
Electronic Hardware
Onboarding: How to Read Datasheets
#003
2023

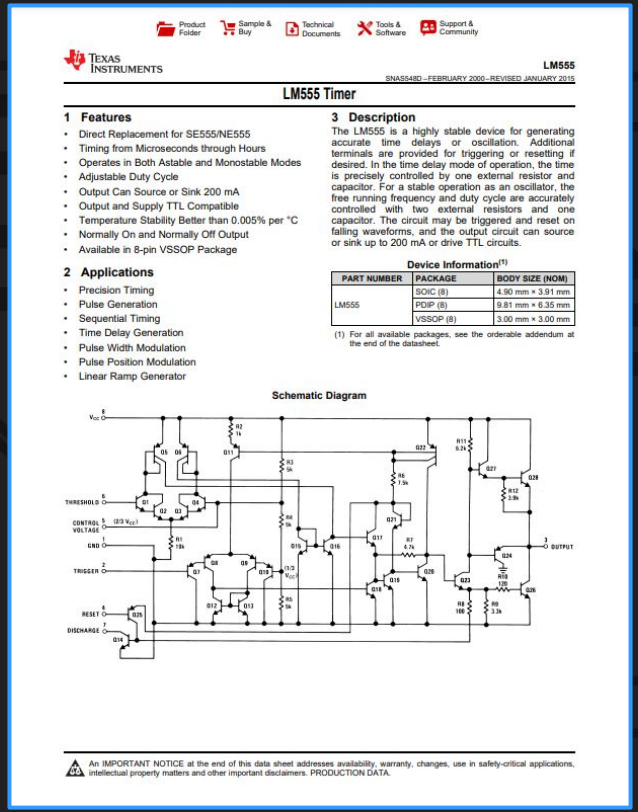
Introduction

Agenda:

1. Format of Datasheets
2. Features and Applications
3. Pin Configuration
4. Electrical Characteristics
5. Implementation
6. Dimension and Packaging
7. Related Resources

Goal:

Understand when/where to find the information needed in a datasheet



Product Folder | Sample & Buy | Technical Documents | Tools & Software | Support & Community

TEXAS INSTRUMENTS

LM555

SNAS548D – FEBRUARY 2000 – REVISED JANUARY 2015

LM555 Timer

1 Features

- Direct Replacement for SE555/NE555
- Timing from Microseconds through Hours
- Operates in Both Astable and Monostable Modes
- Adjustable Duty Cycle
- Output Can Source or Sink 200 mA
- Output and Supply TTL Compatible
- Temperature Stability Better than 0.005% per °C
- Normally On and Normally Off Output
- Available in 8-pin VSSOP Package

2 Applications

- Precision Timing
- Pulse Generation
- Sequential Timing
- Time Delay Generation
- Pulse Width Modulation
- Pulse Position Modulation
- Linear Ramp Generator

3 Description

The LM555 is a highly stable device for generating accurate time delays or oscillation. Additional terminals are provided for triggering or resetting if desired. In the time delay mode of operation, the time is precisely controlled by one external resistor and capacitor. For a stable operation as an oscillator, the free running frequency and duty cycle are accurately controlled with two external resistors and one capacitor. The circuit may be triggered and reset on falling waveforms, and the output circuit can source or sink up to 200 mA or drive TTL circuits.

Device Information(1)

PART NUMBER	PACKAGE	BODY SIZE (NOM)
LM555	SOIC (8)	4.90 mm × 3.91 mm
	PDIP (8)	9.81 mm × 6.35 mm
	VSSOP (8)	3.00 mm × 3.00 mm

(1) For all available packages, see the orderable addendum at the end of the datasheet.

Schematic Diagram

An IMPORTANT NOTICE at the end of this data sheet addresses availability, warranty, changes, use in safety-critical applications, intellectual property matters and other important disclaimers. PRODUCTION DATA.

Format of Datasheets

Features and Applications
- What is this device capable of? When should I use it?

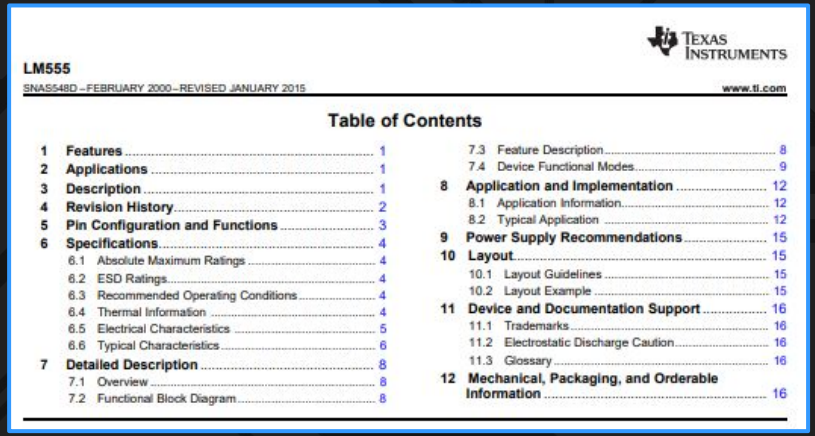
Pin Configuration
- How are the pins arranged?

Electrical Characteristics
- How much current/voltage can this device take/produce?

Implementation
- How is this device usually used/implemented?

Dimension and Packaging
- What's the physical dimensions of this device?

Related Resources
- Where to find other information about this device?



LM555

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Table of Contents

Note:

A datasheet can be very long and intimidating! However, there is usually only a certain amount of information needed. Being able to find those information quickly and accurately is key to the success of a project

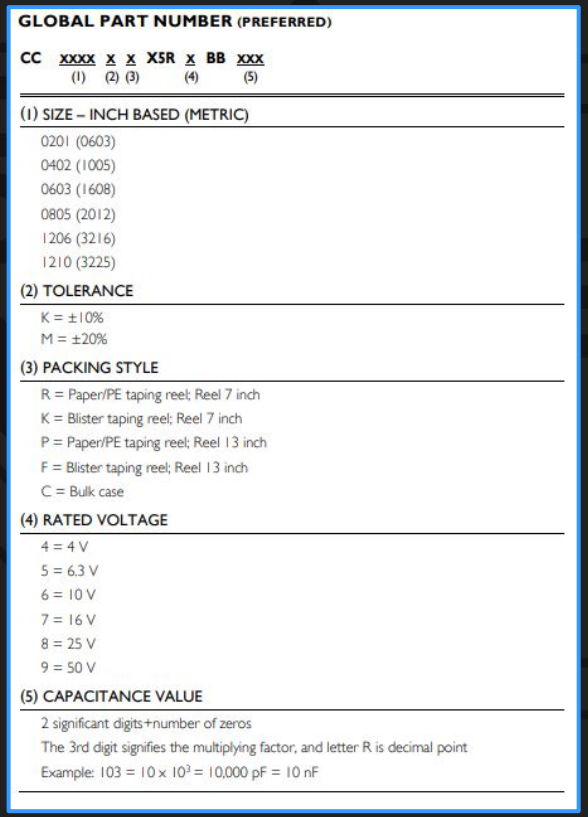
Features and Applications

When to Look at this Section

- When determining if this device satisfies your general requirements
- When trying to quickly understand what this device does

Section Includes:

- Features: A list of things this device can achieve
- Applications: A list of common use cases of this device
- Description: A slightly more detailed summary of its functionalities and limits (**good for getting a general understanding of this device**)
- Series Comparison (if applicable): Comparison between different devices within the same family
    - **Important Note: Typically, a datasheet is made for a family of devices instead of one specific device. So, be mindful with which specific part number you are looking at!**
- Part Number Comparison (if applicable): How to use part number to identify the capability of the device
    - Ex. the figure on the right for a family of capacitors



GLOBAL PART NUMBER (PREFERRED)

CC XXXX (1) X (2) X (3) X5R X (4) BB XXX (5)

(1) SIZE – INCH BASED (METRIC)

0201 (0603)
0402 (1005)
0603 (1608)
0805 (2012)
1206 (3216)
1210 (3225)

(2) TOLERANCE

K = ±10%
M = ±20%

(3) PACKING STYLE

R = Paper/PE taping reel; Reel 7 inch
K = Blister taping reel; Reel 7 inch
P = Paper/PE taping reel; Reel 13 inch
F = Blister taping reel; Reel 13 inch
C = Bulk case

(4) RATED VOLTAGE

4 = 4 V
5 = 6.3 V
6 = 10 V
7 = 16 V
8 = 25 V
9 = 50 V

(5) CAPACITANCE VALUE

2 significant digits+number of zeros
The 3rd digit signifies the multiplying factor, and letter R is decimal point
Example: 103 = 10 x 10^3 = 10,000 pF = 10 nF

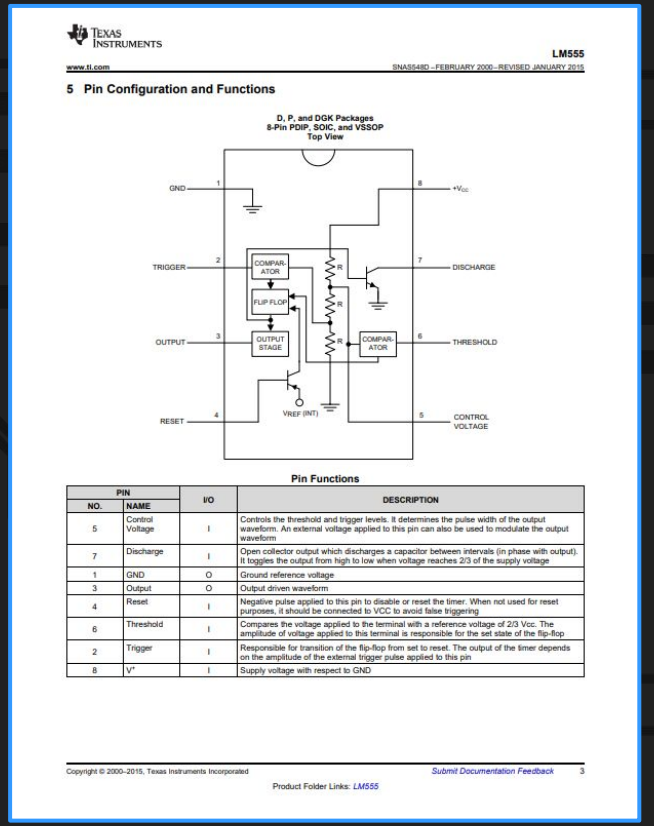
Pin Configuration

When to Look at this Section

- When determining how to use this device
- When having questions about functionalities of specific pins

Section Includes:

- Pin Layout: A diagram showing how pins are arranged
- Pin Description: A list of pin names and their corresponding functionalities
- Other Pin-related information (if applicable):
  - Ex: Strapping Pins for certain microcontrollers (pins used as parameters in boot mode)
  - **Be mindful when using strapping pins as they may affect the booting process for the device!**



TEXAS INSTRUMENTS

LM555

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5 Pin Configuration and Functions

D, P, and DGK Packages
8-Pin PDIP, SOIC, and VSSOP
Top View

Pin Functions

PIN		I/O	DESCRIPTION
NO.	NAME		
5	Control Voltage	I	Controls the threshold and trigger levels. It determines the pulse width of the output waveform. An external voltage applied to this pin can also be used to modulate the output waveform
7	Discharge	I	Open collector output which discharges a capacitor between intervals (in phase with output). It toggles the output from high to low when voltage reaches 2/3 of the supply voltage
1	GND	O	Ground reference voltage
3	Output	O	Output driven waveform
4	Reset	I	Negative pulse applied to this pin to disable or reset the timer. When not used for reset purposes, it should be connected to VCC to avoid false triggering
6	Threshold	I	Compares the voltage applied to the terminal with a reference voltage of 2/3 Vcc. The amplitude of voltage applied to this terminal is responsible for the set state of the flip-flop
2	Trigger	I	Responsible for transition of the flip-flop from set to reset. The output of the timer depends on the amplitude of the external trigger pulse applied to this pin
8	V+	I	Supply voltage with respect to GND

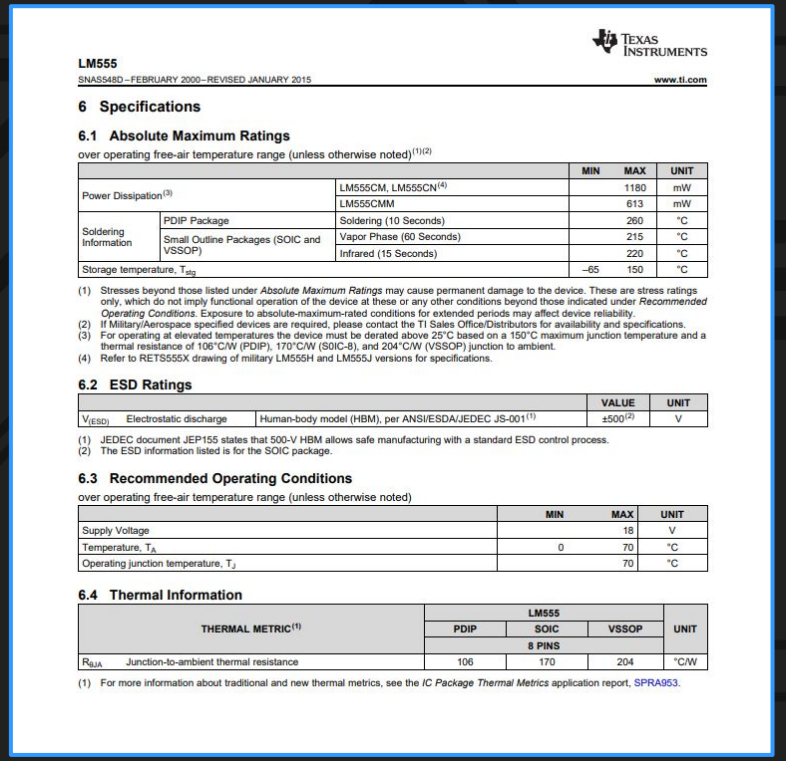
Electrical Characteristics

When to Look at this Section

- When determining the input or output voltage/current of this device
- When determining the voltage/current limit for this device

Section Includes:

- Absolute Maximum Ratings: The theoretical maximum voltage/current/temperature this device can withstand
- Recommended Operating Conditions: The ideal condition voltage/current/temperature this device should operate at
  - **Note: Those condition should be your reference when designing the circuit!**
- Other Electrical Characteristics (if applicable):
  - Ex: current/power consumption, threshold voltage for MOSFETs, wireless specifications, etc.
  - **Note: this section can contain many plots and graphs. It is typically not necessary to understand them unless in special circumstances**



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6 Specifications

6.1 Absolute Maximum Ratings

over operating free-air temperature range (unless otherwise noted)(1)(2)

			MIN	MAX	UNIT
Power Dissipation(3)		LM555CM, LM555CN(4)		1180	mW
		LM555CMM		613	mW
Soldering Information	PDIP Package	Soldering (10 Seconds)		260	°C
	Small Outline Packages (SOIC and VSSOP)	Vapor Phase (60 Seconds)		215	°C
		Infrared (15 Seconds)		220	°C
Storage temperature, T_{stg}			–65	150	°C

(1) 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.
(2) If Military/Aerospace specified devices are required, please contact the TI Sales Office/Distributors for availability and specifications.
(3) For operating at elevated temperatures the device must be derated above 25°C based on a 150°C maximum junction temperature and a thermal resistance of 106°C/W (PDIP), 170°C/W (SOIC-8), and 204°C/W (VSSOP) junction to ambient.
(4) Refer to RETS555X drawing of military LM555H and LM555J versions for specifications.

6.2 ESD Ratings

			VALUE	UNIT
$V_{(ESD)}$	Electrostatic discharge	Human-body model (HBM), per ANSI/ESDA/JEDEC JS-001(1)	±500(2)	V

(1) JEDEC document JEP155 states that 500-V HBM allows safe manufacturing with a standard ESD control process.
(2) The ESD information listed is for the SOIC package.

6.3 Recommended Operating Conditions

over operating free-air temperature range (unless otherwise noted)

	MIN	MAX	UNIT
Supply Voltage		18	V
Temperature, T_A	0	70	°C
Operating junction temperature, T_J		70	°C

6.4 Thermal Information

THERMAL METRIC(1)		LM555			UNIT
		PDIP	SOIC	VSSOP	
		8 PINS			
$R_{\theta JA}$	Junction-to-ambient thermal resistance	106	170	204	°C/W

(1) For more information about traditional and new thermal metrics, see the *IC Package Thermal Metrics* application report, SPRA953.

Implementation

When to Look at this Section

- When determining how to use/design circuits around this device

Section Includes:

- Application Information: A quick summary of the modes and common applications for this device
- Typical Application: A diagram showing how this device is usually connected to other components
  - **Note: This diagram should be your reference when designing the circuit! It is typically required to follow the recommended setup, or the device may not work properly!**
- Other Application Information(if applicable):
  - Ex: frequency/duty cycle calculation formula for a 555 timer

7.4.2 Astable Operation

If the circuit is connected as shown in Figure 14 (pins 2 and 6 connected) it will trigger itself and free run as a multivibrator. The external capacitor charges through $R_A + R_B$ and discharges through R_B. Thus the duty cycle may be precisely set by the ratio of these two resistors.

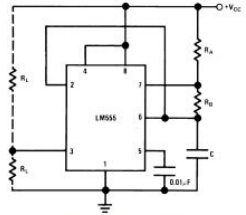


Figure 14. Astable

In this mode of operation, the capacitor charges and discharges between 1/3 V_{CC} and 2/3 V_{CC}. As in the triggered mode, the charge and discharge times, and therefore the frequency are independent of the supply voltage.

Figure 15 shows the waveforms generated in this mode of operation.

The charge time (output high) is given by:

$$t_1 = 0.693 (R_A + R_B) C \quad (1)$$

And the discharge time (output low) by:

$$t_2 = 0.693 (R_B) C \quad (2)$$

Thus the total period is:

$$T = t_1 + t_2 = 0.693 (R_A + 2R_B) C \quad (3)$$

The frequency of oscillation is:

$$f = \frac{1}{T} = \frac{1.44}{(R_A + 2R_B) C} \quad (4)$$

Figure 16 may be used for quick determination of these RC values.

The duty cycle is:

$$D = \frac{R_B}{R_A + 2R_B} \quad (5)$$

Dimension and Packaging

When to Look at this Section

- When determining this parts will fit under constrained space
- When designing the footprint or the layout of the PCB

Section Includes:

- Physical Dimension: The diagrams showing the physical dimensions of the device and distances between pins and other components.
- Recommended Footprint: The diagrams showing the recommended distances between pads, size of those pads and other size constraints.
  - **Note: Most likely, you will be provided footprints by the distributor like Digikey or be able to find existing footprints when designing a PCB on websites like Ultra Librarian. In very rare cases, it is still possible that you need to design the footprint yourself.**

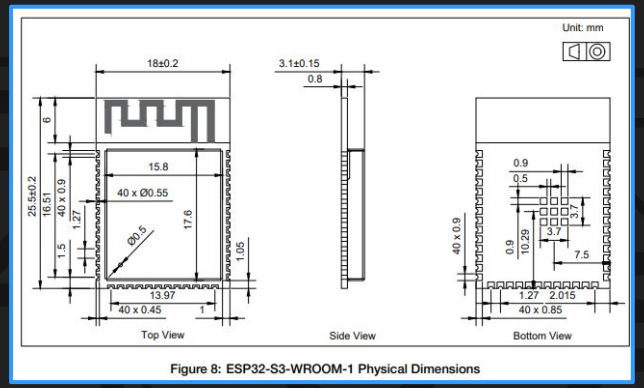


Figure 8: ESP32-S3-WROOM-1 Physical Dimensions

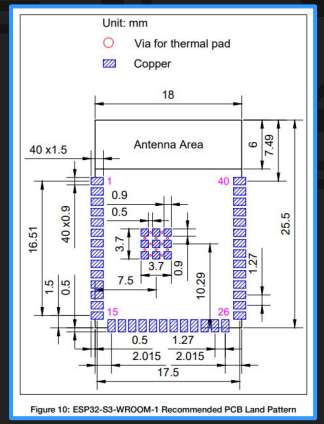


Figure 10: ESP32-S3-WROOM-1 Recommended PCB Land Pattern

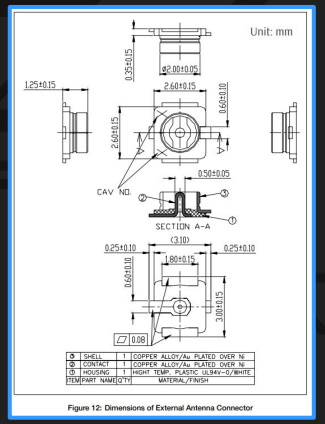


Figure 12: Dimensions of External Antenna Connector

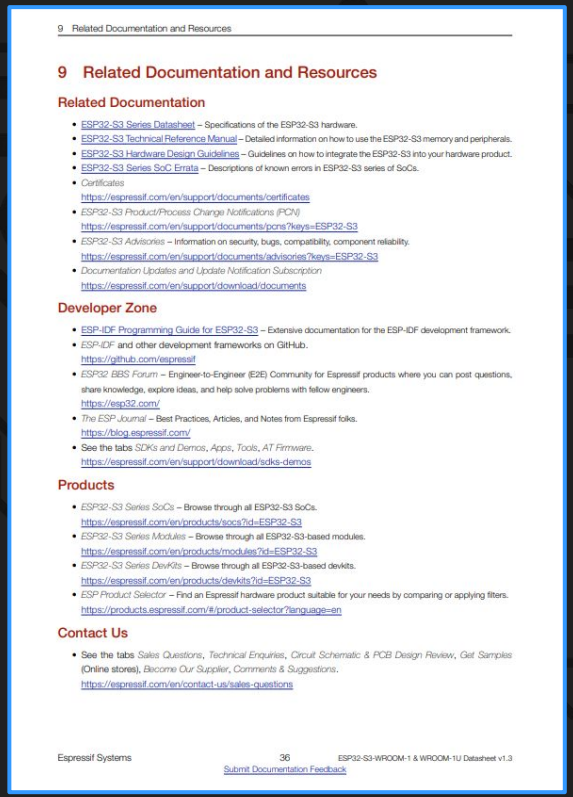
Related Resources

When to Look at this Section

- When having questions about this datasheet
- When more detailed information is required

Section Includes:

- Related Documents
  - Ex: If the datasheet describes a certain module made of various components, this section can include details for each specific component
- Link to Developer Forum or Other Websites
  - Most Developer Forums have proven to be great resources for asking and answering questions like the Arduino Forum and ESP32 Forum
- Contact information



9 Related Documentation and Resources

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Related Documentation

- ESP32-S3 Series Datasheet – Specifications of the ESP32-S3 hardware.
- ESP32-S3 Technical Reference Manual – Detailed information on how to use the ESP32-S3 memory and peripherals.
- ESP32-S3 Hardware Design Guidelines – Guidelines on how to integrate the ESP32-S3 into your hardware product.
- ESP32-S3 Series SoC Errata – Descriptions of known errors in ESP32-S3 series of SoCs.
- *Certificates*
  https://espressif.com/en/support/documents/certificates
- *ESP32-S3 Product/Process Change Notifications (PCN)*
  https://espressif.com/en/support/documents/pcns?keys=ESP32-S3
- *ESP32-S3 Advisories* – Information on security, bugs, compatibility, component reliability.
  https://espressif.com/en/support/documents/advisories?keys=ESP32-S3
- *Documentation Updates and Update Notification Subscription*
  https://espressif.com/en/support/download/documents

Developer Zone

- ESP-IDF Programming Guide for ESP32-S3 – Extensive documentation for the ESP-IDF development framework.
- *ESP-IDF* and other development frameworks on GitHub.
  https://github.com/espressif
- *ESP32 BBS Forum* – Engineer-to-Engineer (E2E) Community for Espressif products where you can post questions, share knowledge, explore ideas, and help solve problems with fellow engineers.
  https://esp32.com/
- *The ESP Journal* – Best Practices, Articles, and Notes from Espressif folks.
  https://blog.espressif.com/
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  https://espressif.com/en/support/download/sdks-demos

Products

- *ESP32-S3 Series SoCs* – Browse through all ESP32-S3 SoCs.
  https://espressif.com/en/products/socs?id=ESP32-S3
- *ESP32-S3 Series Modules* – Browse through all ESP32-S3-based modules.
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  https://espressif.com/en/products/devkits?id=ESP32-S3
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Espressif Systems 36 ESP32-S3-WROOM-1 & WROOM-1U Datasheet v1.3
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Further Reading

Works Cited:

"ESP32-S3-WROOM-1 ESP32-S3-WROOM-1U Datasheet." *Espressif Systems*, Nov. 2023, https://www.espressif.com/sites/default/files/documentation/esp32-s3-wroom-1_wroom-1u_datasheet_en.pdf.

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"SURFACE MOUNT MULTILAYER CERAMIC CAPACITORS DATA SHEET." *YAGEO*, https://www.yageo.com/upload/media/product/app/datasheet/mlcc/upy-gphc_x5r_4v-to-50v.pdf.