1 Features

- **Valve SteamVR™ Tracking Compatible Light to Digital Integrated Circuit**
- Convert infrared light pulses to electrical envelope pulses used to track position
- 1MHz to 5MHz optical carrier frequencies
- 50Hz/60Hz ambient noise rejection
- Standby-mode for low power operation
- AVDD: 3.3V
- Small Package Size simplifies industrial design of tracked objects
  - 3x3 WLCSP Package
  - 1.61mm x 1.61mm

2 Applications

- SteamVR™ Compatible Object Tracking
- Room-scale Virtual Reality Tracking
- Virtual Reality Controllers
- Tracking of Physical Objects in VR
- Adding SteamVR™ Tracking to VR Head Mounted Displays
- Robotics Positioning
- Volumetric Entertainment Systems
- Optical Ranging
- Optical Detection
- Free-Space Optical Communication
- Low Complexity, Low Computation Requirement Embedded Tracking Systems
- Indoor and Outdoor Position Systems

For the latest TS3633 information visit
online version of TS3633 datasheet.

3 Description

Triad Semiconductor's TS3633 enables cost effective deployment of Valve Corporation's SteamVR™ Tracking System. Working with a photodiode, the TS3633 converts infrared light pulses into position indicating digital envelope signals. The TS3633 takes care of photodiode biasing and provides high gain, noise filtering and envelope detection of pulsed IR light sources. The ENVELOPE output of the TS3633 is a digital signal that tracks the envelope of the amplitude modulated (OOK or ASK) infrared light that is incident on the photodiode. The TS3633's dynamic standby mode can greatly extend battery life of wireless tracked objects. A SteamVR-compatible tracked object contains multiple TS3633 ICs plus photodiode sites distributed across the surface of each tracked object. Downstream electronics and software analyze the envelope pulse timing from each site to compute the position and orientation of a tracked object to within less than 1mm in a tracked volume spanning several meters using triangulation and tracking algorithms.

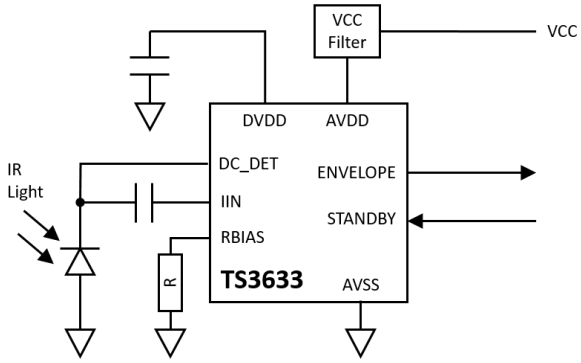


Figure 1 Simplified Application Circuit

TS3633 Device Size
1.61mm x 1.61mm

4 Device Overview

The TS3633 is a mixed-signal integrated circuit for use in optical position tracking applications. Utilizing Wafer Level Chip Scale Packaging (WLCSP), it achieves a minimal footprint size for use in space-constrained assemblies. The TS3633 provides pulse detection circuitry for use in room scale tracking/positioning for virtual reality gaming and other applications which require millimeter position accuracy. The signal path is driven from an external photodiode which is AC coupled into the IIN pin. The IC contains several blocks to bias and sense the photodiode. The IIN input is amplified through an integrated TIA and filtered to limit noise. The preconditioned signal then drives into circuits used to generate the envelope output signal. Figure 2 shows the block diagram of the TS3633. The TS3633 is available in a 9-bump WLCSP package.

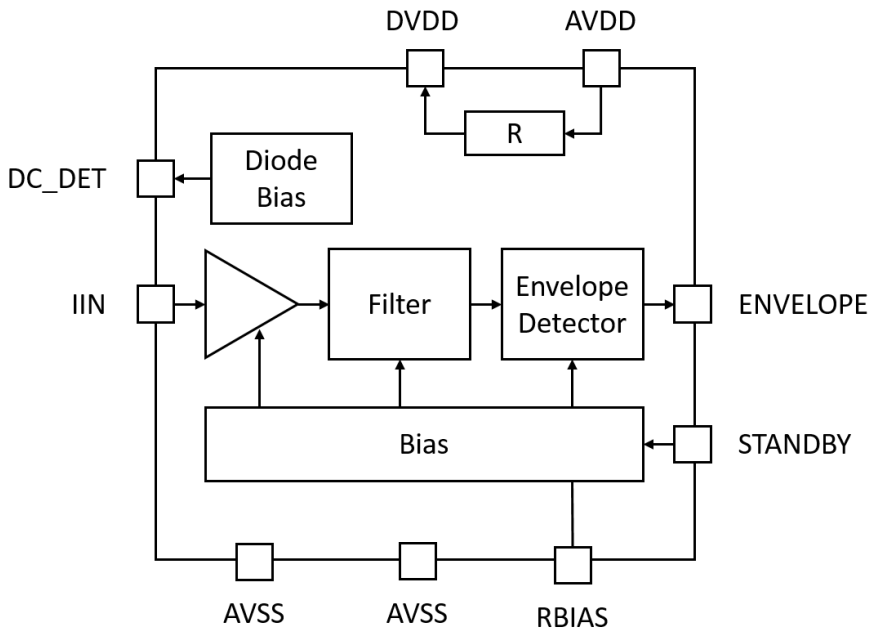


Figure 2: TS3633 Basic Block Diagram

5 Bias

5.1 Bias Circuitry

The TS3633 contains an internal reference system that controls the device's internal detection levels. An external resistor connected to the RBIAS bump is used to set the internal reference. The internal reference will remain constant (within the resistor and reference tolerance) over process corners.

5.2 Diode Bias

The Diode Bias function provides DC bias to the optical detector diode. It is designed to provide a reverse diode voltage of AVDD at a 0.0mA load and approximately 1.0V at a 2.0mA load. Diode biasing is specified at the DC_DET output pin. External circuitry connected between DC_DET and the photodiode will affect the bias voltage presented to the photodiode.

6 Signal Path

6.1 TIA & Filter Amplifier

The TIA is designed to amplify an input current pulse, created by an optical detector diode, into an output voltage pulse. A detector diode input load of 30 pF is expected for nominal operation. Detector sensitivity will vary with diode input load and can also be affected by board stray capacitance at the IIN and DC_DET pins. The Filter amplifier is implemented using successive band limiting gain stages.

6.2 Envelope Detector

The Envelope Detector is triggered by level crossings of the preconditioned input signal. The ENVELOPE output is asserted low during detection of light pulses incident on the external photodiode. See Figure 3 for a simplified I/O diagram.

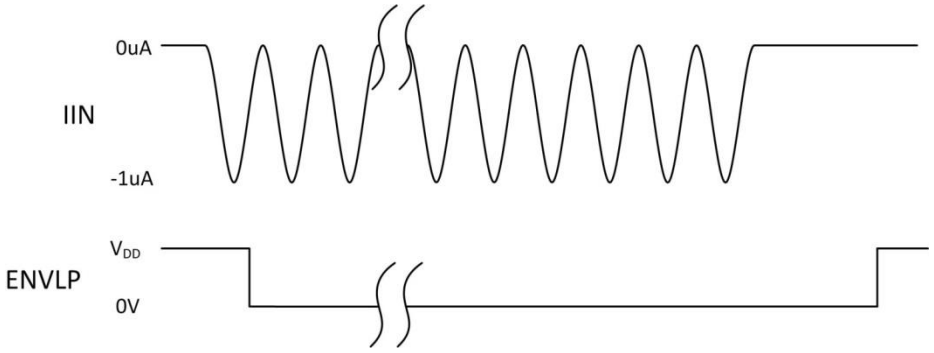


Figure 3: Simplified TS3633 Input / Output Diagram

6.3 Standby Control

When the STANDBY input is logic level low, the TS3633 is in normal operation mode. Asserting the STANDBY input logic level high places the TS3633 into low power standby mode. The TS3633 is capable of switching between normal and standby modes quickly enabling dynamic power savings capabilities. If standby mode is not required in the application, the STANDBY input should be directly connected to ground.

7 Target Performance Characteristics

7.1 Absolute Maximum Ratings

Parameter(1)(2)	Notes/Conditions	MIN	MAX	units
Analog Supply Voltage (AVDD)			3.6	V
Digital Supply Voltage (DVDD)	Internally connected to AVDD	-	-	V
Analog Input Voltage		-0.3	3.6	V
Digital Input Voltage		-0.3	3.6	V
Junction Temperature T_{JMAX}	Maximum junction temperature		150	°C
Storage Temperature, T_{STOR}	Storage temperature range	-40	150	°C
Soldering Information: infrared or convection (30 sec)	Peak body temperature (reflow)		260	°C

(1) All Voltages are specified with respect to GND = 0Vdc
(2) Stresses beyond those listed under Absolute Maximum Ratings may cause permanent damage to the device. These are stress ratings only, which do not imply functional operation of the device at these or any other conditions beyond those indicated under Recommended Operating Conditions. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability

7.2 ESD Ratings

Parameter	Notes/Conditions	Value	Units
$V_{(ESD)}$ Electrostatic Discharge	Human Body Model (HBM), per ANSI/ESDA/JEDEC JS-001-2014 (1)	2000	V

(1) JEDEC document JEP155 States that 500-V HBM allows safe manufacturing with a standard ESD control process.

7.3 Recommended Operating Conditions

Over operating free-air temperature range (unless otherwise noted).

Parameter	Notes/Conditions	MIN	TYP	MAX	units
Supply Voltage (AVDD)	Operating voltage	3.0	3.3	3.6	V
DVDD	For bypass purposes only, Inter-tied to AVDD		3.3		V
T_{AMB}(1)	Operating temperature range	0		85	°C

(1) The maximum power dissipation is a function of $T_{J(MAX)}$, Θ_{JA} and the ambient temperature T_A. The maximum allowable power dissipation at any ambient temperature is PD = ($T_{J(MAX)}$ – T_{AMB})/ Θ_{JA}. All numbers apply for packages soldered directly onto a PC Board

7.4 Thermal Information

Parameter	Thermal Metric	9 Ball WLCSP	units
$R_{\Theta JA}$	Junction-to-ambient thermal resistance	60	°C/W

7.5 Electrical Characteristics

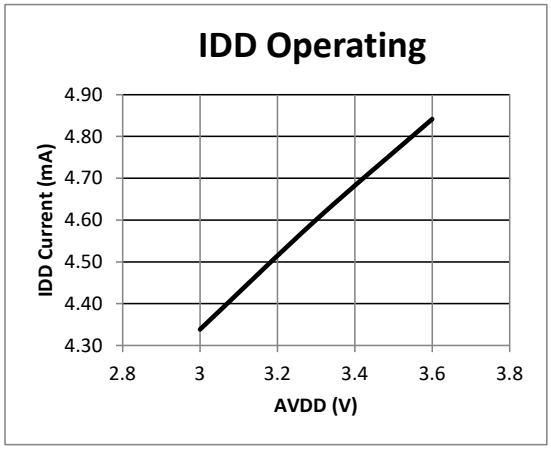
Operating conditions: AVDD = 3.3V, T_{AMB} = 25 °C unless otherwise noted(1).

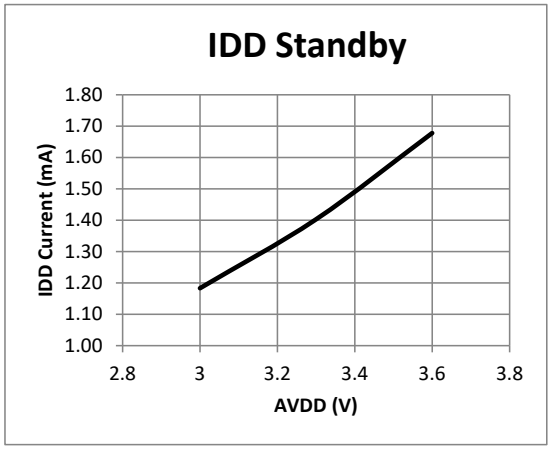
Parameter	Notes/Conditions		MIN(2)	TYP(3)	MAX(2)	units
Power Supply						
I_{VDD}	Operating current				7	mA
STANDBY_I_{VDD}	Standby mode current			1.4		mA
Digital IO						
V_{IL}	Input Low Voltage				0.3 * VDD	V
V_{IH}	Input High Voltage		0.7 * VDD			V
V_{OL}	Output Low Voltage	@ 2 mA load			0.1 * VDD	V
V_{OH}	Output High Voltage	@ 2 mA load	0.9 * VDD			V
System						
REJ_{50KHz}	50KHz Rejection	@ filter output		40		dB
$STANDBY_{PDN}$	Standby Mode Power Down timing	10 - 90% on I_{VDD}		50		µS
$STANDBY_{RCVRY}$	Standby Mode Recovery timing	10 - 90% on I_{VDD}		50		µS
Supply Filtering	Using PI network at least 1 µF (@ board) plus	ferrite bead+0.1 µF (@ each sensor)	60			dB
I_{IN}	Input Current Range		1		50	µA
DC_{DET}	Diode bias DC Current Range	Due to ambient light	0		1.4	mA
BW	Typical 3dB Passband thru filter	Carrier Frequency	1.5		5	MHz
	RBIAS pin stray capacitance				10	pF
	RBIAS resistor value	1% tolerance		15		kΩ

(1) Electrical Characteristic values apply only for factory testing conditions at the temperature indicated. No specification of parametric performance is indicated in the electrical tables under conditions different than those tested
(2) Limits are 100% production tested at 25°C. Limits over the operating temperature range are specified through correlation using Statistical Quality Control (SQC) methods.
(3) Typical values represent the most likely parametric norm as determined at the time of characterization. Actual typical values may vary over time and will also depend on the application and configuration. The typical values are not tested and are not ensured on shipped production material.

8 Typical Characteristics

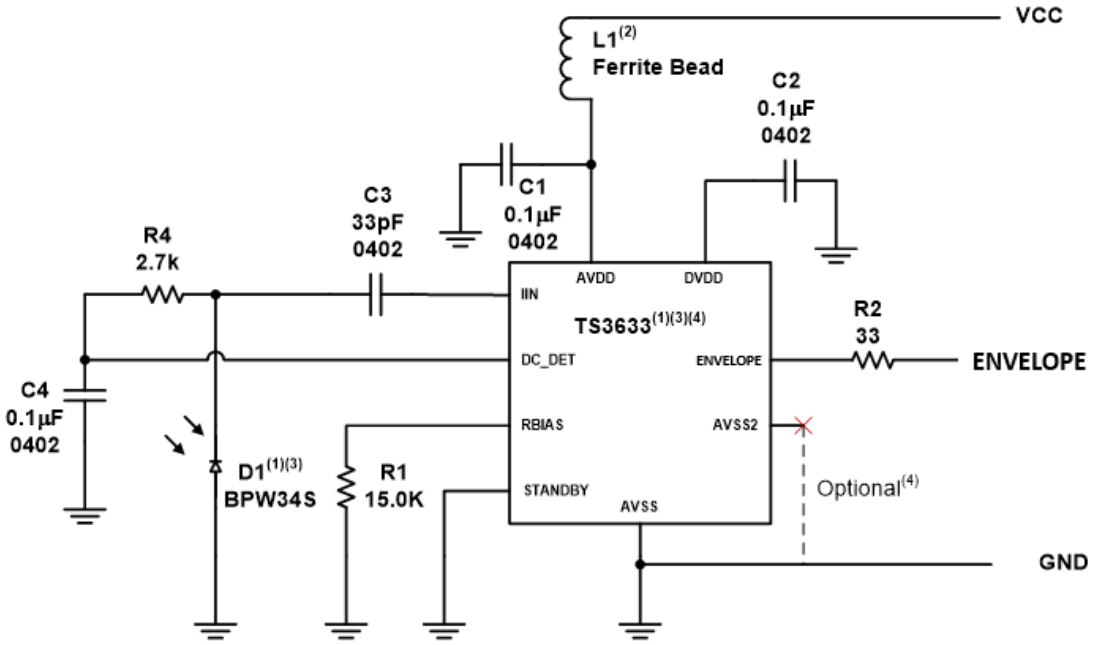
Operating conditions: T_{AMB} = 25°C





9 Applications and Design Considerations

9.1 Example Application Schematic



(1) Minimize stray capacitance at device pins IIN and RBIAS, and at D1.
(2) Supply filtering (L1) required for each sensor. Taiyo Yuden BK1005HM102-T, BK1005HW601-T or equivalent ferrite bead.
(3) Ground plane recommended for D1 and TS3633.
(4) AVSS2 can be left unconnected or connected to AVSS. PCB layout can be eased by routing the GND signal through AVSS2 to access AVSS at the package center bump.

Figure 4: TS3633 Example Application Schematic

9.2 Power Supply Recommendations

The TS3633 was designed to be operated from a 3.3V power supply. The voltage range for AVDD and DVDD is shown in ***Recommended Operating Conditions***. Power supply accuracy of 10% or better is advised.
Power supply noise rejection is accomplished by placing a 1 µF or greater bypass capacitor at VCC. Bulk bypassing can be shared on the system board for multiple sensors; however, each sensor's supply should be isolated with a ferrite bead and local 0.1 µF capacitors at AVDD and DVDD, as shown in Figure 4.

9.3 Example Layout

Figure 5 is the recommended layout for the TS3633 application circuit, which was illustrated in Figure 4. The layout utilizes a 2-sided printed circuit board to minimize manufacturing costs for high-volume production. In the figure, L1 and R2 of the application circuit are not shown, and an optional pull-down resistor is connected to the TS3633's STANDBY input to allow for standby mode to be dynamically switched. Package bump C2 (AVSS2) is implemented as an optional GND connection to allow easy routing access to the AVSS bump at B2.

Optimum performance can be achieved with the TS3633 by adhering to the following layout guidelines which will help minimize layout parasitics:

1) C1 and C2 should be placed as close as practical to their respective AVDD and DVDD package bumps
2) Shield the IIN and DC_DET nets with ground
3) Minimize routing lengths on the IIN and DC_DET nets
4) The ENVELOPE output should be routed over a solid ground plane

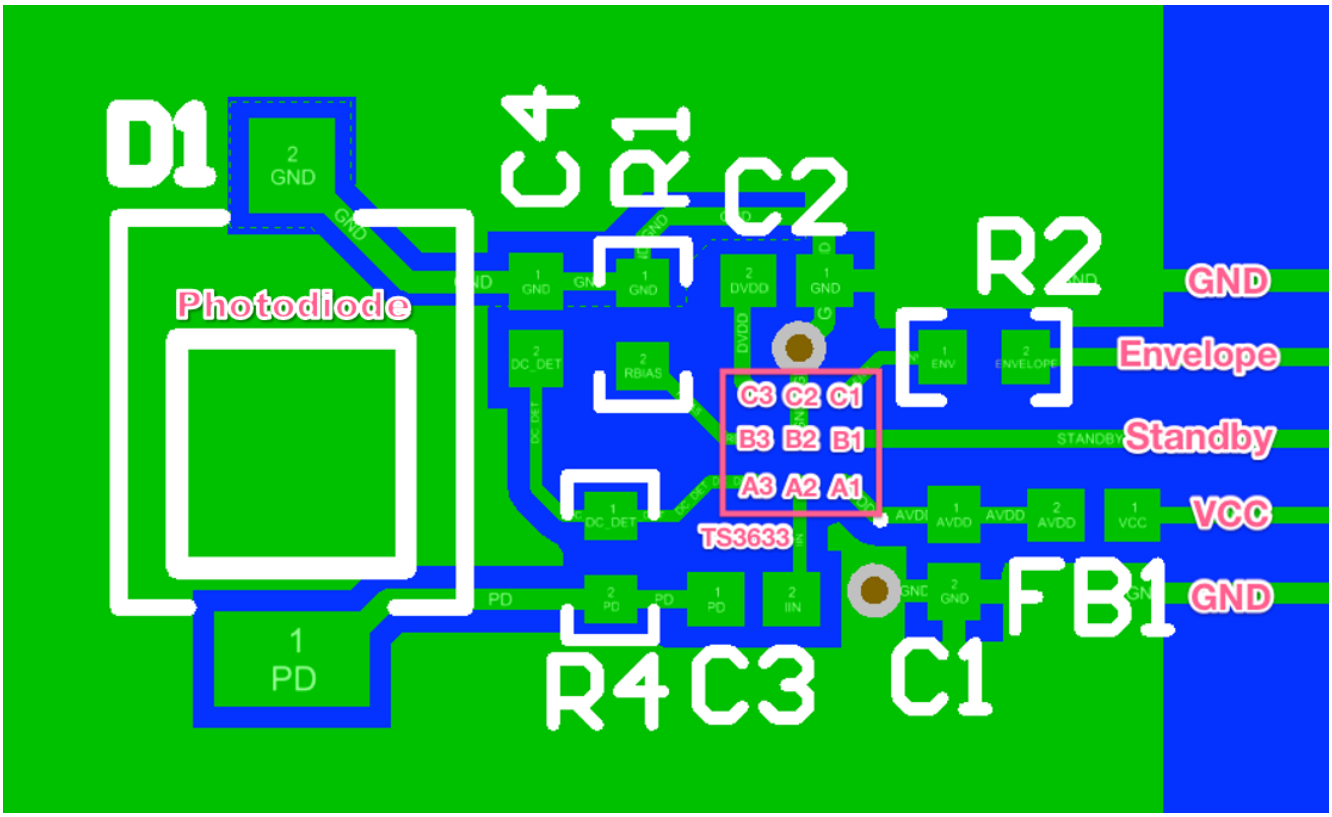
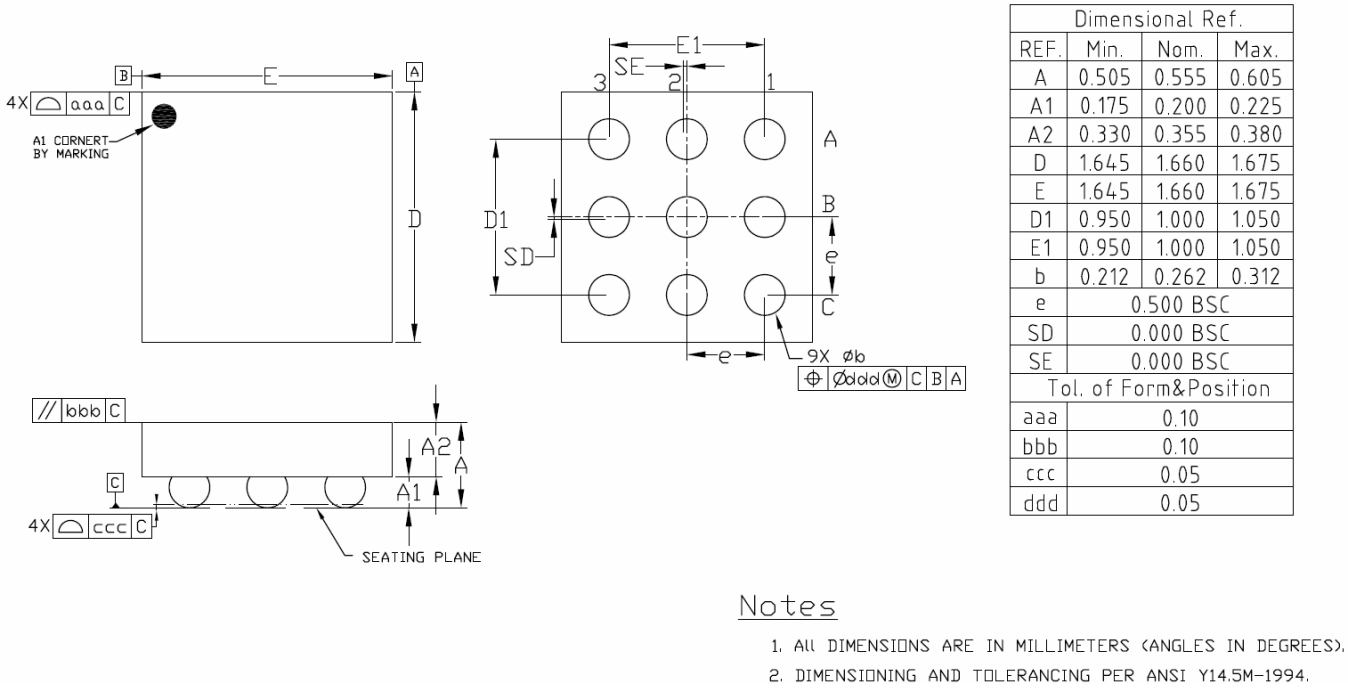


Figure 5: TS3633 Example Layout

10 Part Packaging Information

10.1 Package Drawing

The TS3633 – Light to Digital Converter is packaged as a 9 bump WLCSP. Figure 6 shows the WLCSP configuration. Recommended Land Pattern is 0.200mm for each bump (per IPC 7351A guidelines).



Dimensional Ref.			
REF.	Min.	Nom.	Max.
A	0.505	0.555	0.605
A1	0.175	0.200	0.225
A2	0.330	0.355	0.380
D	1.645	1.660	1.675
E	1.645	1.660	1.675
D1	0.950	1.000	1.050
E1	0.950	1.000	1.050
b	0.212	0.262	0.312
e	0.500 BSC		
SD	0.000 BSC		
SE	0.000 BSC		
Tol. of Form&Position			
aaa	0.10		
bbb	0.10		
ccc	0.05		
ddd	0.05		

Notes

1. All DIMENSIONS ARE IN MILLIMETERS (ANGLES IN DEGREES).
2. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M-1994.

Figure 6: TS3633 Outline Drawing

10.2 Date Code

The manufacturing date code is printed on the package as described in Section 13 of this document. The date code has the format of YYWW where YY is the last 2 digits of the manufacturing year, and WW is the week of manufacture in the year.

11 Pin List

#	Pin Name	Pin Type	Pin Description
A1	AVDD	Supply	Power (0.1 µF bypass)
A2	IIN	Input	TIA Input
A3	DC_DET	Output	Detector Bias
B1	STANDBY	Input	Digital Input, High -> Standby mode enabled
B2	AVSS	Supply	Ground
B3	RBIAS	Input	1% 15k Resistor for current reference
C1	ENVELOPE	Digital Output	Envelope Output
C2	AVSS2	Supply or Not Connected	AVSS2 can be left unconnected or connected to AVSS. PCB layout can be eased by routing the GND signal through AVSS2 to access AVSS at the package center bump.
C3	DVDD	Digital Supply	Digital IO power bypass (0.1 µF bypass)

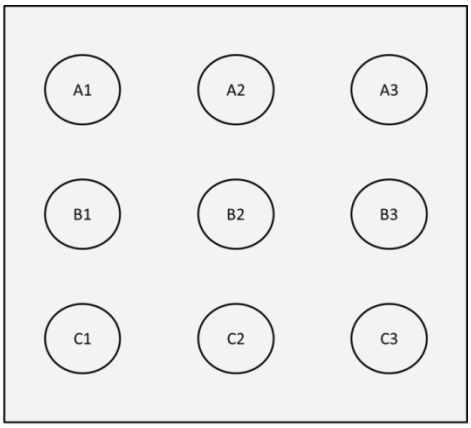
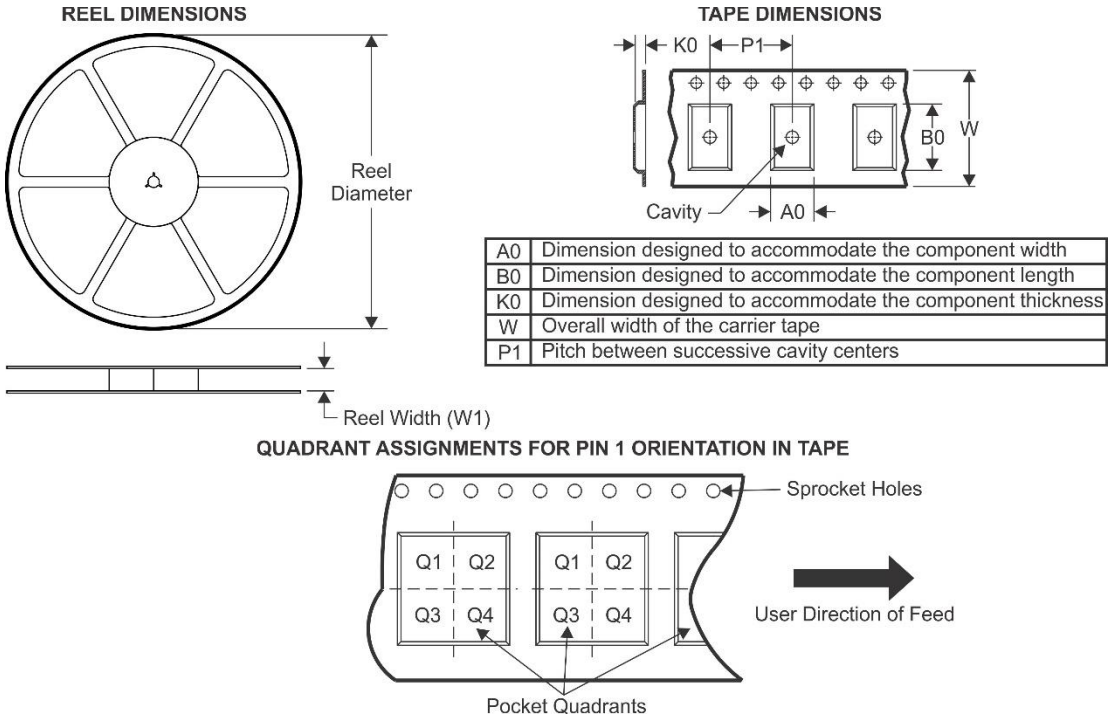


Figure 7: Top View Pin Location

12 Tape and Reel Packaging

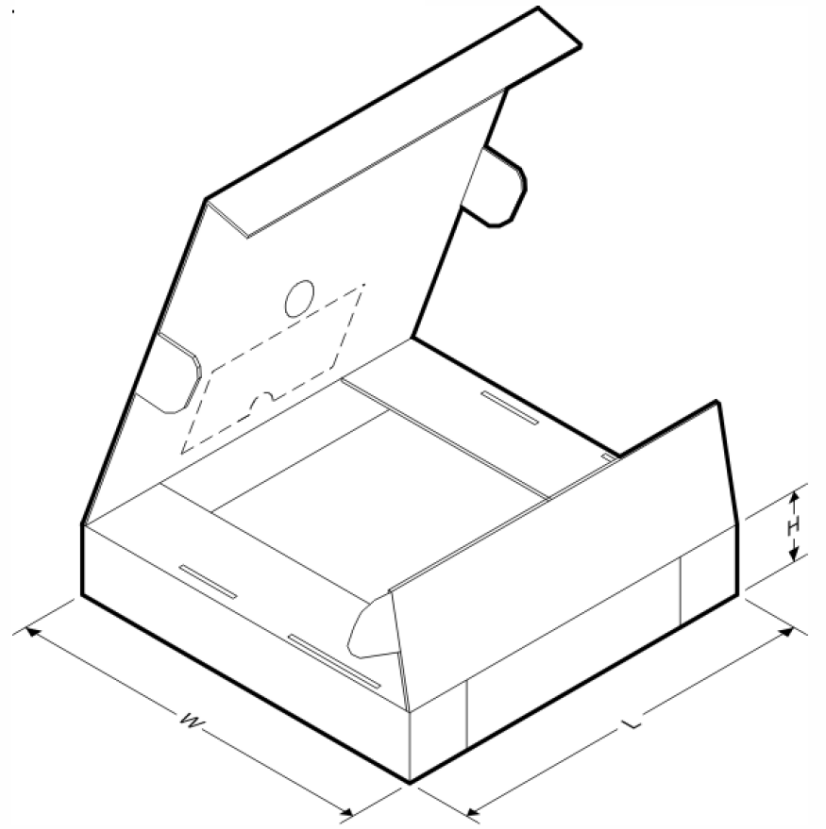
12.1 Tape and Reel Information



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

Device	Package Type	Bumps	Qty / Reel	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin 1 Quadrant
TS3633	WLCSP	9	4000	178.0	9.0	1.85	1.85	0.7	4.0	8.0	Q1

12.2 Tape and Reel Box Dimensions



Device	Package Type	Bumps	Qty / Reel	Length (mm)	Width (mm)	Height (mm)
TS3633	WLCSP	9	4000	215.0	200.0	40.0

Note: All dimensions are nominal

13 Branding

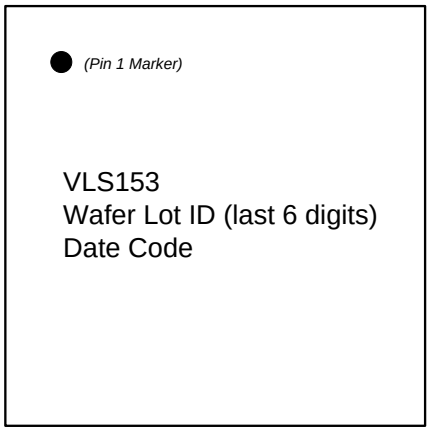


Figure 8: TS3633 Branding Diagram

Note: VLS153 is a customer defined part number

14 Mechanical, Packaging and Handling Information

Device	Package Type	Bumps	Package Qty	RoHS Plan	Lead/Ball Finish	MSL Peak Temp	Op Temp (°C)	Storage Temp (°C)	Device Marking
TS3633	WLCSP	9	4000	RoHS & no Sb/Br	Cu Sn Ag	Level-1-260C-168 HR	0 to 85	-40 to 150	VLS153

14.1 Electrostatic Discharge Caution

TS3633 is an ESD sensitive device with an HBM rating of Class 1C (2,000V) per JS-001-2014. The device should be placed in conductive foam during storage or handling to prevent electrostatic discharge damage to the device. Refer to JESD625 for handling precautions.

14.2 MSL

TS3633 is an MSL1 device per J-STD-020. Refer to J-STD-033 for specific handling requirements and conditions.

14.3 Shelf Life

Shelf life is 12 months as per J-STD-033. Refer to J-STD-033 for additional shelf life information.

15 RoHS

TS3633 fully complies with the RoHS Directive 002/95/EC requirements without exemption and is Halogen-Free as defined by IEC 61249-2-21.

Revision History

Revision	Modifications	Modification Date
A	Initial release Rev A Datasheet	17 August 2016

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No rights are granted to use of the SteamVR™ Tracking system. Those rights are only available from Valve Corporation. https://partner.steamgames.com/vrtracking/.

Latest information about the TS3633 may be found at triadsemi.com/product/ts3633.

Triad Semiconductor designs and manufactures analog and mixed signal integrated circuits. Founded in 2002, Triad provides custom IC, ASSP and standard product solutions to customers in all major markets.

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