How to Read a Datasheet

Prepared for the WIMS outreach program

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outreach program

5/6/02, D. Grover

PIC

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555

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data...
concisely tell you everything you need to know about the device, a common
555 timer chip (the duct-tape of the electronics hobbyist). Most datasheets
for ICs follow the same general layout.

You don't have to understand everything in a datasheet. There's a lot of
information that might not be of any use to you. The annotations that follow
try to point out parts of the datasheet that you should pay particular attention
to.

Where do you find datasheets? Nowadays you can find almost any
datasheet on the internet, often in PDF (Acrobat) form. For example, the

LM555   LM555

555

IC   555   CD4538

What is the LM555? The LM555 is a timer chip that uses external resistors
and capacitors to generate either a single pulse of a certain duration, or a
continuous sequence of pulses with a variety of pulse widths possible.
Because it is a very general purpose collection of functional blocks such as
comparators, a flip-flop, internal voltage divider, high power output stage,
and so on, a number of different timing-related functions are possible.
Entire books have been written about the 555, though it is often used when
another IC would work better. (See for example the CD4538 timer chip.)

There will always be a date. Datasheets do change, especially if Preliminary or Advance. Check the date!

Look up here to see if the datasheet is Advance Information or Preliminary.

N a t i o n a l S

LM555
Timer

General Description

The LM555 is a highly sta... time delays or oscillation... for triggering or resetting i... operation, the time is prec... sistor and capacitor. For ... the free running frequen... controlled with two extern... circuit may be triggered a... the output circuit can so... TTL circuits.

Features tell you general characteristics-- always check the Electrical Characteristics for conditions and exceptions.
*Features*   --

Sometimes the General Description will tell you about a feature or usage not mentioned anywhere else! For example, you might need to hold a specific pin low for some operation.
General Description

Features

■ ... for SE555/NE555
■ ... seconds through hours
■ ... stable and monostable modes
■ ... cle
■ ... or sink 200 mA
■ ... TTL compatible
■ ... ity better than 0.005% per ˚C
■ ... ormally off output
■ Available in 8-pin MSOP package

Applications

■ Precision timing
■ Pulse generation
■ Sequential timing
■ Time delay generation
■ Pulse width modulation
■ Pulse position modulation
■ Linear ramp generator

Application suggestions can often tell you quickly if this device is in the ballpark for what you want to do, but these lists are often very general.
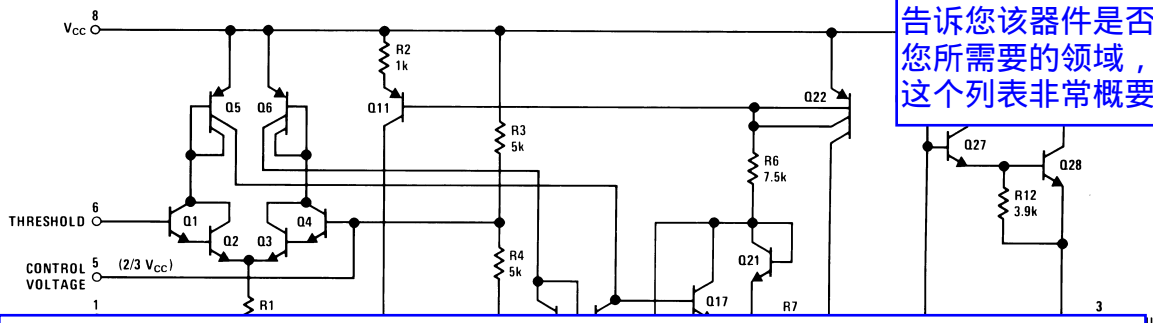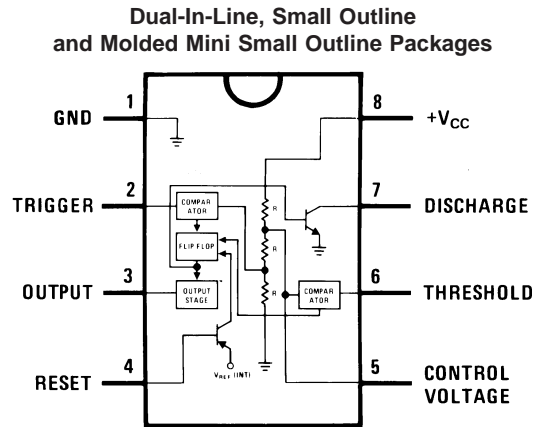
Schematic Diagram

Usually called the Equivalent Schematic Diagram, this schematic isn't what is necessarily in the device, but the device acts as if this was what was inside. It can help explain behavior that isn't otherwise described in the datasheet. Could you duplicate this circuit on a breadboard? Only if you knew what the characteristics of the transistors were--which are not given.

Connection Diagram

Make sure you're looking at the pinout for the correct package. In the back pages you'll find drawings of the package types. Here all the packages have the same pinout--that's not always the case!

Dual-In-Line, Small Outline and Molded Mini Small Outline Packages

1	GND		+V_CC	8
2	TRIGGER		DISCHARGE	7
3	OUTPUT		THRESHOLD	6
4	RESET		CONTROL VOLTAGE	5

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Top View

Ordering Information

Package	Part Number	Package Marking	Media Transport	NSC Drawing
8-Pin SOIC	LM555CM	LM555CM	Rails	M08A
	LM555CMX	LM555CM	2.5k Units Tape and Reel	
8-Pin MSOP	LM555CMM	Z55	1k Units Tape and Reel	MUA08A
	LM555CMMX	Z55	3.5k Units Tape and Reel	
8-Pin MDIP	LM555CN	LM555CN	Rails	N08E

Under Ordering Information you'll find a list of every variation of this device along with the COMPLETE part number. Often the first few letters are either industry-standard or identify the manufacturer (e.g., PIC). The generic identifier comes next ("555"). Suffixes generally give package type (surface mount and through hole types), temperature range (wider range = more expensive), speed (faster = more expensive), and other variations such as power, voltage range, etc.

Ordering Information

PIC

" 555"

Other elements in datasheets:
--Related devices, such as devices this supercedes, exactly replaces, or is replaced by
--Block diagrams of internals
--Information to support programming or configuring the device (registers, etc.)
--Interfacing with other devices (including input/output characteristics)

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Absolute Maximum Ratings tell you what will damage the chip--NOT the maximum operating limits!

Absolute Maximum Ratings

If Military/Aerospace specified devices are required, please contact the National Semiconductor Sales Office/

Electrical Characteristics are sometimes split into DC (power supply, static input/ouput characteristics) and AC or Timing, these tell you what you can count on.
DC / AC

Dual-In-Line Package
  Soldering (10 Seconds)   260˚C
Small Outline Packages
  (SOIC and MSOP)
  Vapor Phase (60 Seconds)   215˚C
  Infrared (15 Seconds)
See AN-450 "Surface Mounting M
on Product Reliability" for other m
surface mount devices.

See Note 2 for details.
2

Electrical Characteristics (Notes 1, 2)
(T_A = 25˚C, V_{CC} = +5V to +15V, unless otehwise specified)

Watch out--the datasheet might discuss more than one part!
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Parameter	Conditions	Min	Typ	Max	Units
Supply Voltage		4.5		16	V
Supply Current	V_{CC} = 5V, R_L = ∞		3	6	
	V_{CC} = 15V, R_L = ∞ (Low State) (Note 4)		10	15	mA
Timing Error, Monostable					
Initial Accuracy					
Drift with Temperature	R_A = 1k to C = 0.1µF				/˚C
Accuracy over Temperature					
Drift with Supply					/V
Timing Error, Astable					
Initial Accuracy					
Drift with Temperature	R_A, R_B = 1 C = 0.1µF, (Note 5)				/˚C
Accuracy over Temperature			3.0		%
Drift with Supply			0.30		%/V
Threshold V			0.667		x V_{CC}
Trigger Vol			5		V
			1.67		V
Trigger Cur			0.5	0.9	µA
Reset Volta		0.4	0.5	1	V
Reset Curre			0.1	0.4	mA
Threshold C			0.1	0.25	µA
Contro		9	10	11	V
		2.6	3.33	4	
Pin 7 Leaka			1	100	nA
Pin 7 Sat (I					
Output Low	V_{CC} = 15V, I_7 = 15mA		180		mV
Output Low	V_{CC} = 4.5V, I_7 = 4.5mA		80	200	mV

Design to the minimum and maximum limits, not to the typical. This gives you an idea of the likely behavior, but not the worst-case. Good, robust design does not count on the typical!

Pay attention to the conditions noted. Here the device is at a specific temperature. Often, plots later on in the datasheet will show temperature-related parameters (as well as those dependent on supply voltage, speed, etc.).

Electrical Characteristics (Notes 1, 2) (Continued)

(T$_A$ = 25˚C, V$_{CC}$ = +5V to +15V, unless othewise specified)

Parameter	Conditions	Limits LM555C			Units
		Min	Typ	Max	
Output Voltage Drop (Low)	V$_{CC}$ = 15V				
	I$_{SINK}$ = 10mA		0.1	0.25	V
	I$_{SINK}$ = 50mA		0.4	0.75	V
	I$_{SINK}$ = 100mA		2	2.5	V
	I$_{SINK}$ = 200mA		2.5		V
	V$_{CC}$ = 5V				
	I$_{SINK}$ = 8mA				V
	I$_{SINK}$ = 5mA		0.25	0.35	V
Output Voltage Drop (High)	I$_{SOURCE}$ = 200mA, V$_{CC}$ = 15V		12.5		V
	I$_{SOURCE}$ = 100mA, V$_{CC}$ = 15V	12.75	13.3		V
	V$_{CC}$ = 5V	2.75	3.3		V
Rise Time of Output			100		ns
Fall Time of Output			100		ns

Note 1: All voltages are measured with respect to the ground pin, unless otherwise specified.

Note 2: Absolute Maximum Ratings indicate limits beyond which damage to the device may occur. Operating Ratings indicate conditions for which the device is functional, but do not guarantee specific performance limits. Electrical Characteristics state DC and AC electrical specifications under particular test conditions which guarantee specific performance limits. This assumes that the device is within the Operating Ratings. Specifications are not guaranteed for parameters where no limit is given, however, the typical value is a good indication of device performance.

Note 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 (DIP), 170˚C/W (S0-8), and 204˚C/W (MSOP) junction to ambient.

Note 4: Supply current when output high typically 1 mA less at V$_{CC}$ = 5V.

Note 5: Tested at V$_{CC}$ = 5V and V$_{CC}$ = 15V.

Note 6: This will determine the maximum value of R$_A$ + R$_B$ for 15V operation. The maximum total (R$_A$ + R$_B$) is 20MΩ.

Note 7: No protection against excessive pin 7 current is necessary providing the package dissipation rating will not be exceeded.

Note 8: Refer to RETS555X drawing of military LM555H and LM555J versions for specifications.

(Here is Note 2 in large print)

Note 2: Absolute Maximum Ratings indicate limits beyond which damage to the device may occur. Operating Ratings indicate conditions for which the device is functional,but do not guarantee specific performance limits. Electrical Characteristics state DC and AC electrical specifications under particular test conditions which guarantee specific performance limits. This assumes that the device is within the Operating Ratings. Specifications are not guaranteed for parameters where no limit is given, however, the typical value is a good indication of device performance.
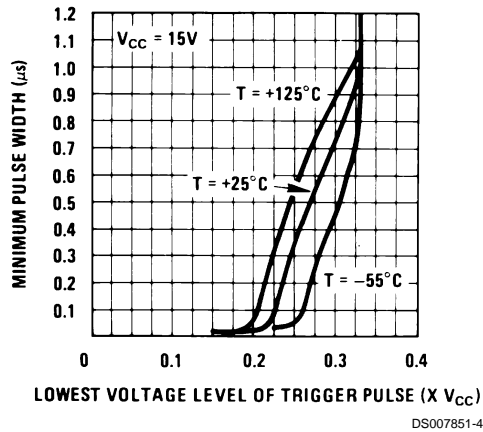
2

2 Absolute Maximum Ratings

Operating Ratings

Electrical Characteristics

Typical Performance Characteristics

**Minimuim Pulse Width
Required for Triggering**

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**Supply Current vs.
Supply Voltage**

DS007851-19
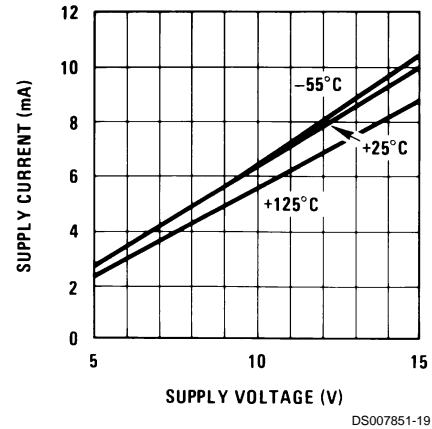
**High Output Voltage vs.
Output Source Current**

DS007851-20
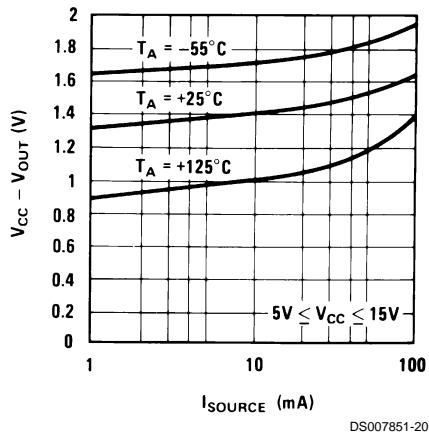
**Low Output ~~Voltage vs.~~
Output Sink~~ Current~~**

Graphs are used to describe characteristics that can't be captured easily in a table. Often several things are being varied--above, supply current is measured as voltage is changed, but this is also being show for three different temperatures. Note that 25C is roughly room temperature (77F).

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25C

77F

DS007851-21

**Low Output Voltage vs.
Output Sink Current**

DS007851-22

**Low Output Voltage vs.
Output Sink Current**

DS007851-23
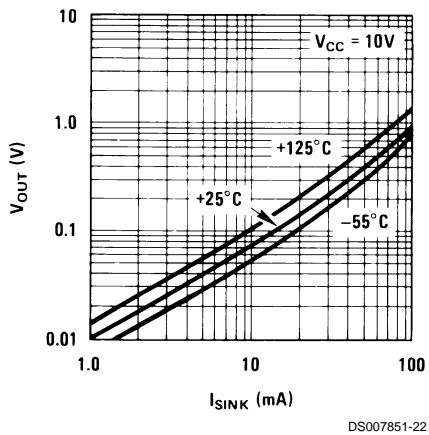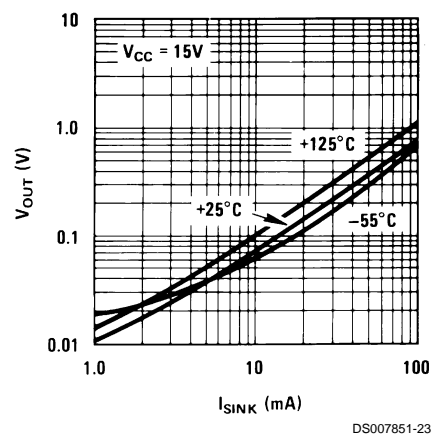
Page 6 of the datasheet is omitted.
6

Applications Information

MONOSTABLE OPERATION

In this mode of operation, the timer functions as a one-shot (*Figure 1*). The external capacitor is initially held discharged

NOTE: In monostable operation, the trigger should be driven high before the end of timing cycle.

Here are example circuits and application notes. Note too that often there are other sources for application information, such as separate Application Notes available from the manufacturer.
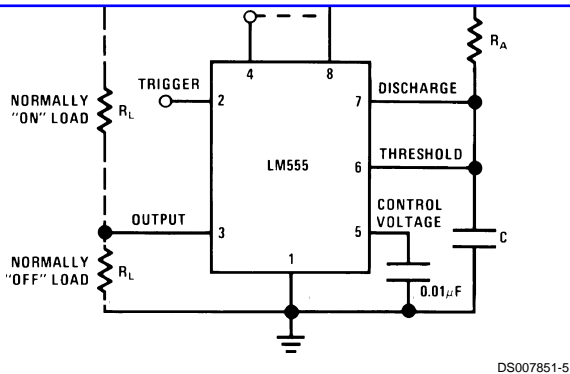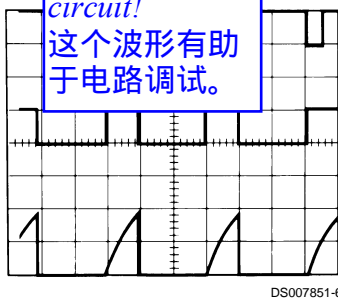

DS007851-5

FIGURE 1. Monostable

The voltage across the capacitor then increases exponentially for a period [...] end of which time the voltage equals 2 [...] ator then resets the flip-flop which in t [...] pacitor and drives the output to its low s [...] he waveforms generated in this mod [...] the charge and the threshold level o [...] both directly proportional to supply v [...] nal is independent of supply.

These waveforms would be helpful in debugging a circuit!

DS007851-6

V_CC = 5V   Top Trace: Input 5V/Div.
TIME = 0.1 ms/DIV.   Middle Trace: Output 5V/Div.
R_A = 9.1kΩ   Bottom Trace: Capacitor Voltage 2V/Div.
C = 0.01µF

FIGURE 2. Monostable Waveforms

During the timing cycle when the output is high, the further application of a trigger pulse will not effect the circuit so long as the trigger input is returned high at least 10µs before the end of the timing interval. However the circuit can be reset during this time by the application of a negative pulse to the reset terminal (pin 4). The output will then remain in the low state until a trigger pulse is again applied.

When the reset function is not in use, it is recommended that it be connected to V_CC to avoid any possibility of false triggering.

Figure [...] R, C values for [...]

Pages 8-11 have been omitted.
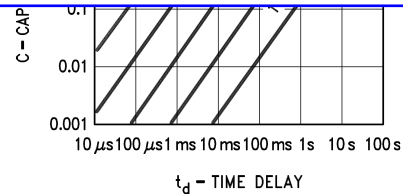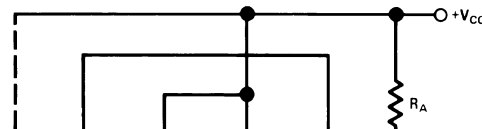*8-11*

DS007851-7
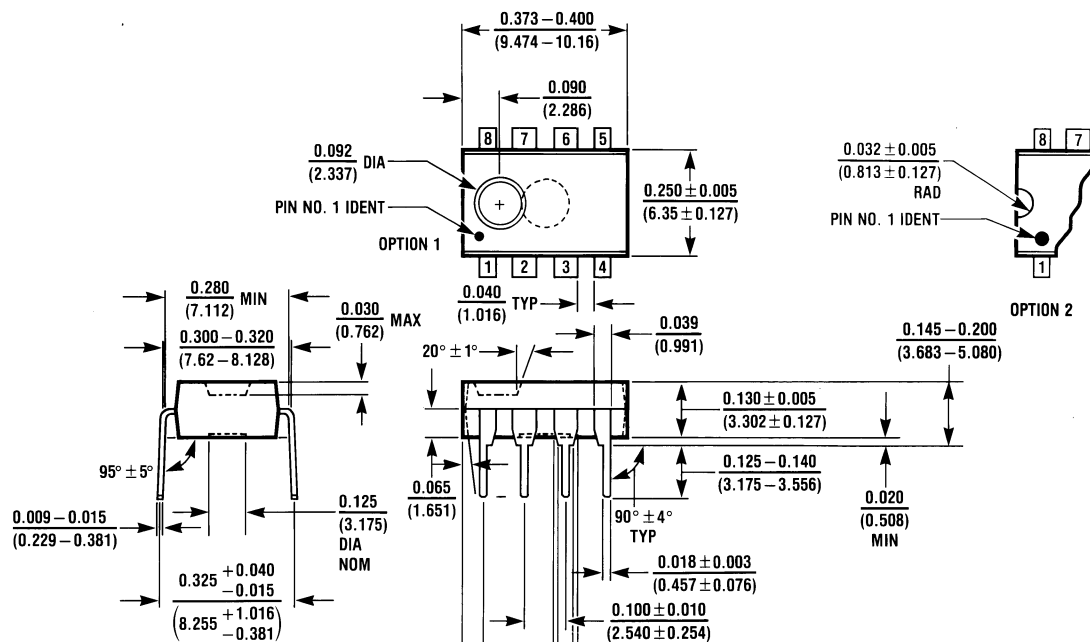
FIGURE 3. Time Delay

ASTABLE OPERATION

If the circuit is connected as shown in *Figure 4* (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.

Not all datasheet application examples are so well written--sometimes you just get the raw schematics. For more complex devices, such as microcontrollers, different aspects might be handled in different sections--for example, a clock circuit in one part, a reset circuit in another. Read over all the sections to make sure you are using the device correctly and have supplied all the necessary components.

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Physical Dimensions inches (millimeters) unless otherwise noted (Continued)

0.373 − 0.400
(9.474 − 10.16)

0.090
(2.286)

0.092
(2.337) DIA

PIN NO. 1 IDENT

OPTION 1

0.250 ± 0.005
(6.35 ± 0.127)

0.032 ± 0.005
(0.813 ± 0.127)
RAD

PIN NO. 1 IDENT

OPTION 2

0.280
(7.112) MIN

0.030
(0.762) MAX

0.300 − 0.320
(7.62 − 8.128)

0.040
(1.016) TYP

20° ± 1°

0.039
(0.991)

0.145 − 0.200
(3.683 − 5.080)

0.130 ± 0.005
(3.302 ± 0.127)

0.125 − 0.140
(3.175 − 3.556)

0.020
(0.508) MIN

95° ± 5°

0.009 − 0.015
(0.229 − 0.381)

0.125
(3.175) DIA NOM

0.065
(1.651)

90° ± 4° TYP

0.018 ± 0.003
(0.457 ± 0.076)

0.325 +0.040 −0.015
(8.255 +1.016 −0.381)

0.100 ± 0.010
(2.540 ± 0.254)

(REV F)

The package outlines can also be a source for pin-numbering if you are in doubt. Note that plastic DIP is the most common package for prototyping. Avoid surface mount packages (e.g., SOIC, MSOP, PQFP), though with the proper socket PLCC packages can be soldered to relatively easily (but not used in a plastic prototype board without an adapter). There is great variation in pricing depending on package type (and other factors such as temperature range, speed, etc.), so be sure to double-check part numbers.

DIP

SOIC   MSOP   PQFP

PLCC

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Finally, remember that datasheets can always be in error. But just like programming, 99% of errors are user errors. If you find what you think is an error, make sure you have the most recent datasheet, and send a polite query to the appropriate technical support. Newsgroups such as sci.electronics.design might be useful to query first.

99%

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