Integrated Driver and MOSFET

The NCP81081 integrates a MOSFET driver, high-side MOSFET and low-side MOSFET into a 6 mm x 6 mm 40-pin QFN package. The driver and MOSFETs have been optimized for high-current DC-DC buck power conversion applications. The NCP81081 integrated solution greatly reduces package parasitics and board space compared to a discrete component solution.

Features

- Capable of Switching Frequencies Up to 1 MHz
- Capable of Output Currents Up to 35 A
- PWM Input Capable of 3.3 V and 5 V
- Internal Bootstrap Diode
- Zero Current Detection
- Undervoltage Lockout
- Internal Thermal Warning / Thermal Shutdown
- These are Pb-Free Devices

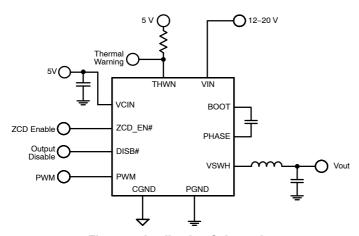


Figure 1. Application Schematic



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QFN40 MN SUFFIX CASE 485AZ

MARKING DIAGRAM

O NCP81081 AWLYYWWG

A = Assembly Location

WL = Wafer Lot
 YY = Year
 WW = Work Week
 G = Pb-Free Package

ORDERING INFORMATION

Device	Package	Shipping [†]
NCP81081MNR2G	QFN40 (Pb-Free)	2500/Tape & Reel
NCP81081MNTWG	QFN40 (Pb-Free)	2500/Tape & Reel

[†]For information on tape and reel specifications, including part orientation and tape sizes, please refer to our Tape and Reel Packaging Specification Brochure, BRD8011/D.

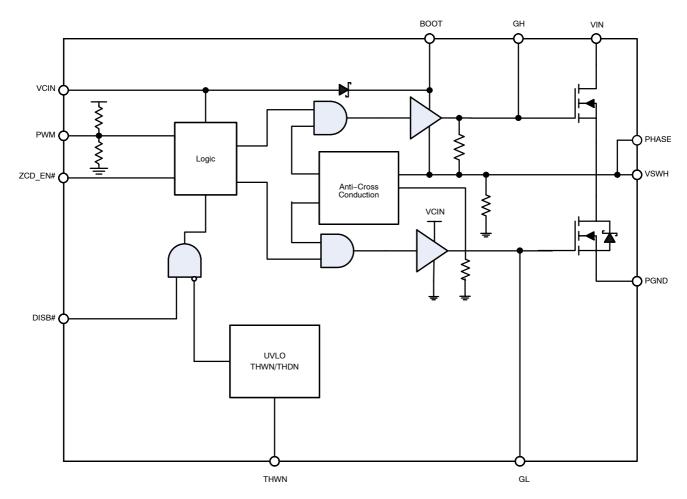


Figure 2. Simplified Block Diagram

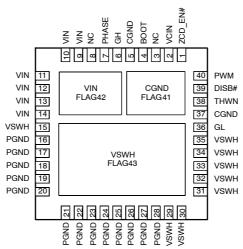


Figure 3. Pin Connections (Top View)

Table 1. PIN FUNCTION DESCRIPTION

Pin No.	Pin Name	Description
1	ZCD_EN#	Enable Zero Current Detection
2	VCIN	Control Input Voltage
3, 8	NC	No Connect
4	воот	Bootstrap Voltage
5, 37, FLAG 41	CGND	Control Signal Ground
6	GH	High Side FET Gate Access
7	PHASE	Provides a return path for the high side driver of the internal IC. Place a high frequency ceramic capacitor of 0.1 uF to 1.0 uF from this pin to BOOT pin.
9-14, FLAG 42	VIN	Input Voltage
15, 29–35, FLAG 43	VSWH	Switch Node Output
16-28	PGND	Power Ground
36	GL	Low Side FET Gate Access
38	THWN	Thermal Warning
39	DISB#	Output Disable Pin
40	PWM	PWM Drive Logic

Table 2. ABSOLUTE MAXIMUM RATINGS

Pin Symbol	Pin Name	Min	Max
VCIN	Control Input Voltage	-0.3 V	7 V
VIN	Power Input Voltage	-0.3 V	30 V
воот	Bootstrap Voltage	-0.3 V wrt/VSWH	35 V wrt/PGND 40 V < 50 ns wrt/PGND 7 V wrt/VSWH
VSWH	Switch Node Output	-0.3 V	30 V
ZCD_EN#	Zero Current Detection	-0.3 V	6.5 V
PWM	PWM Drive Logic	-0.3 V	6.5 V
DISB#	Output Disable	-0.3 V	6.5 V
THWN	Thermal Warning	-0.3 V	6.5 V

Stresses exceeding Maximum Ratings may damage the device. Maximum Ratings are stress ratings only. Functional operation above the Recommended Operating Conditions is not implied. Extended exposure to stresses above the Recommended Operating Conditions may affect device reliability.

Table 3. THERMAL CHARACTERISTICS

Rating	Symbol	Value	Unit
Thermal Resistance, High-Side FET	$R_{\Theta JPCB}$	13	°C/W
Thermal Resistance, Low-Side FET	$R_{\Theta JPCB}$	5	°C/W
Operating Junction Temperature	T _J	0 to 150	°C
Storage Temperature	T _S	-55 to 150	°C
Moisture Sensitivity Level	MSL	3	

Table 4. OPERATING RANGES

Rating	Symbol	Min	Тур	Max	Unit
Control Input Voltage	VCIN	4.5	5	5.5	V
Input Voltage	VIN	4.5	12	25	V

 $\textbf{ELECTRICAL CHARACTERISTICS} \text{ (Note 1) (VCIN = 5 V, VIN = 12 V, } T_{A} = -10^{\circ}\text{C to } + 100^{\circ}\text{C}, \text{ unless otherwise noted)}$

VCIN Current (normal mode)	Parameter	Symbol	Condition	Min	Тур	Max	Unit
FSW = 400 kHz	SUPPLY CURRENT				•	•	
UVLO Startup	VCIN Current (normal mode)	-			14	20	mA
UVLO Startup	VCIN Current (shutdown mode)	-	DISB# = GND		15	30	μΑ
UNLO Hysteresis -	UNDERVOLTAGE LOCKOUT						
Forward Voltage - VCIN = 5 V, forward bias current = 2 mA 0.1 0.4 0.6 V	UVLO Startup	-		3.8	4.35	4.5	V
Forward Voltage	UVLO Hysteresis	-		150	200	250	mV
PWM Input PWM Input Voltage High V _{PWM_HI} 2.65 - - V PWM Input Voltage MidState V _{PWM_MID} 1.4 - 2.0 V PWM Input Voltage Low V _{PWM_LO} - - 0.7 V TriState Shutdown Holdoff Time tholdoff 250 ns PWM Input Resistance 63 kΩ PWM Input Bias Voltage 1.7 V Output DISABLE 2.0 - - V Output Disable Input Voltage High V _{DISB#_HI} 2.0 - - V Output Disable Input Voltage Low V _{DISB#_LO} - - 0.8 V Output Disable Propagation Delay - - 0.8 V Output Disable Propagation Delay - - 0.0 - mV Output Disable Propagation Delay - 2.0 - - V - - 0.8 V ZERO Cross Detect High V _{ZCD_EN#_H} 2.0 - -	BOOTSTRAP DIODE					-	
PWM Input Voltage High VPWM_HI 2.65 - - V	Forward Voltage	-	VCIN = 5 V, forward bias current = 2 mA	0.1	0.4	0.6	V
PWM Input Voltage Mid-State V _{PWM_MID} 1.4 - 2.0 V PWM Input Voltage Low V _{PWM_LO} - - 0.7 V Tri-State Shutdown Holdoff Time tholdoff 250 ns PWM Input Resistance 63 kΩ PWM Input Bias Voltage 1.7 V OUTPUT DISABLE Output Disable Input Voltage High V _{DISB#_HI} 2.0 - - V Output Disable Input Voltage Low V _{DISB#_LO} - - 0.8 V Output Disable Hysteresis - - 500 - mV Output Disable Propagation Delay - 20 40 ns ZERO CROSS DETECT Zero Cross Detect High V _{ZCD_EN#_H} 2.0 - - V Zero Cross Detect Low V _{ZCD_EN#_LO} - - 0.8 V Zero Cross Detect Threshold - - - 0.8 V Zero Cross Detect Threshold - -	PWM INPUT					-	
PWM Input Voltage Low VPWM_LO - - 0.7 V Tri-State Shutdown Holdoff Time tholdoff 250 ns PWM Input Resistance 63 kΩ PWM Input Bias Voltage 1.7 V OUTPUT DISABLE Output Disable Input Voltage High VDISB#_HI 2.0 - - V Output Disable Input Voltage Low VDISB#_LO - - 0.8 V Output Disable Hysteresis - - 500 - mV Output Disable Propagation Delay - 20 40 ns ZERO CROSS DETECT Zero Cross Detect High VZCD_EN#_HI 2.0 - - V Zero Cross Detect Low VZCD_EN#_LO - - 0.8 V Zero Cross Detect Threshold - - 0 ns THERMAL WARNING/SHUTDOWN - - 0 ns Thermal Warning Hysteresis 150 °C C Thermal Shutdown Temperature	PWM Input Voltage High	V _{PWM_HI}		2.65	_	_	V
Tri-State Shutdown Holdoff Time tholdoff 250 ns PWM Input Resistance 63 kΩ PWM Input Bias Voltage 1.7 V OUTPUT DISABLE Output Disable Input Voltage High VDISB#_HI 2.0 - - V Output Disable Input Voltage Low VDISB#_LO - - 0.8 V Output Disable Hysteresis - - 500 - mV Output Disable Propagation Delay - 20 40 ns ZERO CROSS DETECT Zero Cross Detect High VZCD_EN#_HI 2.0 - - V Zero Cross Detect Low VZCD_EN#_LO - - 0.8 V Zero Cross Detect Threshold - - 0 ns T THERMAL WARNING/SHUTDOWN Thermal Warning Temperature 150 °C Thermal Shutdown Temperature 180 °C	PWM Input Voltage Mid-State	V _{PWM_MID}		1.4	_	2.0	V
PWM Input Resistance 63 kΩ PWM Input Bias Voltage 1.7 V OUTPUT DISABLE Output Disable Input Voltage High V _{DISB#_HI} 2.0 - - V Output Disable Input Voltage Low V _{DISB#_LO} - - 0.8 V Output Disable Hysteresis - - 500 - mV Output Disable Propagation Delay - 20 40 ns ZERO CROSS DETECT Zero Cross Detect High V _{ZCD_EN#_HI} 2.0 - - V Zero Cross Detect Low V _{ZCD_EN#_LO} - - 0.8 V Zero Cross Detect Threshold - - - 0.8 V ZCD Blanking Timer 250 ns THERMAL WARNING/SHUTDOWN Thermal Warning Temperature 150 °C Thermal Shutdown Temperature 180 °C	PWM Input Voltage Low	V _{PWM_LO}		-	-	0.7	V
PWM Input Bias Voltage	Tri-State Shutdown Holdoff Time	t _{holdoff}			250		ns
OUTPUT DISABLE Output Disable Input Voltage High VDISB#_HI 2.0 - - V Output Disable Input Voltage Low VDISB#_LO - - 0.8 V Output Disable Hysteresis - 500 - mV Output Disable Propagation Delay - 20 40 ns ZERO CROSS DETECT Zero Cross Detect High VZCD_EN#_HI 2.0 - - V Zero Cross Detect Low VZCD_EN#_LO - - 0.8 V Zero Cross Detect Threshold -6 mV ZCD Blanking Timer 250 ns THERMAL WARNING/SHUTDOWN Thermal Warning Temperature 150 °C Thermal Warning Hysteresis 15 °C Thermal Shutdown Temperature 180 °C	PWM Input Resistance				63		kΩ
Output Disable Input Voltage High VDISB#_HI 2.0 - - V Output Disable Input Voltage Low VDISB#_LO - - 0.8 V Output Disable Hysteresis - - 500 - mV Output Disable Propagation Delay - 20 40 ns ZERO CROSS DETECT Zero Cross Detect High VZCD_EN#_HI 2.0 - - V Zero Cross Detect Low VZCD_EN#_LO - - 0.8 V Zero Cross Detect Threshold - -6 mV ZCD Blanking Timer 250 ns THERMAL WARNING/SHUTDOWN Thermal Warning Temperature 150 °C Thermal Shutdown Temperature 150 °C	PWM Input Bias Voltage				1.7		V
Output Disable Input Voltage Low VDISB#_LO - - 0.8 V Output Disable Hysteresis - - 500 - mV Output Disable Propagation Delay - 20 40 ns ZERO CROSS DETECT Zero Cross Detect High VZCD_EN#_HI 2.0 - - V Zero Cross Detect Low VZCD_EN#_LO - - 0.8 V Zero Cross Detect Threshold - -6 mV ZCD Blanking Timer 250 ns THERMAL WARNING/SHUTDOWN Thermal Warning Temperature 150 °C Thermal Warning Hysteresis 15 °C Thermal Shutdown Temperature 180 °C	OUTPUT DISABLE						
Output Disable Hysteresis - 500 - mV Output Disable Propagation Delay - 20 40 ns ZERO CROSS DETECT Zero Cross Detect High V _{ZCD_EN#_HI} 2.0 - - V Zero Cross Detect Low V _{ZCD_EN#_LO} - - 0.8 V Zero Cross Detect Threshold - - 0 mV ZCD Blanking Timer 250 ns THERMAL WARNING/SHUTDOWN Thermal Warning Temperature 150 °C Thermal Warning Hysteresis 15 °C Thermal Shutdown Temperature 180 °C	Output Disable Input Voltage High	V _{DISB#_HI}		2.0	_	_	V
Output Disable Propagation Delay - 20 40 ns ZERO CROSS DETECT Zero Cross Detect High VZCD_EN#_HI 2.0 - - V Zero Cross Detect Low VZCD_EN#_LO - - 0.8 V Zero Cross Detect Threshold - - - 0.8 V ZCD Blanking Timer 250 ns THERMAL WARNING/SHUTDOWN Thermal Warning Temperature 150 °C Thermal Warning Hysteresis 15 °C Thermal Shutdown Temperature 180 °C	Output Disable Input Voltage Low	V _{DISB#_LO}		-	_	0.8	V
ZERO CROSS DETECT Zero Cross Detect High VZCD_EN#_HI 2.0 - - V Zero Cross Detect Low VZCD_EN#_LO - - 0.8 V Zero Cross Detect Threshold -6 mV ZCD Blanking Timer 250 ns THERMAL WARNING/SHUTDOWN Thermal Warning Temperature 150 °C Thermal Warning Hysteresis 15 °C Thermal Shutdown Temperature 180 °C	Output Disable Hysteresis	-		-	500	-	mV
Zero Cross Detect High VZCD_EN#_HI 2.0 - - V Zero Cross Detect Low VZCD_EN#_LO - - 0.8 V Zero Cross Detect Threshold -6 mV ZCD Blanking Timer 250 ns THERMAL WARNING/SHUTDOWN Thermal Warning Temperature 150 °C Thermal Warning Hysteresis 15 °C Thermal Shutdown Temperature 180 °C	Output Disable Propagation Delay			-	20	40	ns
Zero Cross Detect Low VZCD_EN#_LO - - 0.8 V Zero Cross Detect Threshold -6 mV ZCD Blanking Timer 250 ns THERMAL WARNING/SHUTDOWN Thermal Warning Temperature 150 °C Thermal Warning Hysteresis 15 °C Thermal Shutdown Temperature 180 °C	ZERO CROSS DETECT						
Zero Cross Detect Threshold -6 mV ZCD Blanking Timer 250 ns THERMAL WARNING/SHUTDOWN Thermal Warning Temperature 150 °C Thermal Warning Hysteresis 15 °C Thermal Shutdown Temperature 180 °C	Zero Cross Detect High	V _{ZCD_EN#_HI}		2.0	_	_	V
ZCD Blanking Timer 250 ns THERMAL WARNING/SHUTDOWN Thermal Warning Temperature 150 °C Thermal Warning Hysteresis 15 °C Thermal Shutdown Temperature 180 °C	Zero Cross Detect Low	V _{ZCD_EN#_LO}		-	_	0.8	V
THERMAL WARNING/SHUTDOWN Thermal Warning Temperature 150 °C Thermal Warning Hysteresis 15 °C Thermal Shutdown Temperature 180 °C	Zero Cross Detect Threshold				-6		mV
Thermal Warning Temperature 150 °C Thermal Warning Hysteresis 15 °C Thermal Shutdown Temperature 180 °C	ZCD Blanking Timer				250		ns
Thermal Warning Hysteresis 15 °C Thermal Shutdown Temperature 180 °C	THERMAL WARNING/SHUTDOWN						
Thermal Shutdown Temperature 180 °C	Thermal Warning Temperature				150		°C
· · · · · · · · · · · · · · · · · · ·	Thermal Warning Hysteresis				15		°C
Thermal Shutdown Hysteresis 25 °C	Thermal Shutdown Temperature				180		°C
	Thermal Shutdown Hysteresis				25		°C

Performance guaranteed over the indicated operating temperature range by design and/or characterization tested at T_J = T_A = 25°C. Low duty cycle pulse techniques are used during testing to maintain the junction temperature as close to ambient as possible.

APPLICATIONS INFORMATION

Theory of Operation

The NCP81081 is an integrated driver and MOSFET module designed for use in a synchronous buck converter topology. A single PWM input signal is all that is required to properly drive the high-side and low-side MOSFETs.

Low-Side Driver

The low–side driver is designed to drive a ground–referenced low $R_{DS(on)}$ N–Channel MOSFET. The voltage rail for the low–side driver is internally connected to VCIN and PGND.

High-Side Driver

The high-side driver is designed to drive a floating low RDS(on) N-channel MOSFET. The gate voltage for the high side driver is developed by a bootstrap circuit referenced to Switch Node (VSWH) pin.

The bootstrap circuit is comprised of the internal diode and an external bootstrap capacitor. When the NCP81081 is starting up, the VSWH pin is at ground, so the bootstrap capacitor will charge up to VCIN through the bootstrap diode See Figure 1. When the PWM input goes high, the high–side driver will begin to turn on the high–side MOSFET using the stored charge of the bootstrap capacitor. As the high–side MOSFET turns on, the VSWH pin will rise. When the high–side MOSFET is fully on, the switch node will be at 12 V, and the BST pin will be at 5 V plus the charge of the bootstrap capacitor (approaching 17 V).

The bootstrap capacitor is recharged when the switch node goes low during the next cycle.

Zero Current Detect

When ZCD_EN# is set high, the NCP81081 will operate in normal PWM mode.

When ZCD_EN# is set low, zero current detect (ZCD) will be enabled. If PWM goes high, GH will go high after the non-overlap delay. If PWM goes low, GL will go high after the non-overlap delay, and stay high for the duration of the ZCD blanking timer. Once this timer has expired, VSWH will be monitored for zero current detection, and will pull GL low once detected. The threshold on VSWH to determine zero current undergoes an auto-calibration cycle every time DISB# is brought from low to high. This auto-calibration cycle typically takes 25 µs to complete.

Safety Timer and Overlap Protection Circuit

It is very important that MOSFETs in a synchronous buck regulator do not both conduct at the same time. Excessive shoot-through or cross conduction can damage the MOSFETs, and even a small amount of cross conduction will cause a decrease in the power conversion efficiency. The NCP81081 prevents cross conduction by monitoring the status of the MOSFETs and applying the appropriate amount of "dead-time" or the time between the turn off of one MOSFET and the turn on of the other MOSFET.

When the PWM input pin goes high, the gate of the low-side MOSFET (GL pin) will go low after a propagation delay (tpdlGL). The time it takes for the low-side MOSFET to turn off (tfGL) is dependent on the total charge on the low-side MOSFET gate. The NCP81081 monitors the gate voltage of both MOSFETs and the switchnode voltage to determine the conduction status of the MOSFETs. Once the low-side MOSFET is turned off an internal timer will delay (tpdhGH) the turn on of the high-side MOSFET.

Likewise, when the PWM input pin goes low, the gate of the high-side MOSFET (GH pin) will go low after the propagation delay (tpdlGH). The time to turn off the high-side MOSFET (tfGH) is dependent on the total gate charge of the high-side MOSFET. A timer will be triggered once the high-side MOSFET has stopped conducting, to delay (tpdhGL) the turn on of the low-side MOSFET.

Thermal Warning / Thermal Shutdown

When the temperature of the driver reaches 150°C, the THWN pin will be pulled low indicating a thermal warning. At this point, the part continues to function normally. When the temperature drops below 135°C, the THWN will go high.

If the driver temperature exceeds 180°C, the part will enter thermal shutdown and turn off both MOSFETs. Once the temperature falls below 155°C, the part will resume normal operation. The THWN pin has a maximum current capability of 30 mA.

Power Supply Decoupling

The NCP81081 can source and sink relatively large current to the gate pins of the MOSFETs. In order to maintain a constant and stable supply voltage (VCIN) a low ESR capacitor should be placed near the power and ground pins. A 1 μ F to 4.7 μ F multi layer ceramic capacitor (MLCC) is usually sufficient.

Bootstrap Circuit

The bootstrap circuit uses a charge storage capacitor (C_{BST}) and the internal diode. The bootstrap capacitor must have a voltage rating that is able to withstand twice the maximum supply voltage. A minimum 50 V rating is recommended. A bootstrap capacitance greater than 100 nF and a minimum 50 V rating is recommended. A good quality ceramic capacitor should be used.

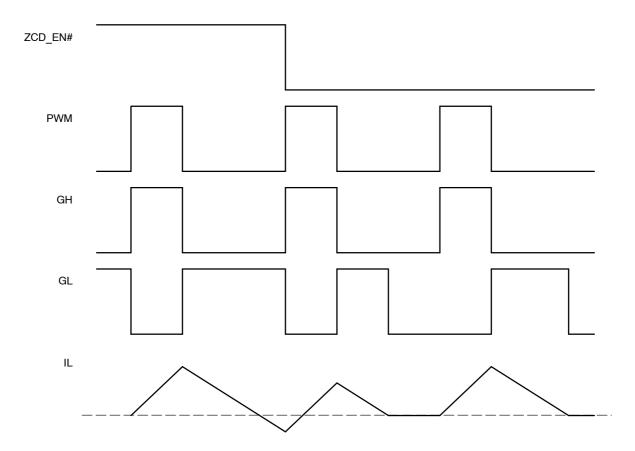


Figure 4. Zero Current Detection

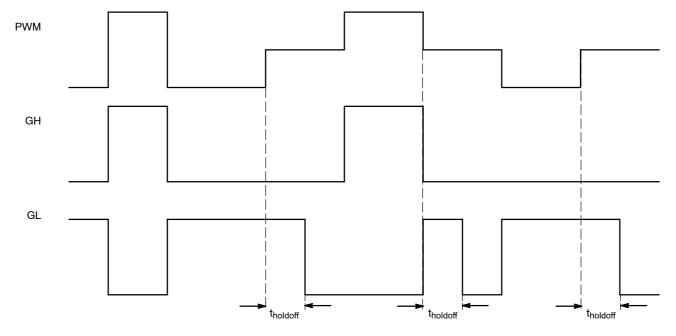
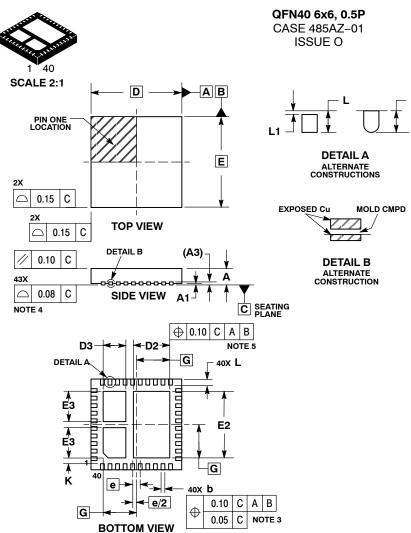


Figure 5. Tri-State Operation



DATE 09 JAN 2009

- NOTES:
 1. DIMENSIONING AND TOLERANCING PER
- ASME Y14.5M, 1994.
 CONTROLLING DIMENSIONS: MILLIMETERS.
- DIMENSION 6 APPLIES TO PLATED
 TERMINAL AND IS MEASURED BETWEEN
- 1EHMINAL AND IS MEASURED BE I WEEN 0.15 AND 0.30mm FROM TERMINAL COPLANARITY APPLIES TO THE EXPOSED PAD AS WELL AS THE TERMINALS. POSITIONAL TOLERANCE APPLIES TO ALL THREE EXPOSED PADS.

	MILLIMETERS			
DIM	MIN	MAX		
Α	0.80	1.00		
A1	-	0.05		
A3	0.20	REF		
b	0.18	0.30		
D	6.00	BSC		
D2	2.30 2.50			
D3	1.40	1.60		
E	6.00 BSC			
E2	4.30	4.50		
E3	1.90	2.10		
е	0.50 BSC			
G	2.20 BSC			
K	0.20			
L	0.30	0.50		
L1		0.15		

GENERIC MARKING DIAGRAM*



XXXXX = Specific Device Code

= Assembly Location = Wafer Lot

WL ΥY = Year WW = Work Week = Pb-Free Package

*This information is generic. Please refer to device data sheet for actual part marking.

Pb-Free indicator, "G" or microdot " ■", may or may not be present.

DESCRIPTION:	QFN40 6x6, 0.5P		PAGE 1 OF 1
DOCUMENT NUMBER:	98AON38217E	Electronic versions are uncontrolled except when accessed directly from Printed versions are uncontrolled except when stamped "CONTROLLED	
PITCH	DIMENSIONS: MILLIMETERS		

0.63

6.30

4.56

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SOLDERING FOOTPRINT

6.30

4.56

PITCH

1.66

1

2.16

2.16

PKG OUTLINE

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