1-Channel Automotive LED Driver

H Bridge 1.5 A, 60 V TSSOP16 EP

NCV78514

TSSOP16 EP
CASE 948BV

The NCV78514 is a part of the **onsemi** LED driver solution family for the automotive market. It's main emphasis is on supporting MCU less applications by integrating smart features like derating based on input voltage and temperature of the LED string. The device is optimized for a one channel LED driver unit and is based on a H−Bridge topology with a synchronous Buck switches and asynchronous Boost with external low side NMOSFET and Schottky diode. Supplying in a constant current mode a single LED string between 2 and 20 LEDs.

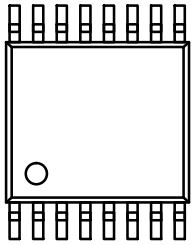
This enables the design of a single PCB design solution or with a separate module approach.

The LED string current is set with a current−encoding resistor. The actual current through the LED string is sensed with a sense resistor.

Features

- Support for MCU Less Application
- Integrated Derating Mechanisms
- Fixed Switching Frequency at 400 kHz
- Input Operating Range from 5 V – 21 V
- Warm Start Management below 9 V
- Withstands Load Dump up to 45 V
- Output Voltage Range up to 60 V
- External Programmable Current 200 mA − 1500 mA
- Pulse Width Modulation from 80 Hz to 600 Hz
- LED Current Dimming Frequency 400 Hz
- External NTC / PTC for LED−temperature
- Spread Spectrum
- Status and Error Mode Handling
- AEC−Q100 Qualified and PPAP Capable

MARKING DIAGRAM



L514001= Specific Device Code
A = Assembly Location
L = Wafer Lot
YW = Year & Work Week
▪ = Pb−Free Indicator Microdot

ORDERING INFORMATION

Device	Package	Shipping†
NCV78514PA0R2G	TSSOP16−EP (Pb−Free)	4000 / 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.

Typical Application

- Fog Lamp
- Cornering Light
- Logo Projection
- Logo Lighting

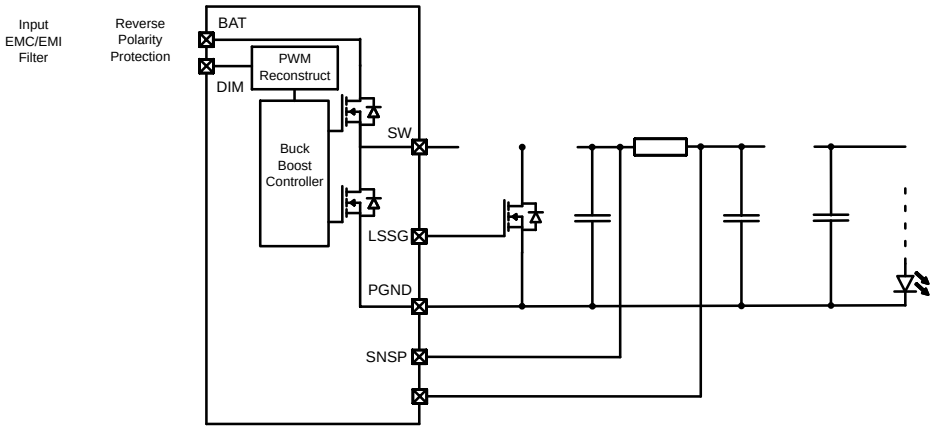


Figure 1. Typical Application Circuit

FUNCTIONAL BLOCK DIAGRAM

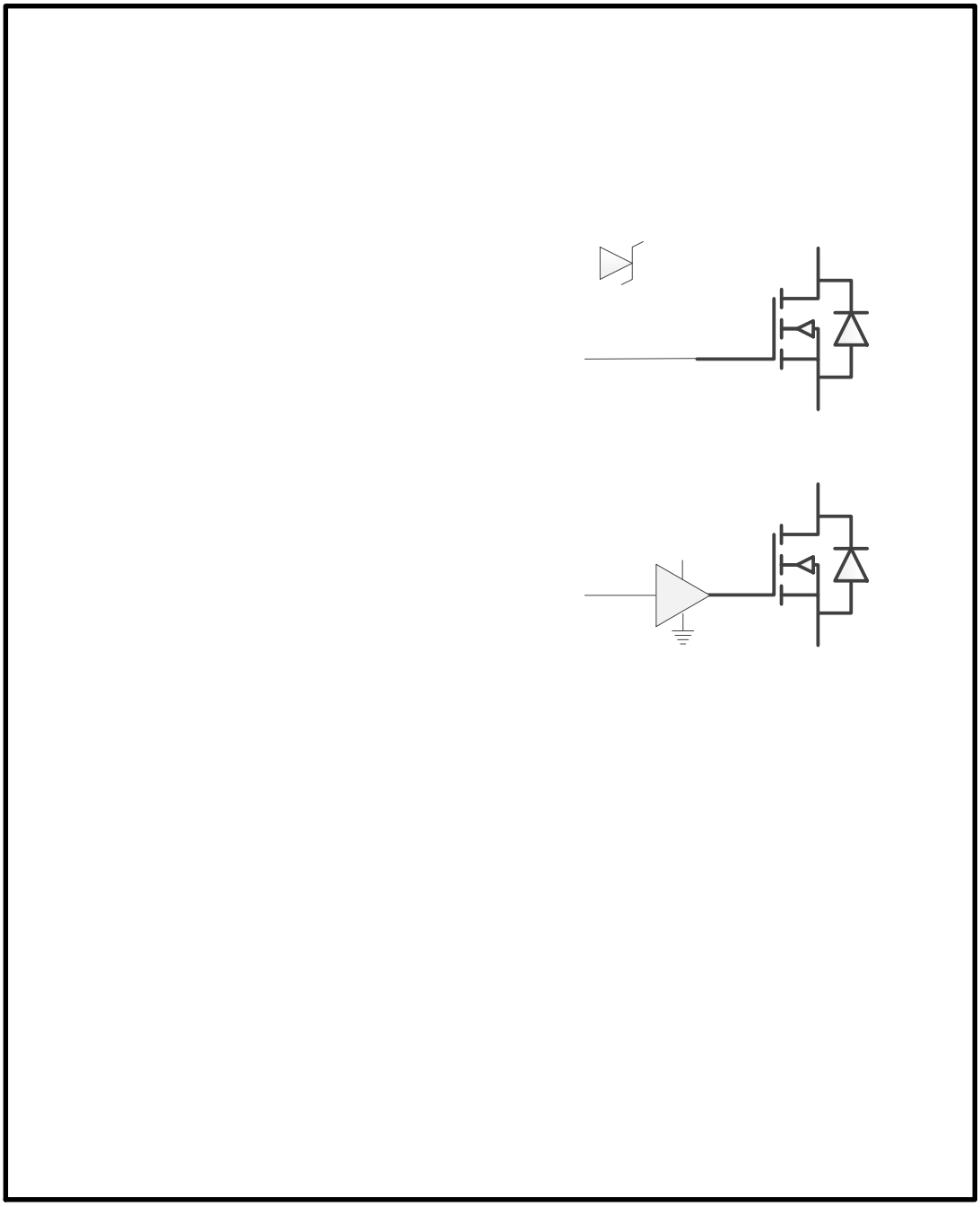


Figure 2. Block Diagram

PIN OUT DESCRIPTION

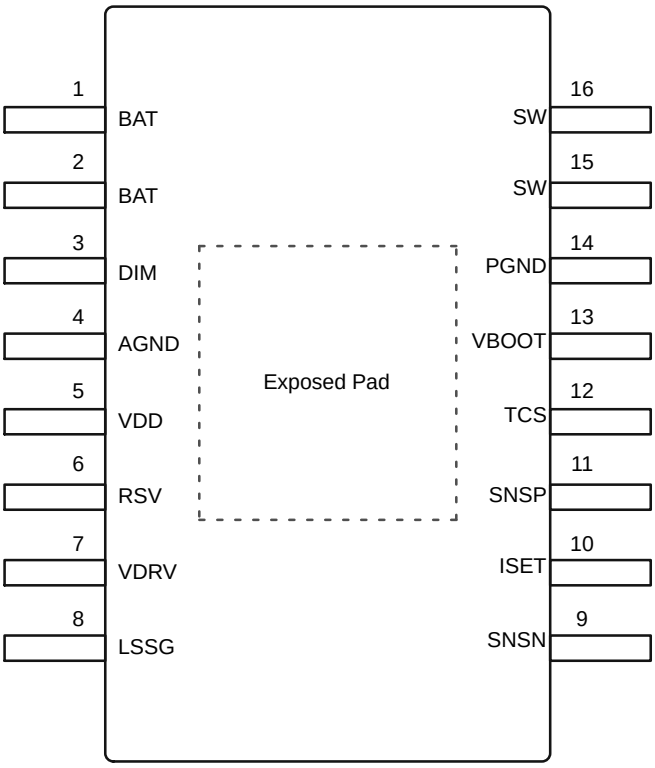


Figure 3. Pin Out (Top View)

Table 1. PIN FUNCTION DESCRIPTION

Number	Name	Description
1, 2	BAT	Input supply voltage, coming from the Battery or ECU, through reverse blocking protection and input Pi filter. Pin 1 and pin 2 must be connected together.
3	DIM	Enable/disable function, including LED current dimming function and error status function.
4	AGND	Must be connected directly to the analog ground plane.
5	VDD	3V3 low dropout output pin. A capacitor must be connected between this pin and ground. Must not be used for external load.
6	RSV	Reserved for production test. Must be connected directly to the analog ground plane in the application.
7	VDRV	

MAXIMUM RATINGS

Pin voltages listed below are referenced to ground plane.

Table 2. MAXIMUM RATINGS

Symbol	Parameter description	Min	Max	Unit
AM_BAT	BAT pin. Main Power Input.	−0.3	45	V
AM_DIM	DIM pin. Signal Input	−20	45	V
AM_RSV	RSV pin Signal Input.	−0.3	3.6	V
AM_VDD	VDD pin. Local Power Supply Output	−0.3	3.6	V
AM_ISET	ISET pin. Signal Input	−0.3	70	V
AM_TCS	TCS pin. Signal Input	−0.3	70	V
AM_VDRV	VDRV pin. Power Output	−0.3	5.5	V
AM_LSSG	LSSG pin. Power Output	−0.3	5.5	V
AM_SW	SW pin. Power Output	−0.3	45	V
AM_VBOOT	VBOOT pin, referring to ground. Power Input	Max of (V_{SW}−0.3,−0.3)	V_{SW}+3.6	V
AM_SNSP	SNSP pin. Signal Input	−0.3	70	V
AM_SNSN	SNSN pin. Signal Input	−0.3	70	V
AM_TS	Storage Temperature Range	−55	150	C
AM_TJ	Maximum Junction Temperature (Note 1)	−40	P_TJ_OFF	C
EOS_HBM	ESD Withstand Voltage (Human Body Model)	2		kV
EOS_CDM_CORNER	ESD Withstand Voltage (CDM). BAT, SW, LSSG, SNSN	750		V
EOS_CDM	ESD Withstand Voltage (CDM), all other pins than corners	500		V

Stresses exceeding those listed in the Maximum Ratings table may damage the device. If any of these limits are exceeded, device functionality should not be assumed, damage may occur and reliability may be affected.

1. The maximum functional operating temperature range can be limited by the IC thermal shutdown: P_TJ_OFF.

RECOMMENDED OPERATING CONDITIONS

Operating ranges define the limits for functional operation and parametric characteristics of the device. Note that the functionality outside the operating ranges described in this section is not warranted. Operating outside the recommended operating ranges for extended periods of time may lead to a not functional device or affect device reliability. A mission profile is a substantial part of the operation conditions; hence the Customer must contact **onsemi** in order to mutually agree in writing on the allowed missions profile(s) in the application.

Table 3. RECOMMENDED OPERATING CONDITIONS

Symbol	Parameter Description	Min	Max	Unit
P_BAT_OP	BAT Range − Operating	P_UVLO_operating	P_OVLO_operating	V
P_BAT_MAX	BAT Range − Full Power	9	P_OVLO_operating	V
P_VOUT	DC to DC VOUT Range	5.6	60	V
P_TA	IC Ambient Temperature Range	−40	125	C
P_TJ	IC Junction Temperature Range (Notes 2 and 3)	−40	150	C
P_OUTPUT_POWER	Output Power		20	W
P_IC_POWER	On−chip Power Dissipation with the recommended heatsink performance		2	W

Functional operation above the stresses listed in the Recommended Operating Ranges is not implied. Extended exposure to stresses beyond the Recommended Operating Ranges limits may affect device reliability.

Table 4. THERMAL INFORMATION (Note 4)

Symbol	Parameter Description	Min	Typ	Max	Unit	Notes
RTHETA_JC	Junction to exposed pad thermal resistance		3.2		C/W	

4. Includes also typical solder thickness under the Exposed Pad (EP).

ELECTRICAL CHARACTERISTICS

In the electrical table of this section, the Min and Max Limits apply for ambient temperature from ǐ40 C to 125 C and junction temperature from ǐ40 C to +150 C and for VBAT from 5 V to

Table 7. DC DC CONVERTER TABLE (continued)

Symbol	Parameter Description	Min	Typ	Max	Unit	Notes
P_SWITCH_FREQ	DC to DC switching frequency	360	400	440	kHz	
P_FSSMB	Spread Spectrum Modulation Bandwidth, of the SWITCH_FREQ	5	6	10	%	
P_FSSMF	Spread Spectrum Modulation Frequency	11.97	13.3	14.65	kHz	
P_ILED_MAX	Maximum output current – RSET= 715 Ω − no dimming – no derating	1.425	1.5	1.575	A	
P_ILED_MIN	Minimum output current – RSET= 10 kΩ − no dimming – no derating	0.18	0.2	0.22	A	
P_ILEDCLAMP	LED Current de−rating minimum value in case of derating, plateau option 50%		100		mA	
P_ILED_ACCURACY_200	ILED accuracy for a 200 mA programmed current – no dimming (RSET = 10 kΩ)	−10		+10	%	

Table 11. IC THERMAL THRESHOLDS TABLE

Symbol	Parameter Description	Min	Typ	Max	Unit	Notes
P_TJWARN	Warning threshold for a LED Current de−rating starting value		130		C	
P_TJ_HYST	Rearming threshold after a direct TSD (no derating)		135		C	
P_TJ_REG	LED Current de−rating end value (ILED = P_ILED_TJILED over this threshold)		150		C	
P_TJ_OFF	Protection for the maximum Junction Temperature. DC to DC is turned off over this value.		170		C	
P_ILED_TJ	End de−rating output current ratio, percentage of the ISET		60		%	
P_TJ_FALL	Response time + timer, falling for rearming		20		ms	
P_ILED_TJ_STEP	Step to Step Current De−rating ratio		1.3	2.5	%	

Table 12. THERMAL COEFFICIENT SENSOR PIN TABLES

Symbol	Parameter	Min	Typ	Max	Unit	Notes
P_$V_{TCS_{START}}$	Derating start voltage on TCS		0.37		* V_{VDD}	
P_V_{TCS}						

[redacted]

[redacted]

Digital Dimming

A first dimming functionality is achieved by applying a square input signal on the DIM pin.

The input duty cycle range is valid in the DIM_DC_IN range and is reconstructed on the output with an identical duty cycle (DIM_DC_OUT).

A duty cycle above 98% is considered as a 100 % duty cycle. The current into the LEDs is then no more dimmed, and set to the DC current, programmed by RSET.

As soon as the part achieves 100 % duty cycle, the part enters in automatic mode.

At start up, the NCV78514 starts after the second identified valid duty cycle.

A duty cycle change, to a higher or lower value, makes a linear change of the LED current. The time to reach new current is proportional to difference of new and previous duty cycle and is described below.

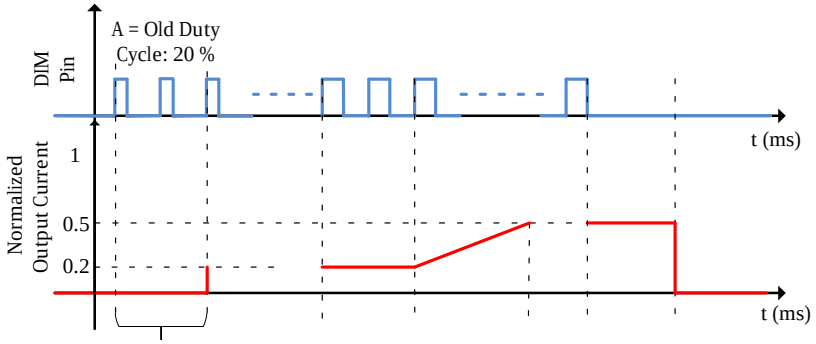
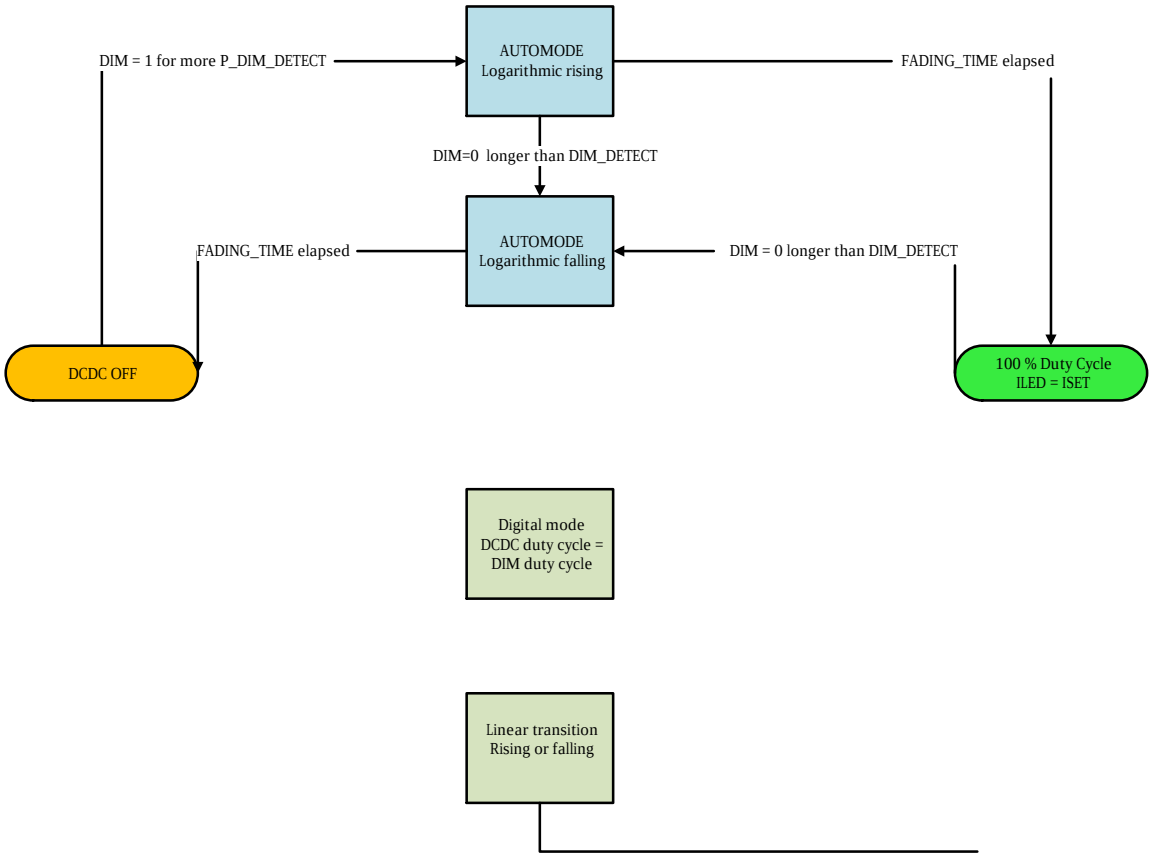


Figure 4. ILED Setting Slope in Digital Dimming Mode


AUTOMODE
Logarithmic rising
DIM = 1 for more P_DIM_DETECT
FADING_TIME elapsed
DIM=0 longer than DIM_DETECT
AUTOMODE
Logarithmic falling
FADING_TIME elapsed
DIM = 0 longer than DIM_DETECT
DCDC OFF
100 % Duty Cycle
ILED = ISET
Digital mode
DCDC duty cycle =
DIM duty cycle
Linear transition
Rising or falling

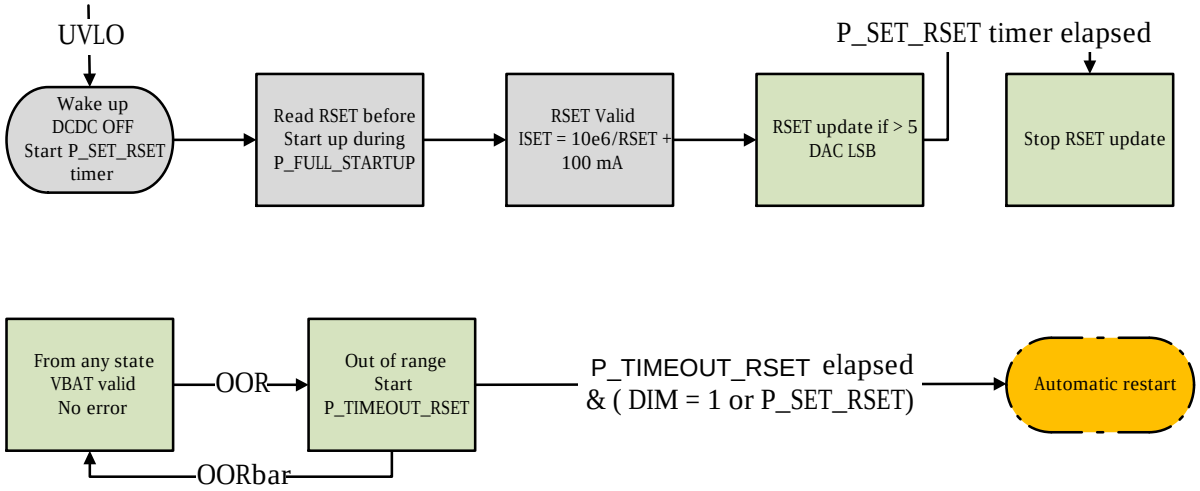


Figure 7. Flow Diagram of the R_COD Identification

LED CURRENT DERATING MANAGEMENT

To limit overheating of the IC an ILED current de ĭ

When VBAT falls under P_BAT_LOW, ILED is derated following the formula with a minimum of P_ILED_CLAMP value:

$$ILED = ISET \times \frac{(BAT + 1)}{10} \quad \text{(eq. 2)}$$

IC Temperature Monitoring

The junction temperature of the IC is monitored thanks to an internal thermometer.

In the situation where the junction temperature exceeds gradually the P_TJWARN, a current deřrating is immediately applied to the LED current, with a controlled slope upon P_DTC_BAT timing.

If the junction temperature continues to increase and crosses the P_TJ_REG threshold, the LED current is maintained around P_ILED_TJ.

If the IC temperature exceeds the P_TJ_OFF, the current into the LED is stopped, and an error is reported on DIM pin. A power on reset is required to reset the error.

In case of a very fast temperature increase (no derating is engaged) and P_TJ_OFF is crossed, the LED string will be rearmed when the junction temperature falls below the P_TJ_HYST threshold, and the error reporting on DIM pin is stopped.

NCV78514

Table 14. ILED DERATING SUMMARY TABLE

ILED Derating List	Reset	DIM Current Sink

MAIN FUNCTIONAL STATE MACHINE

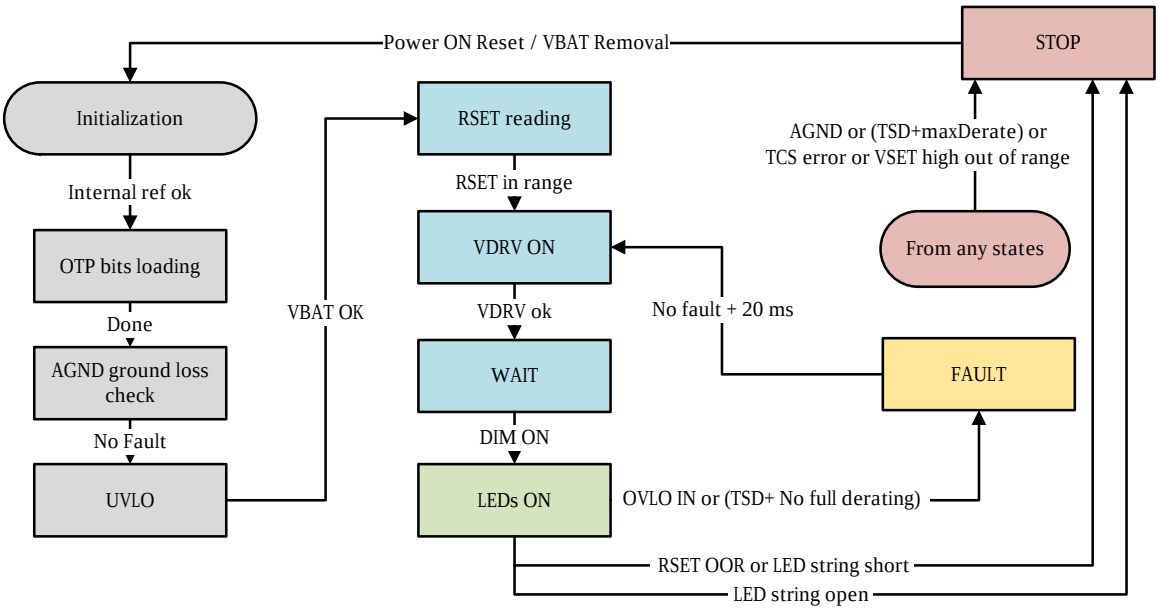


Figure 13. Functional State Machine

COMPONENT LEVEL ELECTROMAGNETIC COMPATIBILITY (EMC)

EMC is a critical item in automotive systems. **onsemi** commits to cooperate technically with the customer to target to build an integrated circuit which is sufficiently EMCĭ

Application level EMC performance will depend on the use of the IC (ASIC) component in an application environment:

The influence of the application environment is typically caused by or related to (but not limited to) the board

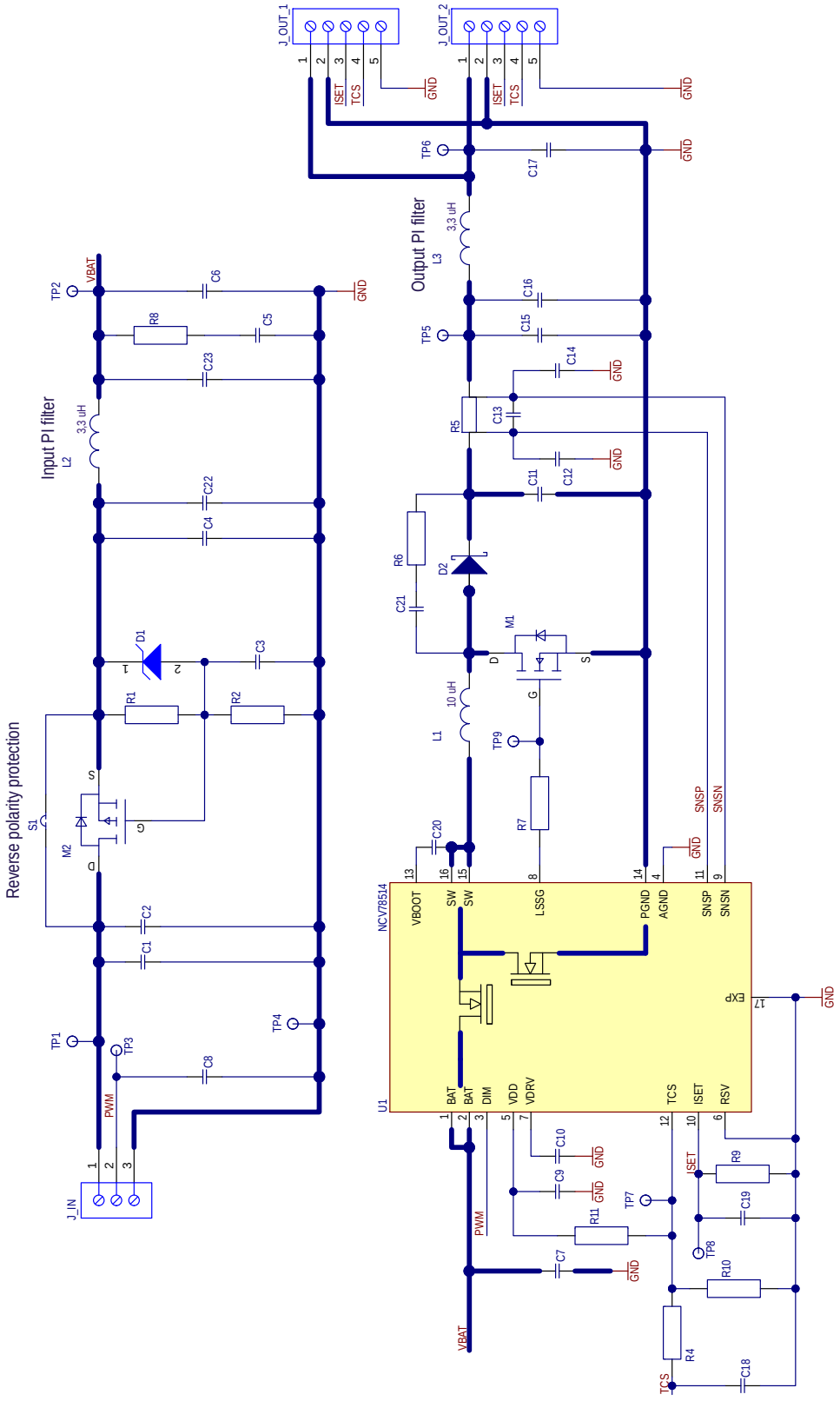


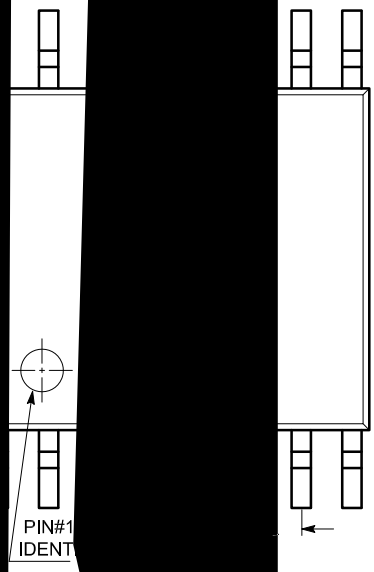
Figure 14. Application Board Schematic

Table 17. BILL OF MATERIAL

Reference	Manufacturer	Manufacturer Reference	Value
C1	Murata	GCJ188R72A104KA01D	100 nF
C2	Murata	GCM32EL8EH106KA07	10 μF
C3	Murata	GCJ188R72A104KA01D	100 nF
C4	Murata	GCM32EL8EH106KA07	10 μF
C5	Murata	GCM32EL8EH106KA07	10 μF
C6	Murata	GCM32EL8EH106KA07	10 μF
C7	Murata	GCJ32DC72A475KE01L	4.7 μF
C8	Murata	GCM21BC72A105KE36L	1 μF
C9	Murata	GCM21BR71C475KA73L	4.7 μF
C10	Murata	GCM21BR71C475KA73L	4.7 μF
C11	Murata	GCJ32DC72A475KE01L	4.7 μF
C12	Murata	GCJ188R72A104KA01D	100 nF
C13	Murata	GCJ188R72A104KA01D	100 nF
C14	Murata	GCJ188R72A104KA01D	100 nF
C15	Murata	GCJ32DC72A475KE01L	4.7 μF
C16	Murata	GCJ32DC72A475KE01L	4.7 μF
C17	Murata	GCM21BC72A105KE36L	1 μF
C18	Murata	GCJ188R72A104KA01D	100 nF
C19	Murata	GCJ188R72A104KA01D	100 nF
C20	Murata	GCJ188R72A104KA01D	100 nF
C21	Murata	GCJ188R72A102KA01	1 nF
C22	Murata	GCJ188R72A104KA01D	100 nF
C23	Murata	GCJ188R72A104KA01D	100 nF
D1	**onsemi**	MM5Z20VT1	MM5Z15VT1G
D2	**onsemi**	NRVTS8100PFST3G	NRVTS8100PFST3G
M2	**onsemi**	NVTFS5116PLT	NVTFS5116PLTWG
U1	**onsemi**	NCV78514	NCV78514
M1	**onsemi**	NVTFS6H860NL	NVTFS6H860NL
L1	TDK	SPM7054VT − 100M−D	10 μH
L2	TDK	SPM4030VT−3R3−D	3.3 μH
L3	TDK	SPM4030VT−3R3−D	3.3 μH
R1	Vishay	MCT06030C2002FP5	20 kΩ
R2	Vishay	MCT06030C1002FP5	10 kΩ
R4	Vishay	MCT06030Z0000ZP5	0R − Optional
R5	Susumu	RL1632R−R100−F	R100
R6	Vishay	MCT0603PD1009DP5	100R − Optional
R7	Vishay	MCT06030Z0000ZP5	0R − Optional
R8	Vishay	MCT06030Z0000ZP5	0R − Optional
R9	Vishay	MCT06030Z0000ZP5	0R − Module Option
R10	Vishay	MCT06030Z0000ZP5	0R − NTC/PTC
R11	Vishay	MCT06030Z0000ZP5	0R − NTC/PTC
J_IN	Wurth	691709710303	Wurth Header 3
J_OUT_1	Molex	502352−0500	Molex Header 5
J_OUT_2	Wurth	691709710305	Wurth Header 5

TSSOP16, 4.4x5 EXPOSED PAD
CASE 948BV
ISSUE O

DATE 22 JUN 2017



END VIEW

BOTTOM VIEW

S

MBOL	M		M	MAX
A				1.10
A1	0.0			0.15
A2	0.85			0.95
b	0.19			0.30
c	0.13			0.20
D	4.90			5.10
E	6.30			6.50
E1	4.30			4.50
e			SC	
L			EF	
L1	0.45			0.75
N	0.90			1.00
P	6.50			6.70
R	4.60			4.80
	0.37			0.47

LAND PATTERN