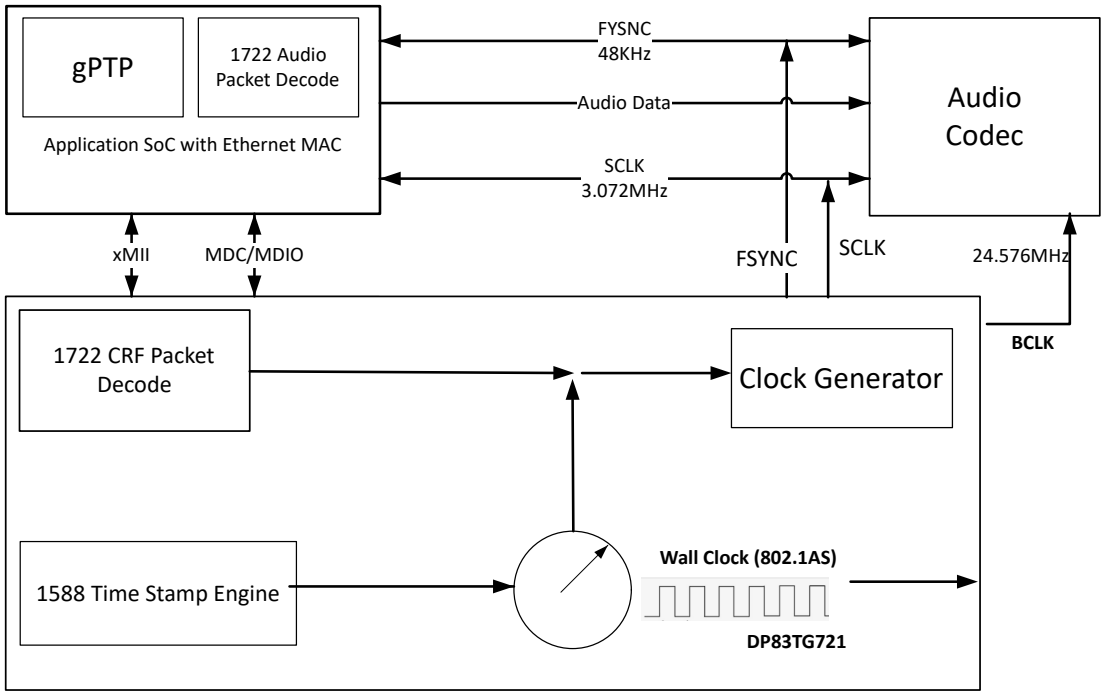


Figure 5-3. Audio Over Ethernet Architecture with DP83TG721-Q1

5.3 TC10 Sleep/Wake-Up

DP83TG721-Q1 supports Open Alliance TC10 Sleep/Wake-up feature. It supports local/remote wake-up, wake-forwarding, sleep negotiation as outlined in the TC10 specification.

The block diagram of a general system implementation of TC10 is as shown below

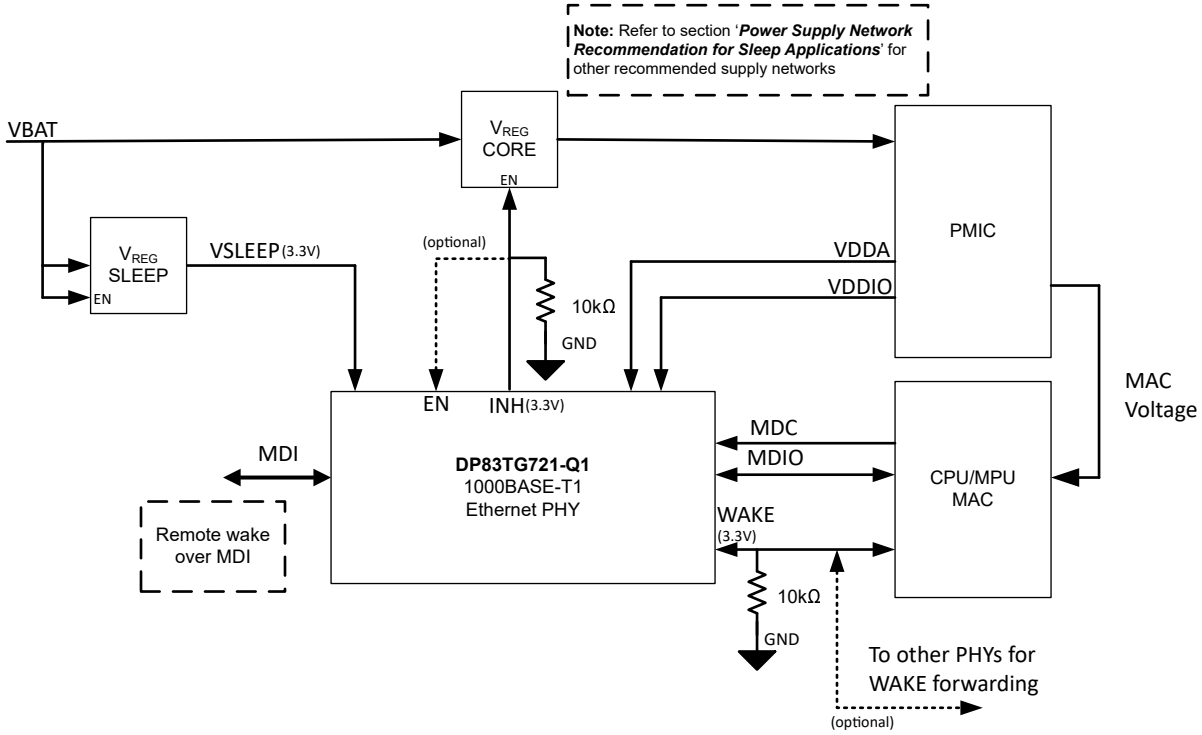


Figure 5-4. TC10 System Implementation Diagram

5.4 DP83TG721 EVM-MC and Software Support

DP83TG721EVM-MC

The DP83TG721EVM-MC supports 1000Mbps speed and a DP83867 is provided for copper (1000BASE-T) media conversion using the RGMII MAC Interface.

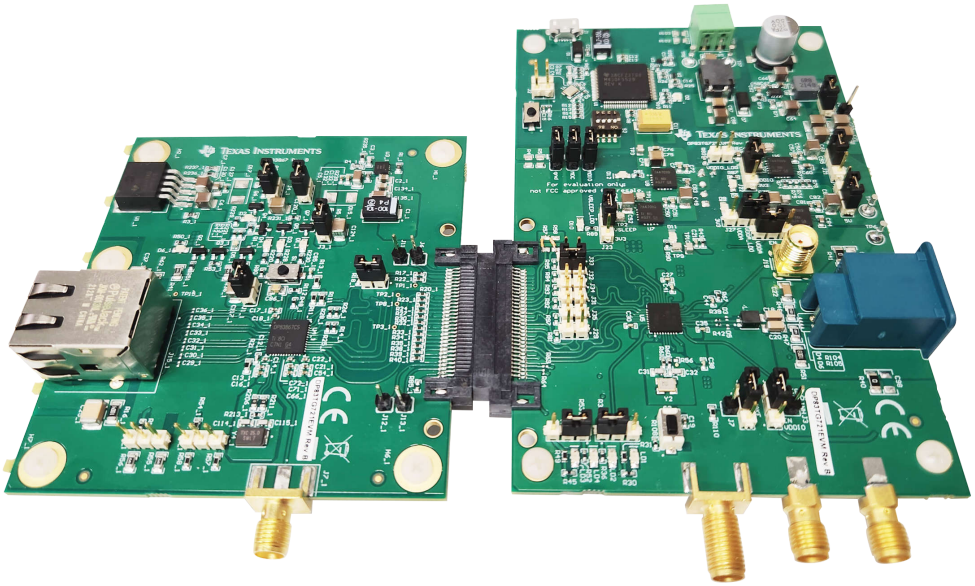


Figure 5-5. DP83TG721EVM-MC

The DP83TG721EVM-MC offers:

- Media Converter: 1000BASE-T to 1000BASE-T1
- IEEE802.3bp Compliant
- RGMII Back-to-Back Configuration
- On-board MSP430F5529
  - USB2MDIO/ DIEP Support
- Status LEDs
  - Link
  - Link + Activity
  - Power-On

New DIEP Debug Interface Experience

DIEP offers all your Ethernet PHY debug needs in one place including MDIO bus serial management, device control registers, access to both extended registers and standard registers, and the ability to save data read and run script text files.

- ***NEW*** restructured navigation and register display
- ***NEW*** improved text script execution

Debug Interface for Ethernet PHY's (DIEP)

5.5 Comparison of Device Features

The DP83TG721-Q1 enables very high time synchronization accuracy for automotive applications. Compared to the DP83TG720x series, the DP83TG721-Q1 offers advanced diagnostic tools, hardware time stamping, TC-10 low power sleep, and has integrated Audio Video Bridging (AVB). Comparison Between DP83TG720x and DP83TG721x provides an overview of feature differences between the two.

Table 5-1. Comparison Between DP83TG720x and DP83TG721x

Feature	DP83TG720x-Q1	DP83TG721x-Q1
Interfaces		
PMA/PMD	1000Base-T1	1000Base-T1
MAC Interface Support	RGMII only (for DP83TG720R-Q1) RGMII, SGMII (for DP83TG720S-Q1)	RGMII only (for DP83TG721R-Q1) RGMII, SGMII (for DP83TG721S-Q1)
Features Supported		
Sleep/Wake functionality	Custom Sleep/Wake Implementation	OA TC10 Compliant Implementation
Internal Power Shutdown	No	Supported with EN pin
Diagnostics	Signal Quality Indicator (SQI) Time Domain Reflectometry (TDR) Built-In Self Test (BIST) Compliance Test Modes	Signal Quality Indicator (SQI) Time Domain Reflectometry (TDR) Built-In Self Test (BIST) Compliance Test Modes Cable Quality Indicator (CQI)
802.1AS Support	No	PTP Wall Clock Tranmsit and Receive Packet Parsing and Timestamping Event Triggering and Timestamping
AVB Clock Generation	No	IEEE1722 CRF packet decode Media, Bit and Codec Clock Generation
Power Supply		
VDDA3P3V	3.3V +/- 10%	3.3V +/- 10%
VDDIO	1.8V +/- 10% 2.5V +/- 10% 3.3V +/- 10%	1.8V +/- 10% 2.5V +/- 10% 3.3V +/- 5%
VSLEEP	3.3V +/- 10%	3.3V +/- 10%
VDD	0.95V - 1.1V	1.05V - 1.21V

6 Device and Documentation Support

Note

TI is transitioning to use more inclusive terminology. Some language may be different than what you would expect to see for certain technology areas.

6.1 Receiving Notification of Documentation Updates

To receive notification of documentation updates, navigate to the device product folder on ti.com. Click on *Notifications* to register and receive a weekly digest of any product information that has changed. For change details, review the revision history included in any revised document.

6.2 Support Resources

TI E2E™ support forums are an engineer's go-to source for fast, verified answers and design help — straight from the experts. Search existing answers or ask your own question to get the quick design help you need.

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6.3 Trademarks

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6.4 Electrostatic Discharge Caution

This integrated circuit can be damaged by ESD. Texas Instruments recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage.

ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its published specifications.

6.5 Glossary

TI Glossary	This glossary lists and explains terms, acronyms, and definitions.

7 Revision History

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

Changes from Revision * (May 2024) to Revision A (June 2024)	Page
• First Public Release	10

PACKAGING INFORMATION

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead finish/ Ball material (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
DP83TG721RRHARQ1	ACTIVE	VQFN	RHA	36	2500	RoHS & Green	NIPDAU	Level-3-260C-168 HR	-40 to 125	721R	Samples
DP83TG721SRHARQ1	ACTIVE	VQFN	RHA	36	3000	RoHS & Green	NIPDAU	Level-3-260C-168 HR	-40 to 125	721S	Samples

(1) The marketing status values are defined as follows:
ACTIVE: Product device recommended for new designs.
LIFEBUY: TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.
NRND: Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.
PREVIEW: Device has been announced but is not in production. Samples may or may not be available.
OBSOLETE: TI has discontinued the production of the device.

(2) **RoHS:** TI defines "RoHS" to mean semiconductor products that are compliant with the current EU RoHS requirements for all 10 RoHS substances, including the requirement that RoHS substance do not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, "RoHS" products are suitable for use in specified lead-free processes. TI may reference these types of products as "Pb-Free".
RoHS Exempt: TI defines "RoHS Exempt" to mean products that contain lead but are compliant with EU RoHS pursuant to a specific EU RoHS exemption.
Green: TI defines "Green" to mean the content of Chlorine (Cl) and Bromine (Br) based flame retardants meet JS709B low halogen requirements of <=1000ppm threshold. Antimony trioxide based flame retardants must also meet the <=1000ppm threshold requirement.

(3) MSL, Peak Temp. - The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

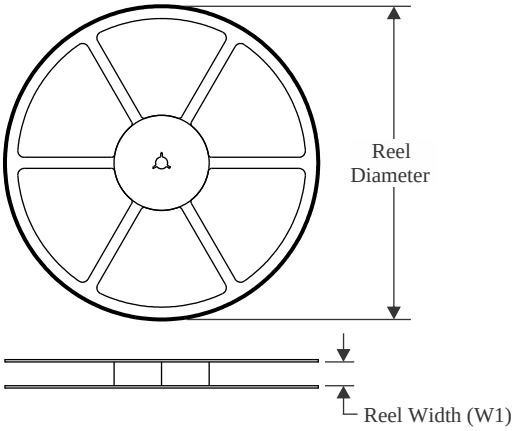
(4) There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

(5) Multiple Device Markings will be inside parentheses. Only one Device Marking contained in parentheses and separated by a "~" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Device Marking for that device.

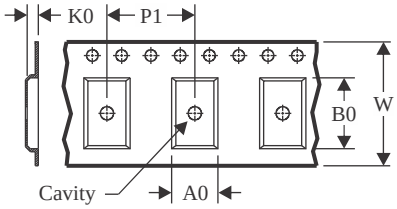
(6) Lead finish/Ball material - Orderable Devices may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead finish/Ball material values may wrap to two lines if the finish value exceeds the maximum column width.

TAPE AND REEL INFORMATION

REEL DIMENSIONS

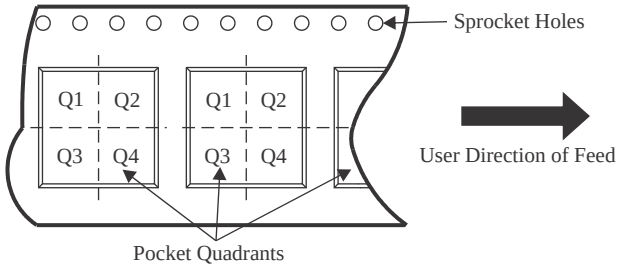


TAPE DIMENSIONS



A0	Dimension designed to accommodate the component width
B0	Dimension designed to accommodate the component length
K0	Dimension designed to accommodate the component thickness
W	Overall width of the carrier tape
P1	Pitch between successive cavity centers

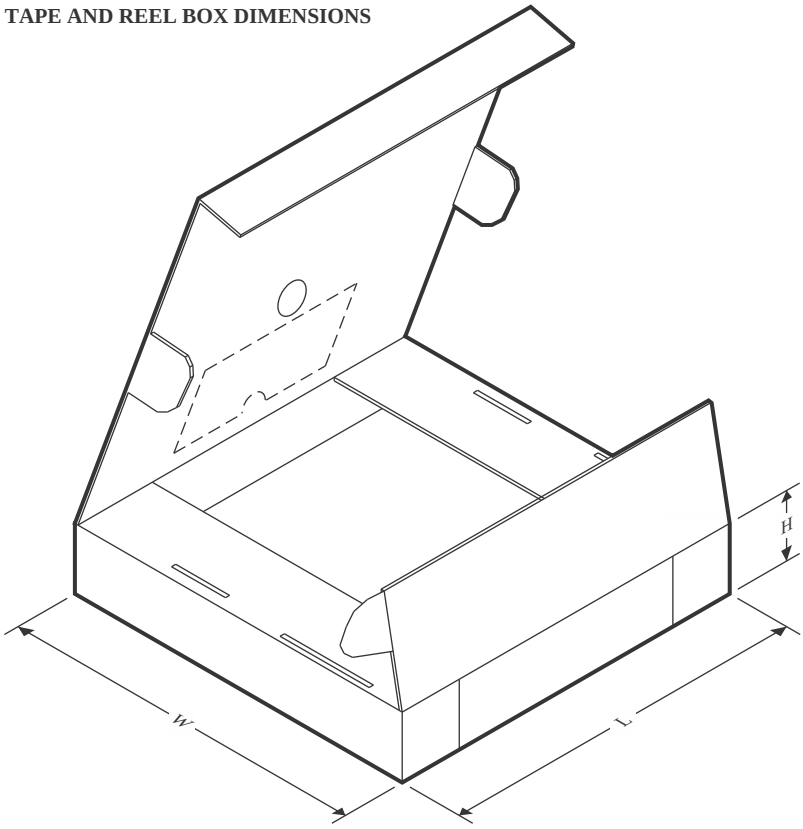
QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
DP83TG721RRHARQ1	VQFN	RHA	36	2500	330.0	16.4	6.3	6.3	1.1	12.0	16.0	Q2
DP83TG721SRHARQ1	VQFN	RHA	36	3000	330.0	16.4	6.3	6.3	1.1	12.0	16.0	Q2

TAPE AND REEL BOX DIMENSIONS



*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
DP83TG721RRHARQ1	VQFN	RHA	36	2500	367.0	367.0	35.0
DP83TG721SRHARQ1	VQFN	RHA	36	3000	367.0	367.0	35.0

GENERIC PACKAGE VIEW

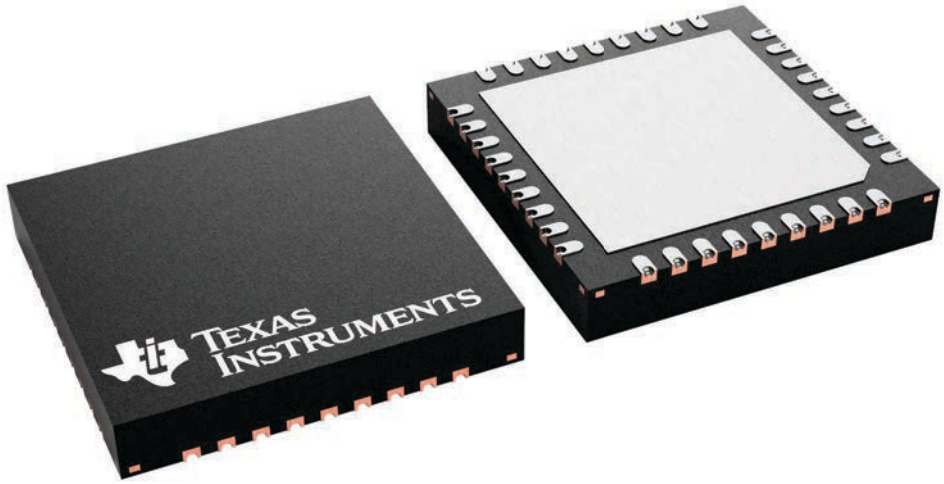
RHA 36

VQFN - 1 mm max height

6 x 6, 0.5 mm pitch

PLASTIC QUAD FLATPACK - NO LEAD

This image is a representation of the package family, actual package may vary.
Refer to the product data sheet for package details.



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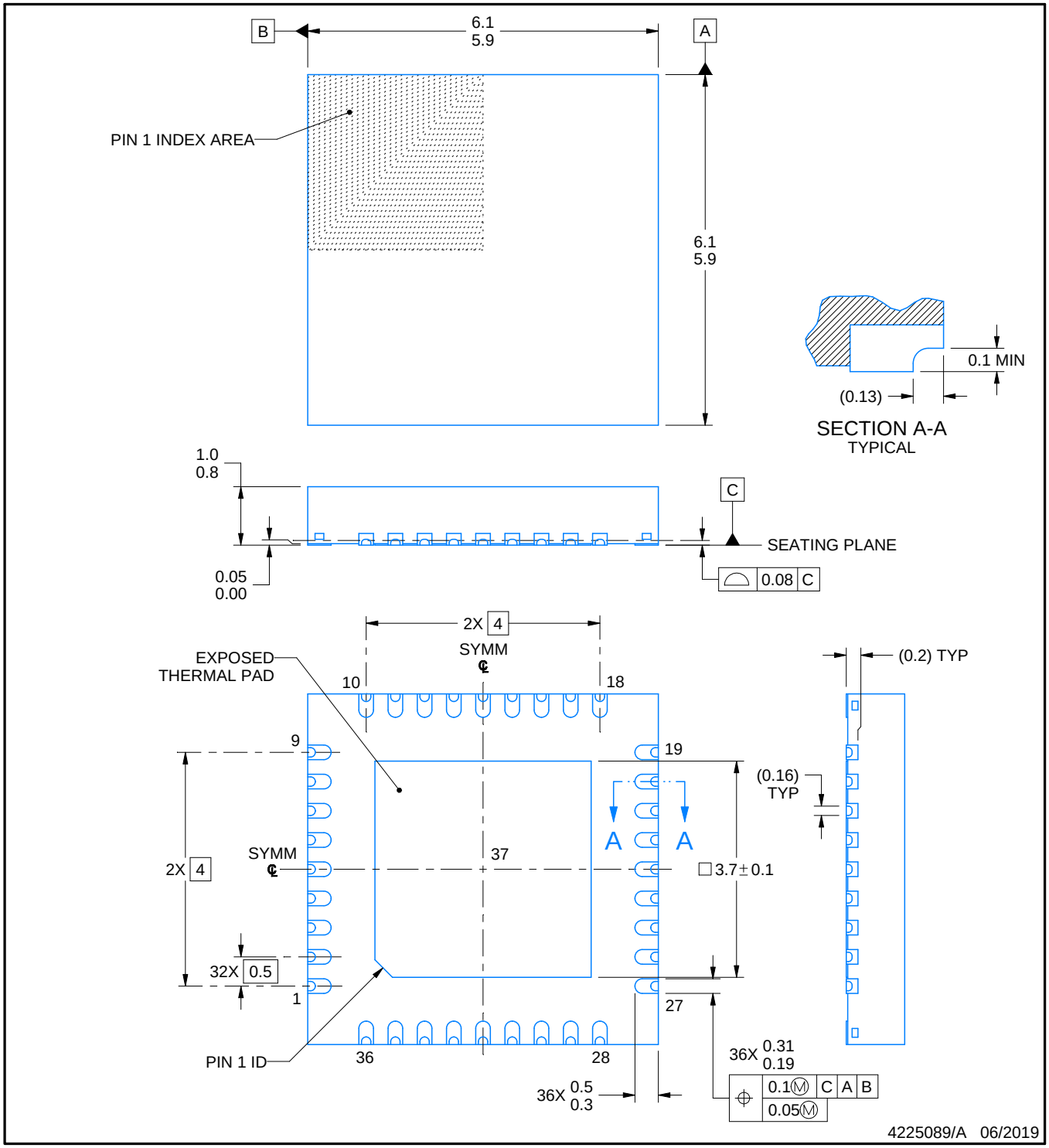
PACKAGE OUTLINE

RHA0036A

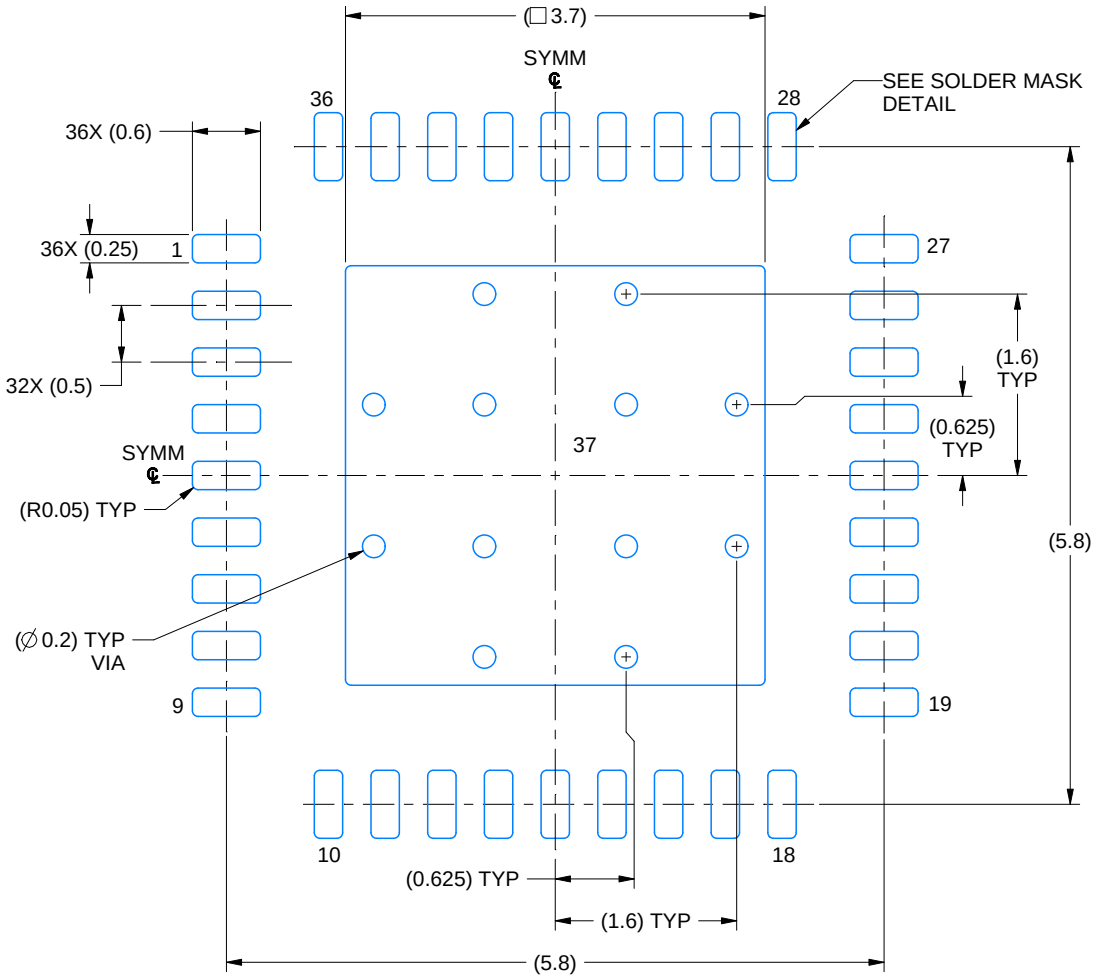
VQFN - 1 mm max height

PLASTIC QUAD FLATPACK - NO LEAD

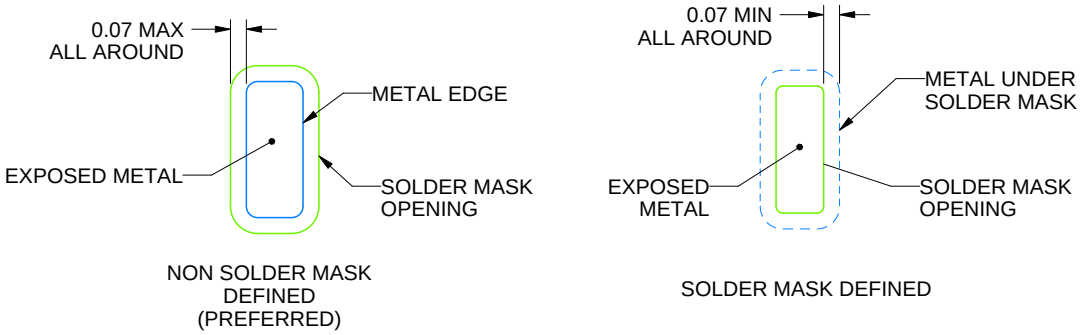


NOTES:

1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. The package thermal pad must be soldered to the printed circuit board for thermal and mechanical performance.



LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE: 15X



SOLDER MASK DETAILS

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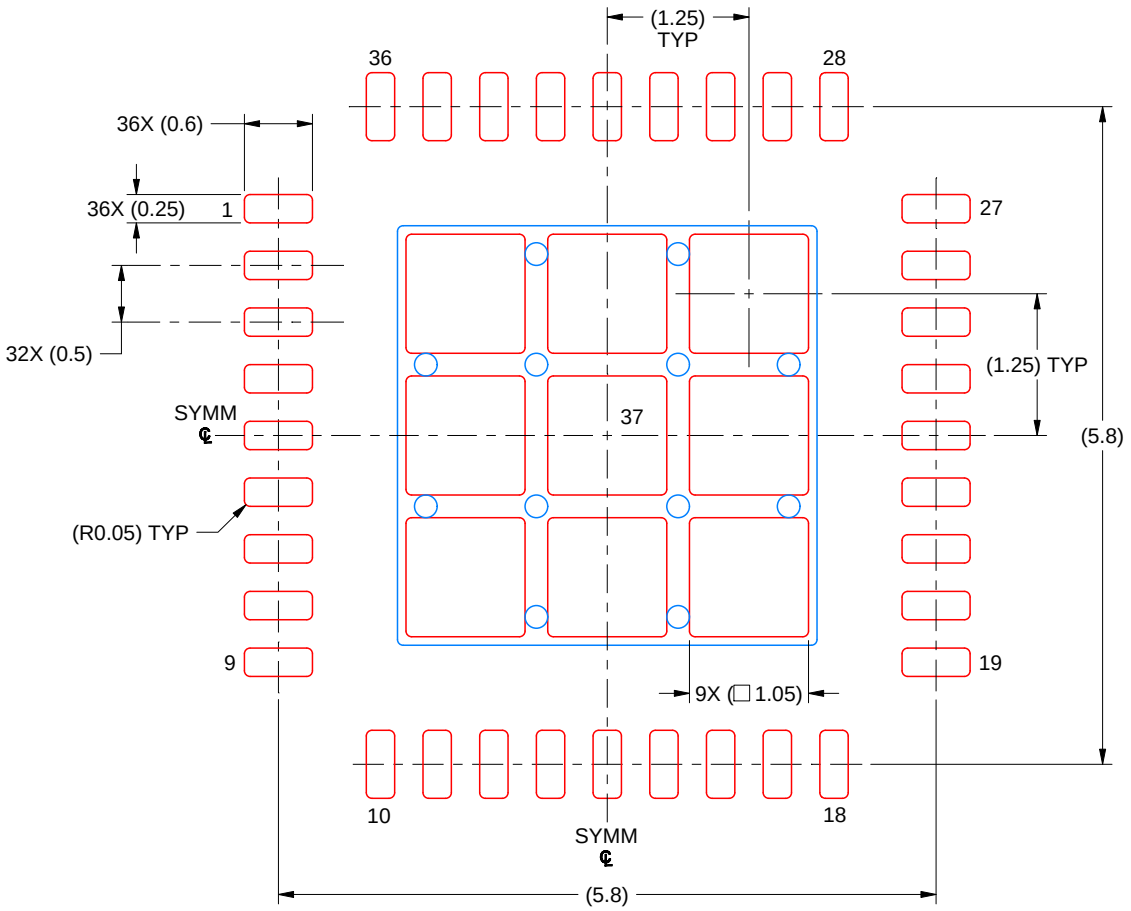
NOTES: (continued)

4. This package is designed to be soldered to a thermal pad on the board. For more information, see Texas Instruments literature number SLUA271 (www.ti.com/lit/slua271).
5. Vias are optional depending on application, refer to device data sheet. If any vias are implemented, refer to their locations shown on this view. It is recommended that vias under paste be filled, plugged or tented.



SOLDER PASTE EXAMPLE
BASED ON 0.125 MM THICK STENCIL
SCALE: 15X

EXPOSED PAD 37
72% PRINTED SOLDER COVERAGE BY AREA UNDER PACKAGE

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NOTES: (continued)

6. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.

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