



Details are subject to change without notice

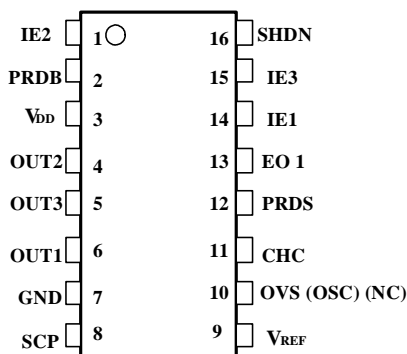
## TRIPLE OUTPUT TFT LCD PWM CONTROLLER

### Features

- Complete PWM Power Control Circuitry
- Precision Reference:  $1.25V \pm 1\%$  ( $25^\circ C$ )
- Low Operating Voltage: 2.5V to 6.5V
- Under-Voltage Lockout Protection
- 5V or 3.3V Selectable Over Voltage Lockout Protection (AAT1101/A only)
- AAT1101/AAT1101A/AAT1101C: 500kHz Fixed
- AAT1101B: 50k~1MHz Programmable
- Internal Power Up Sequence Control
- Totem Pole Output
- Output Short Circuit Protection
- Low Dissipation Current: 2.5mA  
( $f=500kHz$ , Duty=50%)

### Pin Configuration

#### TOP VIEW



(TSSOP-16 PACKAGE)

### General Description

The AAT1101 series provide an integrated triple-channel pulse width modulation (PWM) solution for the power supply of LCD displays. These devices offer system engineers the flexibility to tailor-make the power supply circuitry for specific applications. Each channel contains its own error amplifier, PWM comparator, dead-time control (DTC) and output driver. The under-voltage protection, over voltage protection, power sequence control, shutdown control circuit, oscillator, short circuit protection, and voltage reference circuits are the common features of the three channels.

The AAT1101 series contain two exclusive boost circuits at CH1, CH3 and an exclusive buck\_boost circuit at CH2. AAT1101's Power Up sequence initiates at CH1 then CH2 and finally CH3. AAT1101A/C's Power Up sequence acts in the order of CH2, CH3, and then CH1. AAT1101B's Power Up sequence starts from CH2, CH1, and then CH3. At the completion of the Power Up sequencing, the SCP pin stays low and enters the Wait State of short circuit protection. Power Up sequencing delay and short circuit protection delay are set by connecting a capacitor to the SCP pin. Furthermore, these devices can operate with supply voltage ranging from 2.5V to 6.5V and function efficiently in an environment with low power supply. With a minimum number of external components, the AAT1101 series offer a simple and cost effective solution for TFT LCD.



**Pin Description**

Pin #	Name	I/O	Description
1	IE2	I	Inverted Input of Error Amplifier 2 (EA2)
2	PRDB	O	Power Ready Output
3	V <sub>DD</sub>	I	Supply Voltage
4	OUT2	O	Channel 2 (CH2) Output
5	OUT3	O	Channel 3 (CH3) Output
6	OUT1	O	Channel 1 (CH1) Output
7	GND		Ground
8	SCP	I	Short Circuit Protection
9	V <sub>REF</sub>	O	Reference Voltage Output
10*	OVS	I/O	3.3V or 5.0V Over Voltage Selection and Over Voltage Output
10**	OSC	I/O	Frequency Setting Capacitor & Resistor Input
10***	NC		NC
11	CHC	O	Channel Control
12	PRDS	I	Power Ready Set
13	EO1	I/O	Feedback Input of Error Amplifier 1 (EA1)
14	IE1	I	Inverted Input of Error Amplifier 1 (EA1)
15	IE3	I	Inverted Input of Error Amplifier 3 (EA3)
16	SHDN	I	Shutdown Control

\* : AAT1101A only

\*\* : AAT1101B only

\*\*\* : AAT1101C only

**Absolute Maximum Ratings**

CHARACTERISTICS		SYMBOL	VALUE	UNIT
Supply Voltage		V <sub>DD</sub>	8	V
Input Voltage (IE -)		V <sub>I</sub>	V <sub>DD</sub>	V
Output Voltage		V <sub>O</sub>	V <sub>DD</sub> +0.3	V
Output Current	CH1, CH3	I <sub>O</sub>	-41/+21	mA
	CH2		-21/+41	mA
Output Peak Current	Sink (t <sub>w</sub> 2 μs, Duty 10%)	I <sub>opeak</sub>	+200	mA
	Source (t <sub>w</sub> 2 μs, Duty 10%)		-200	
Operating Free-Air Temperature Range		T <sub>C</sub>	-20 to +85	°C
Storage Temperature Range		T <sub>storage</sub>	-45 to +125	°C

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**Recommended Operating Conditions**

	<b>Symbol</b>	<b>Min</b>	<b>Typ</b>	<b>Max</b>	<b>Unit</b>
Supply Voltage, $V_{DD}$ (with $R_{OVS}$ )	$V_{DD}$	2.5	5.0	5.7	V
Supply Voltage, $V_{DD}$ (without $R_{OVS}$ )	$V_{DD}$	2.5	3.3	3.8	V
Supply Voltage, $V_{DD}$ (AAT1101B/C Only)	$V_{DD}$	2.5	3.3	6.5	V
Input Voltage, IE1, IE3	$V_{I13}$	0.95	-	1.55	V
Input Voltage, IE2	$V_{I2}$	0.4	-	1.0	V
Output Voltage	$V_O$	0	-	$V_{DD}$	V
Output Current, $I_{out1}$ , $I_{out3}$	$I_{O13}$	-	-	-40/+20	mA
Output Current, $I_{out2}$	$I_{O2}$	-	-	-20/+40	mA
Output Current of Error Amplifier	$I_{OE}$	-	-	60	$\mu$ A
Operating Free-Air Temperature	$T_C$	-20	-	85	$^{\circ}$ C



**Electrical Characteristics,  $V_{DD} = 3.3V$  (Unless Otherwise Specified) (See Note 1)**

**Oscillator : ( AAT1101/AAT1101A/AAT1101C )**

Parameter		Test Condition	Min	Typ	Max	Unit
Frequency	$f_{OSC}$	$T_C = 25^\circ C$	400	500	600	kHz
Frequency Changes with $T_C$	$f_{\Delta T}$		-	5	10	%
Maximum Duty Cycle	$T_{xon}$		70	85	95	%

**Oscillator : ( AAT1101B only )**

Parameter		Test Condition	Min	Typ	Max	Unit
Frequency	$f_{OSC}$	$C_{OSC} = 130pf,$ $R_{OSC} = 7k\Omega$	400	500	600	kHz
“H” Level Output Voltage	$V_{OSCH}$	$C_{OSC} = 130pf,$ $R_{OSC} = 7k\Omega$	0.95	1.00	1.05	V
“L” Level Output Voltage	$V_{OSCL}$	$C_{OSC} = 130pf,$ $R_{OSC} = 7k\Omega$	0.35	0.40	0.45	V
Frequency Change with $V_{DD}$	$f_{\Delta V}$	$V_{DD} = 2.5V$ to $6.5V,$ $T_C = 25^\circ C$ $C_{OSC} = 130pf,$ $R_{OSC} = 7k\Omega$	-	1	2	%
Frequency Changes with $T_C$	$f_{\Delta T}$	-	-	5	10	%
Output Source Current	$I_{OSC}$	-	-220	-200	-180	$\mu A$



**Electrical Characteristics,  $V_{DD} = 3.3V$  (Unless Otherwise Specified) (Cont.)**

**Under Voltage (UV) and Over Voltage (OV) Protection**

Parameter		Test Condition	Min	Typ	Max	Unit
UV Upper Threshold Voltage	$V_{UPH}$	$T_C = 25^\circ C$ , AAT1101/A/B	2.1	2.3	2.5	V
		$T_C = 25^\circ C$ , AAT1101C	2.0	2.2	2.4	V
UV Lower Threshold Voltage	$V_{UPL}$	$T_C = 25^\circ C$ , AAT1101/A/B	1.9	2.1	2.3	V
		$T_C = 25^\circ C$ , AAT1101C	1.7	1.87	2.05	V
UV Hysteresis ( $V_{UPH} - V_{UPL}$ )	$V_{HYS}$	$T_C = 25^\circ C$ , AAT1101/A/B	0.1	0.2	0.3	V
		$T_C = 25^\circ C$ , AAT1101C	0.18	0.33	0.48	V
OV 3.3V Threshold Voltage**	$V_{OP33}$	$T_C = 25^\circ C$	3.8	4.1	4.4	V
OV 5V Threshold Voltage**	$V_{OP5}$	$T_C = 25^\circ C$ , OVS connects a 56 k $\Omega$ resistor to $V_{DD}$	5.7	6.1	6.5	V

\*\* : AAT1101/AAT1101A only

**Shutdown Control**

Parameter	Test Condition	Min	Typ	Max	Unit
Shutdown Release Input Voltage		2.0	-	-	V
Shutdown Enable Input Voltage		-	-	0.5	V

**Short Circuit Protection Control**

Parameter		Test Condition	Min	Typ	Max	Unit
Input Threshold Voltage	$V_{r1}$	CH1 (EO1)	1.10	1.15	1.20	V
	$V_{r1}$	CH3 (IE3)	1.20	1.25	1.30	V
	$V_{r2}$	CH2 (IE2)	0.67	0.70	0.73	V
Latch Reset Voltage by $V_{DD}$	$V_{R\_VDD}$	$T_C = 25^\circ C$	0.8	1.5	1.8	V
Latch Reset Voltage by SHDN	$V_{R\_SHDN}$	$T_C = 25^\circ C$	-	-	0.5	V
Short-Circuit Detection Threshold Voltage	$V_{r3}$		1.20	1.25	1.30	V
SCP Terminal Source Current	$I_{SCP}$		-2.6	-2.0	-1.4	$\mu A$

**Electrical Characteristics,  $V_{DD} = 3.3V$  (Unless Otherwise Specified) (Cont.)****Power Ready Output**

Parameter		Test Condition	Min	Typ	Max	Unit
Power Ready Threshold Voltage	$V_{PRTH}$	$T_C = 25\text{ }^\circ\text{C}$	1.18	1.28	1.38	V
Power Ready Source Current	$I_{PRTH}$		-5.2	-4.0	-2.8	$\mu\text{A}$

**Power-Up Sequence Delay**

Parameter		Test Condition	Min	Typ	Max	Unit
Under Voltage - Power Ready	$t_{PR}$	$t_{PR} = (3.2 \times 10^5) C_{PRDS}$	-	$t_{PR}$	-	s
Under Voltage - CH1 Output	$t_{PR}$		-	$t_{PR}$	-	s
CH1 Output - CH2 Output	$t_{CH1}$	$t_{CH1} = (19531.25) C_{SCP}$	-	$t_{CH1}$	-	s
CH2 Output - CH3 Output	$t_{CH2}$		-	$0.8 t_{CH1}$	-	s
CH3 Output - CHC Set High	$t_{CH3}$		-	$0.8 t_{CH1}$	-	s
CH3 Output - SCP Ready to Protect	$t_{CH3}$		-	$0.8 t_{CH1}$	-	s
SCP Enable Time	$t_{SCP}$		-	$32 t_{CH1}$	-	s



Electrical Characteristics,  $V_{DD} = 3.3V$  (Unless Otherwise Specified) (Cont.)

Power-Up Sequence Delay (for AAT1101A/AAT1101C)

Parameter		Test Condition	Min	Typ	Max	Unit
Under Voltage - Power Ready	$t_{PRA}$	$t_{PR} = (3.2 \times 10^5) C_{PRDS}$	-	$t_{PRA}$	-	s
Under Voltage - CH2 Output	$t_{PRA}$		-	$t_{PRA}$	-	s
CH2 Output - CH3 Output	$t_{CH2A}$	$t_{CH2} = (19531.25) C_{SCP}$	-	$t_{CH2A}$	-	s
CH3 Output - CH1 Output	$t_{CH3A}$		-	$0.8 t_{CH2A}$	-	s
CH1 Output - CHC Set High	$t_{CH1A}$		-	$0.8 t_{CH2A}$	-	s
CH1 Output - SCP Ready to Protect	$t_{CH1A}$		-	$0.8 t_{CH2A}$	-	s
SCP Enable Time	$t_{SCPA}$		-	$32 t_{CH2A}$	-	s

Power-Up Sequence Delay (for AAT1101B)

Parameter		Test Condition	Min	Typ	Max	Unit
Under Voltage - Power Ready	$t_{PRB}$	$t_{PR} = (3.2 \times 10^5) C_{PRDS}$	-	$t_{PRB}$	-	s
Under Voltage - CH2 Output	$t_{PRB}$		-	$t_{PRB}$	-	s
CH2 Output - CH1 Output	$t_{CH2B}$	$t_{CH2} = (19531.25) C_{SCP}$	-	$t_{CH2B}$	-	s
CH1 Output - CH3 Output	$t_{CH3B}$		-	$0.8 t_{CH2B}$	-	s
CH3 Output - CHC Set Hi	$t_{CH1B}$		-	$0.8 t_{CH2B}$	-	s
CH3 Output - SCP Ready to Protect	$t_{CH1B}$		-	$0.8 t_{CH2B}$	-	s
SCP Enable Time	$t_{SCPB}$		-	$32 t_{CH2B}$	-	s



**Electrical Characteristics,  $V_{DD} = 3.3V$  (Unless Otherwise Specified) (Cont.)**

**Reference Voltage**

Parameter		Test Conditions	Min	Typ	Max	Unit
Reference Voltage	$V_{REF}$	$I_{REF} = -1mA, T_C = 25^\circ C$	1.237	1.250	1.263	V
Short-Circuit Output Current	$I_{OS}$	$V_{REF} = 0$	-30	-10	-2	mA
Input Voltage Regulation	$V_{RI}$	$I_{REF} = -1mA, V_{DD} = 2.5V \text{ to } 6.5V$	-	2	5	mV
Output Regulation	$V_{RO}$	$I_{REF} = -0.1mA \text{ to } -1mA$	-	1	5	mV
Reference Voltage Change with Temperature	$V_{RT}$	$I_{REF} = -1mA$ (Note 2)	-	15	25	mV

**EA1 (Error Amplifier for Channel 1)**

Parameter		Test Condition	Min	Typ	Max	Unit
Input Offset Voltage	$V_{IO}$	Unity Gain	-	-	15	mV
Input Bias Current	$I_{IB}$	$V_I = 0.95V \text{ to } 1.55V$	-	$\pm 10$	$\pm 20$	nA
Input Voltage Range	$V_{IR}$		0.95	-	1.55	V
Open-Loop Voltage Gain	$A_{VO}$	$R_{FB} = 200k$	-	60	-	dB
Unity-Gain Bandwidth	$BW_1$		-	1	-	MHz
Output Voltage Swing	$V_{OS+}$	$V_{ID} = 0.1V, I_O = -60\mu A$	1.2	-	-	V
	$V_{OS-}$	$V_{ID} = -0.1V, I_O = 0.2mA$	-	-	0.2	
Output Sink Current	$I_{OS+}$	$V_{ID} = -0.1V, V_O = 0.2V$	0.2	1.0	-	mA
Output Source Current	$I_{OS-}$	$V_{ID} = 0.1V, V_O = 1.2V$		-100	-60	$\mu A$
CH2 Input Reference Voltage	$V_{r4}$	$T_C = 25^\circ C$	678	700	722	mV



**Electrical Characteristics,  $V_{DD} = 3.3V$  (Unless Otherwise Specified) (Cont.)****Output Stage**

Parameter		Test Condition	Min	Typ	Max	Unit
High-Level Output Voltage	$V_{OH}$	$I_O = -20mA$ (CH2)	2.90	3.05	-	V
		$I_O = -40mA$ (CH1, CH3)	1.9	2.2	-	
Low-Level Output Voltage	$V_{OL}$	$I_O = 20mA$ (CH1, CH3)	-	0.2	0.4	V
		$I_O = 40mA$ (CH2)	-	0.3	0.6	
Rise time	$t_{RISE}$	$C_L = 1000pF$		130		ns
Fall time	$t_{FALL}$	$C_L = 1000pF$		50		ns

**Operating Current**

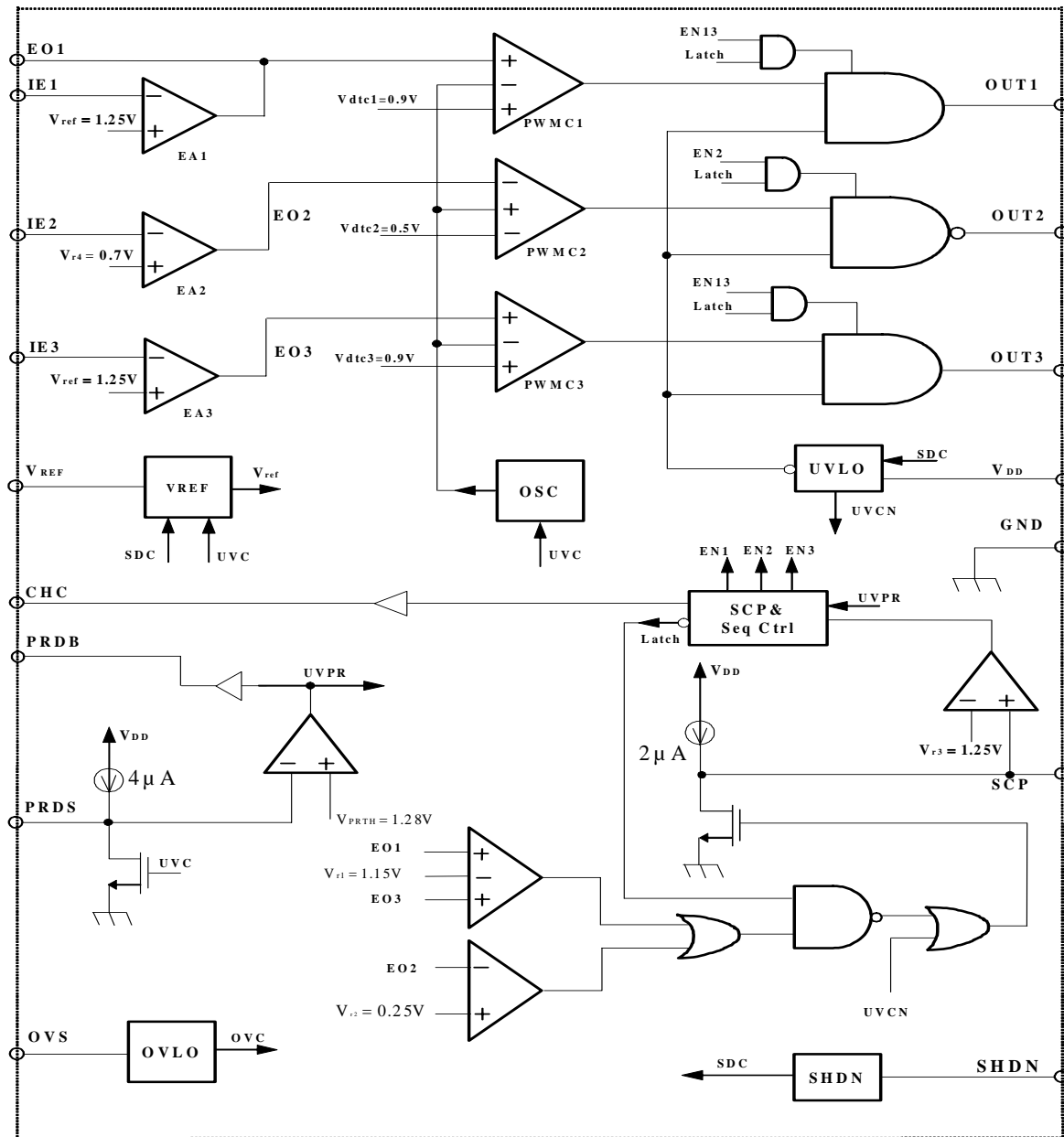
Parameter		Test Condition	Min	Typ	Max	Unit
Supply Current	$I_{DD-ON}$	Duty = 50%, No Load	-	2.5	4.5	mA
	$I_{SHDN}$		-	-	20	$\mu A$

Note 1: Typical values of all parameters except for  $V_{RT}$  (dev) and  $f_{\Delta T}$  are specified at  $T_C = 25^\circ C$ .

Note 2: The deviation parameter  $V_{RT}$  (dev) is defined as the difference between the maximum and minimum values obtained over the recommended free-air temperature range ( $-20^\circ C$  to  $85^\circ C$ ).

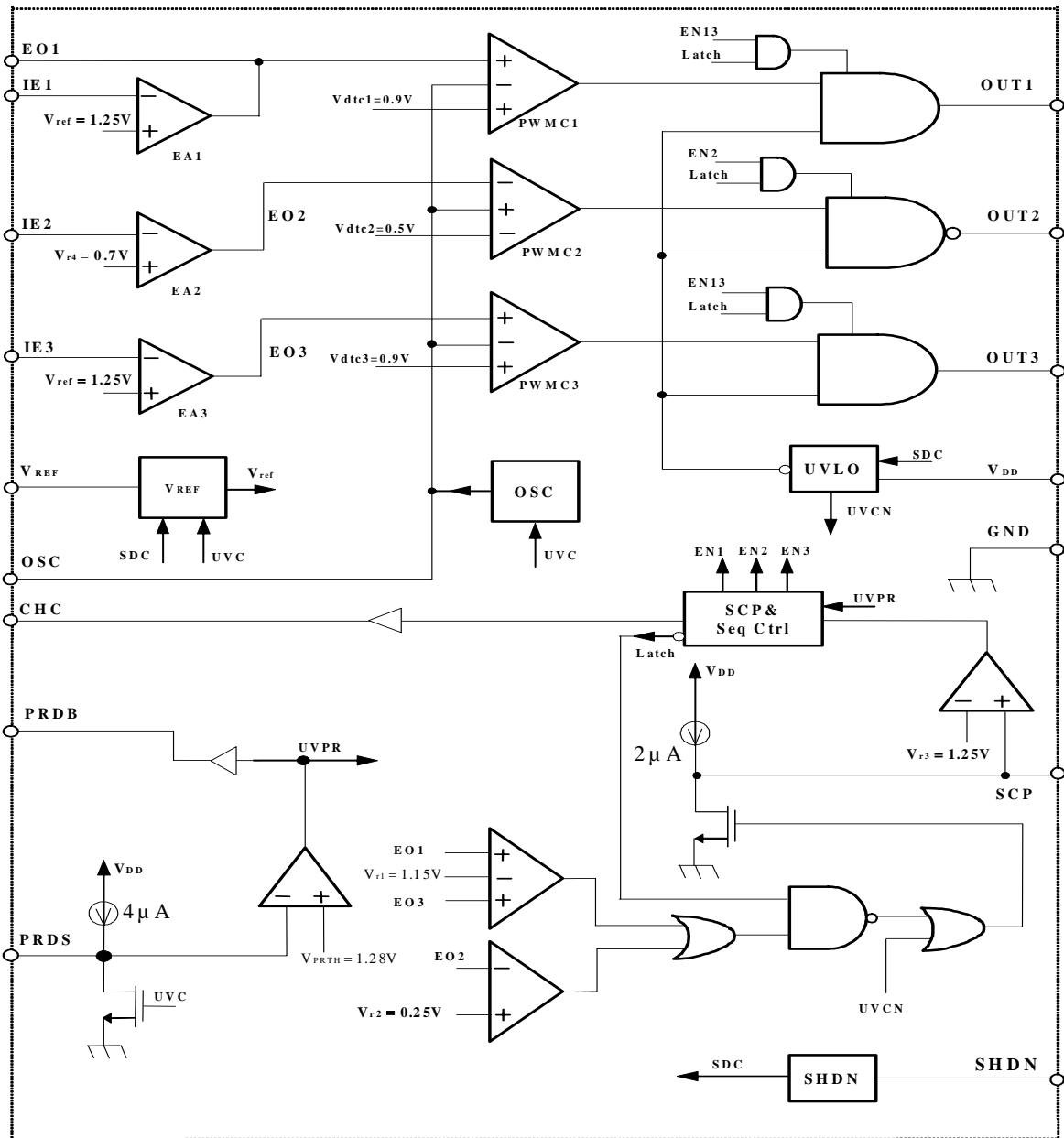


**Block Diagram**  
AAT1101/AAT1101A Only



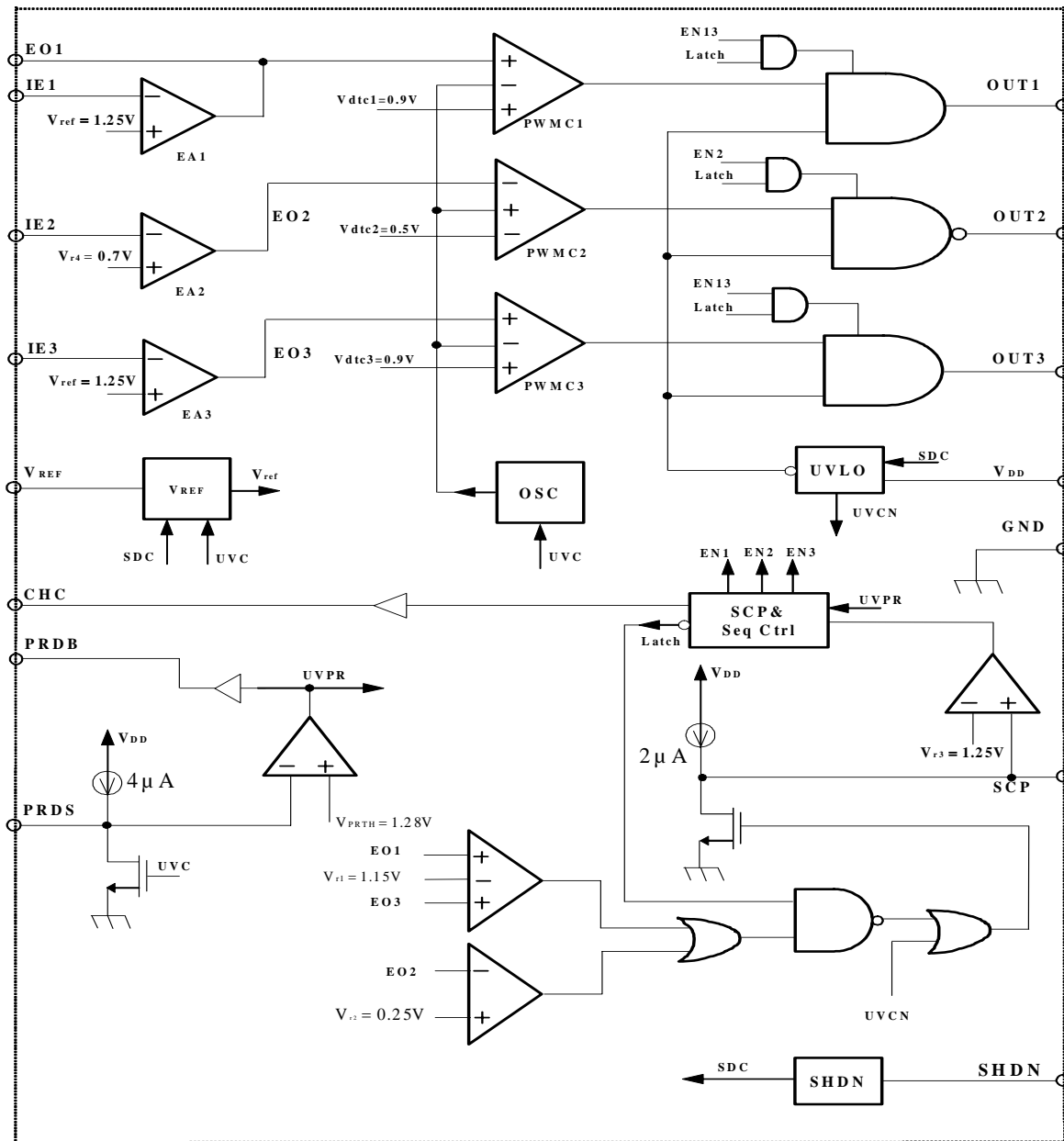


**Block Diagram**  
**AAT1101B Only**





**Block Diagram  
AAT1101C Only**

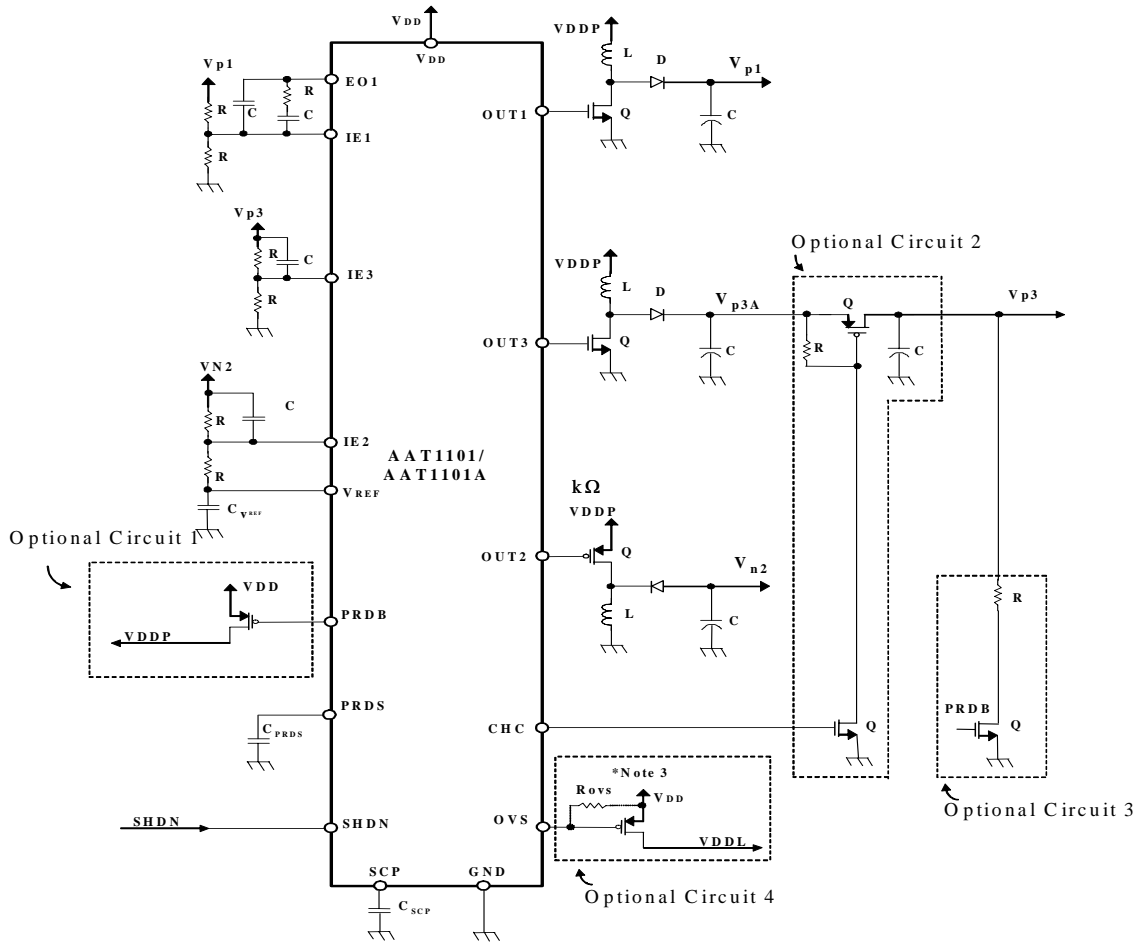




**Application Circuit**

**AAT1101/AAT1101A Only**

kΩ



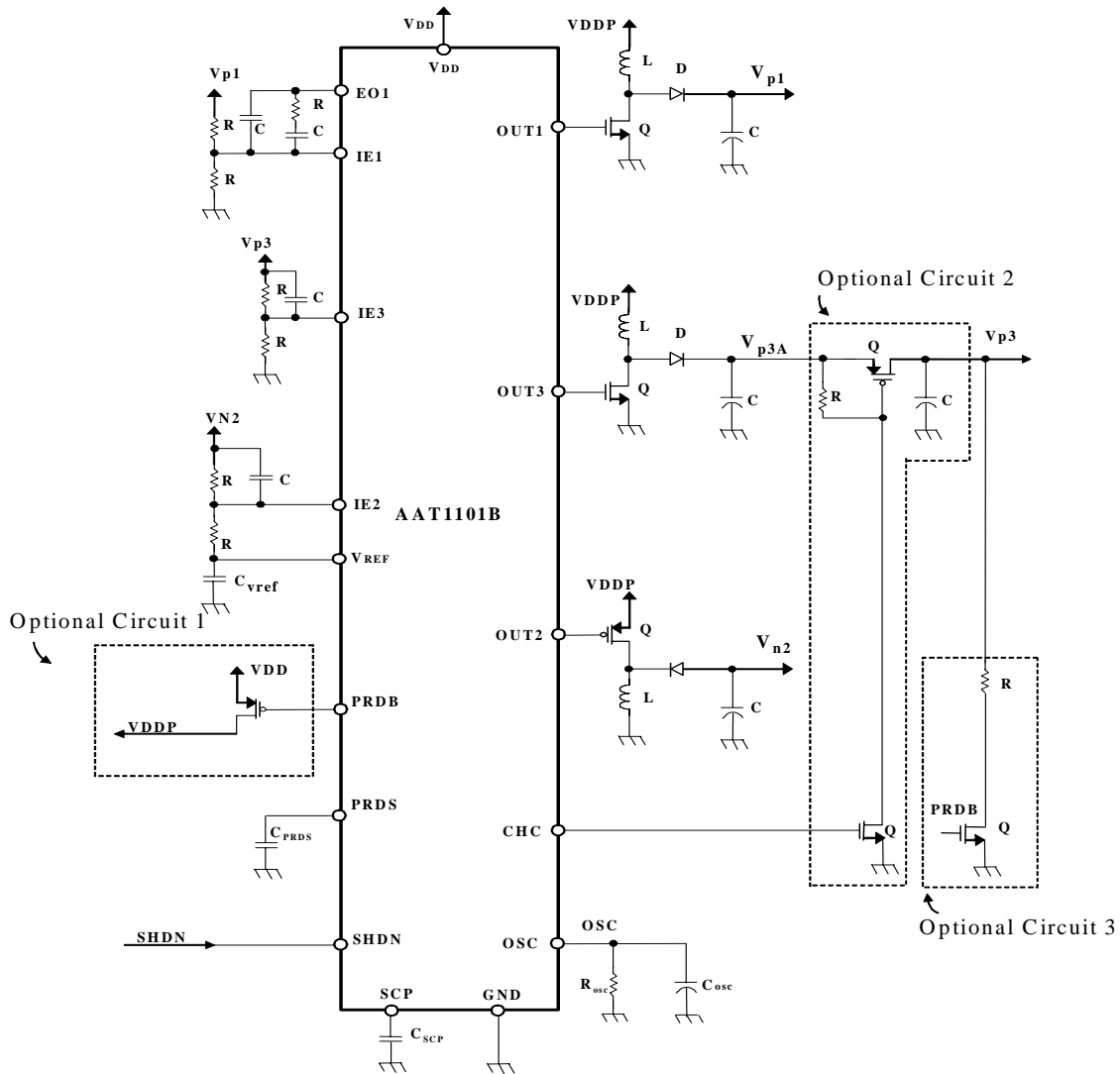
\*Note 3:  $V_{DD} = 5V$ , connects a  $R_{OVS} = 56 k\Omega$  to  $V_{DD}$

$V_{DD} = 3.3V$ , connects no resistor to  $V_{DD}$

Note: All voltage and current values in block diagram (for AAT1101/AAT1101A) are nominal.



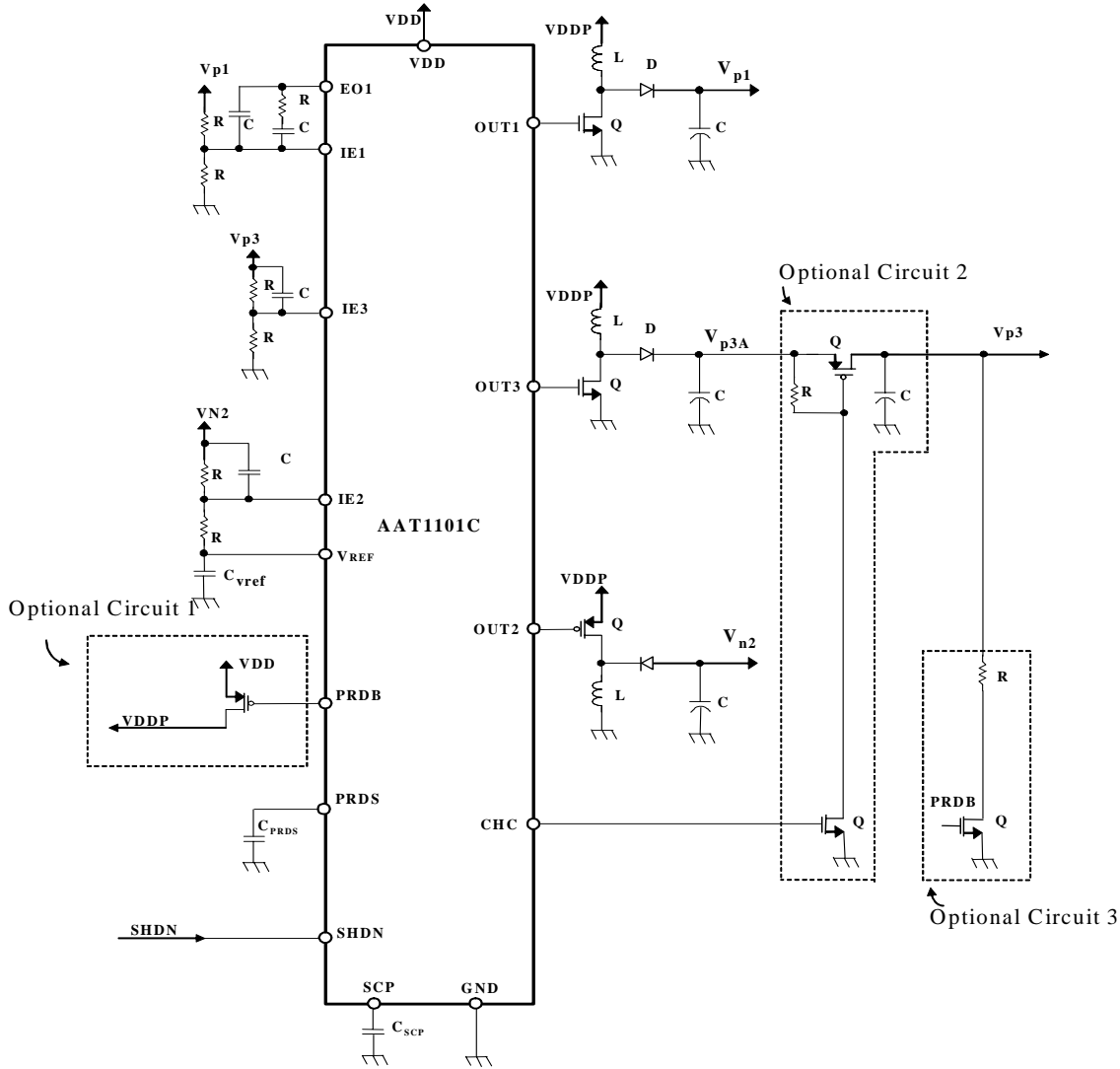
**Application Circuit**  
**AAT1101B Only**



All voltage and current values in block diagram are nominal.

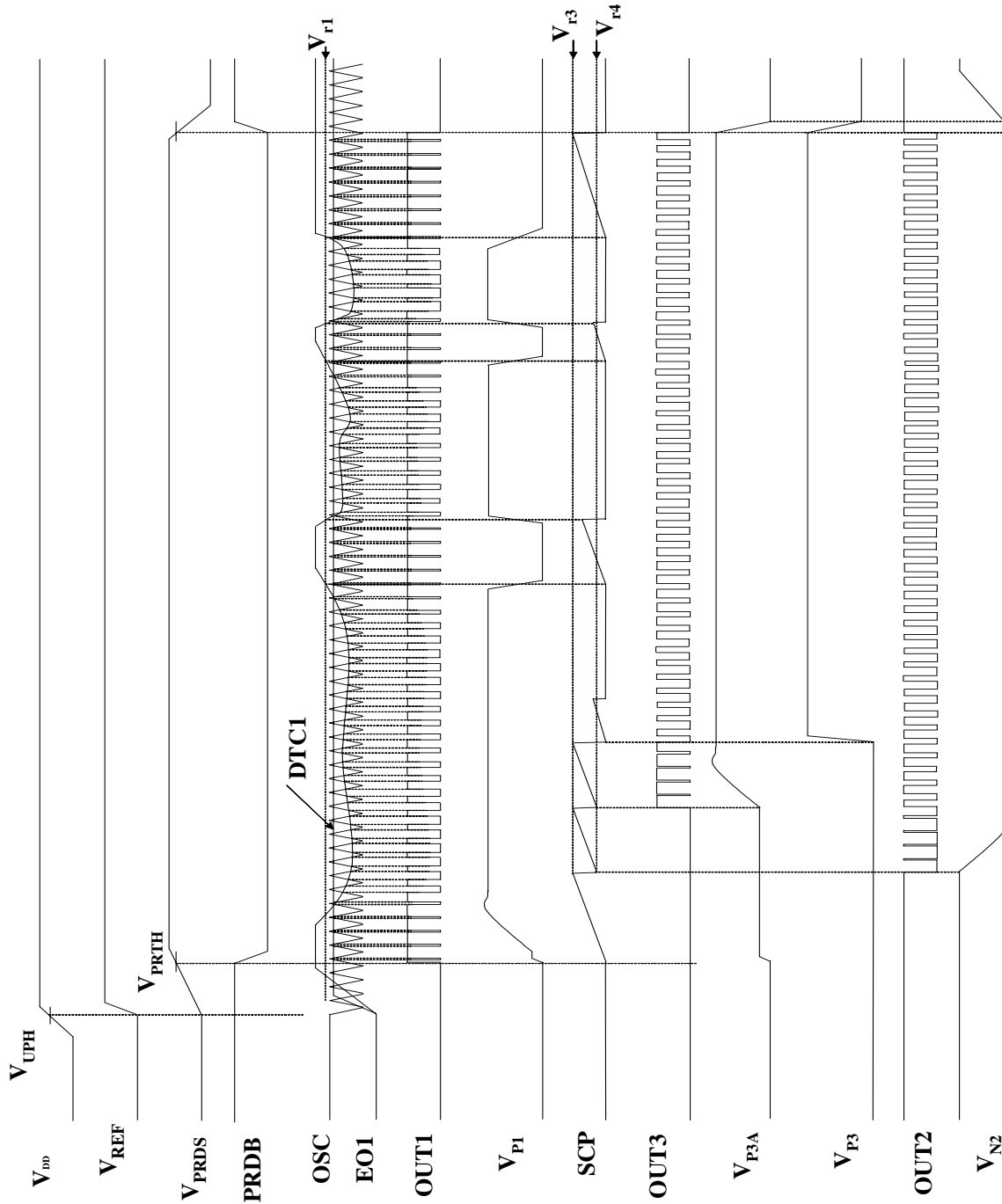


Application Circuit  
AAT1101C Only





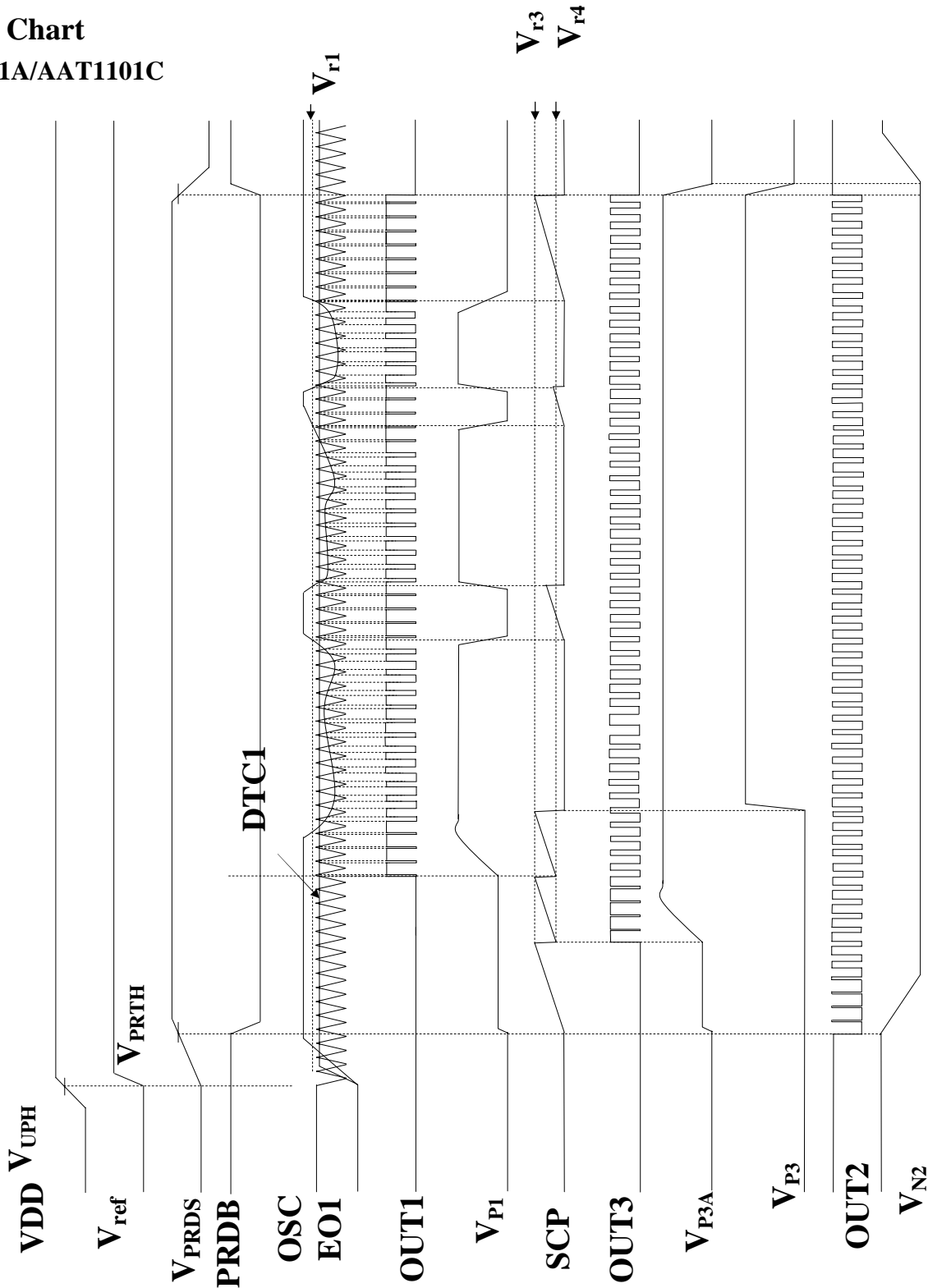
Timing Chart  
AAT1101





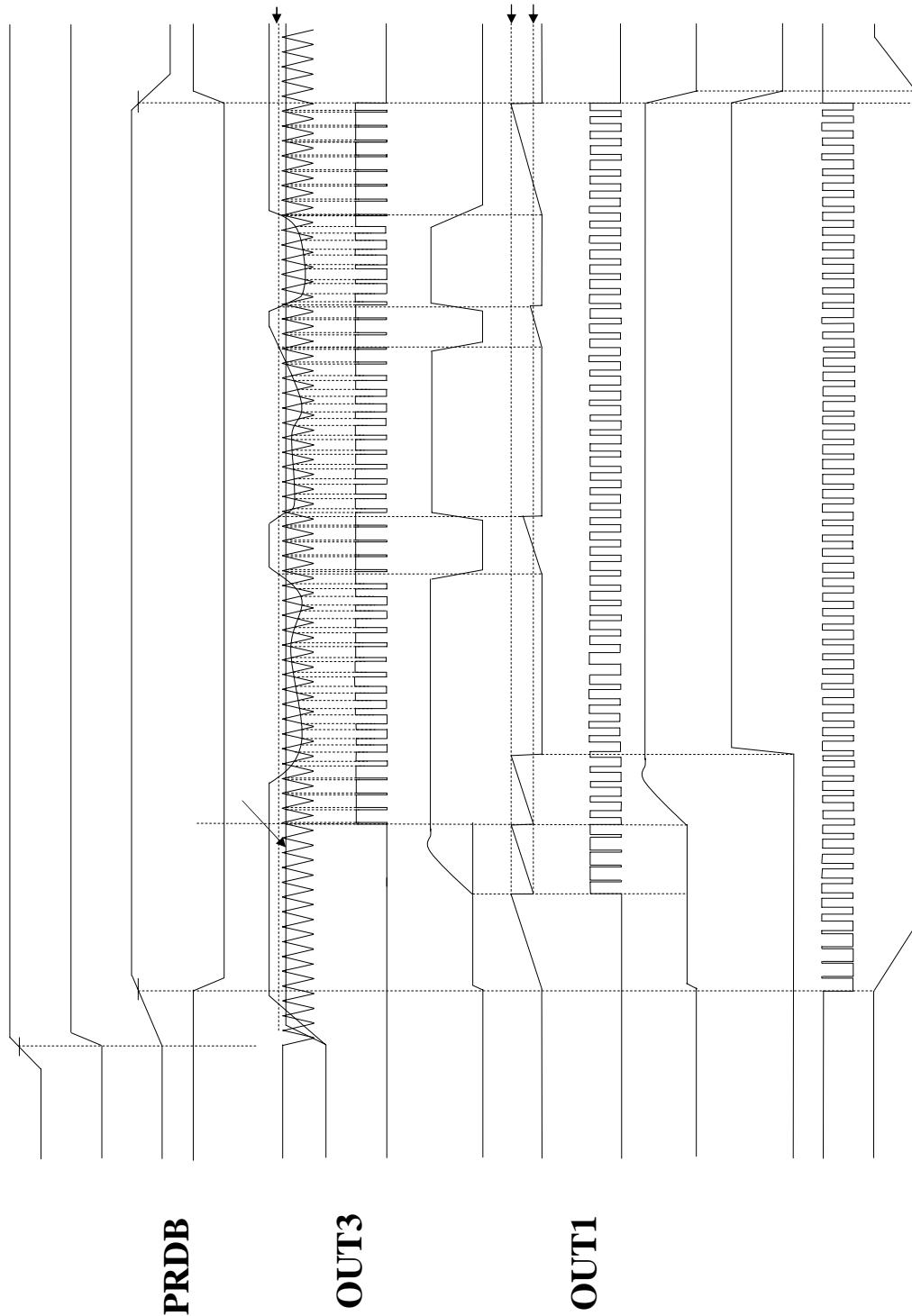


**Timing Chart**  
AAT1101A/AAT1101C



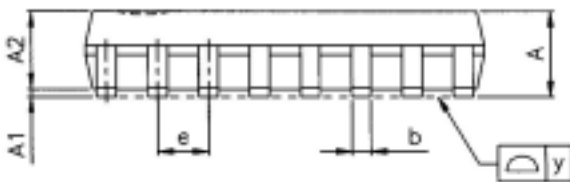
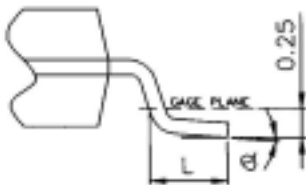
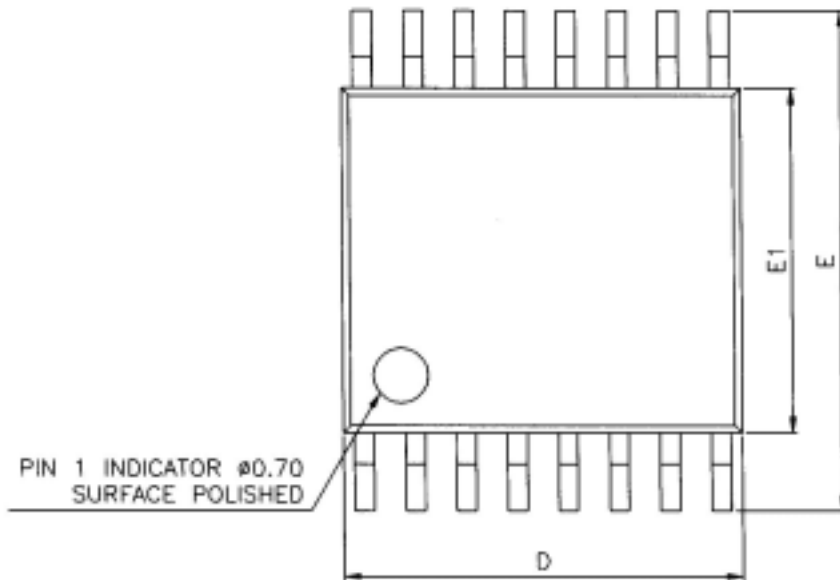


Timing Chart  
AAT1101B



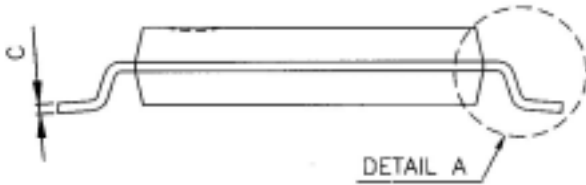


**PACKAGE DIMENSION**  
**16-PIN TSSOP**





PACKAGE DIMENSION (CONT.)



SYMBOLS	DIMENSIONS IN MILLIMETERS			DEMINSIONS IN INCHES		
	MIN	TYP	MAX	MIN	TYP	MAX
A	1.05	1.10	1.20	0.041	0.043	0.047
A1	0.05	0.10	0.15	0.002	0.004	0.006
A2	-----	1.00	1.05	-----	0.039	0.041
b	0.20	0.25	0.28	0.008	0.010	0.011
C	-----	0.127	-----	-----	0.005	-----
D	4.900	5.075	5.100	0.1930	0.1998	0.2000
E	6.20	6.40	6.60	0.244	0.252	0.260
E1	4.30	4.40	4.50	0.170	0.173	0.177
e	-----	0.65	-----	-----	0.026	-----
L	0.50	0.60	0.70	0.020	0.024	0.028
y	-----	-----	0.076	-----	-----	0.003
θ	0°	4°	8°	0°	4°	8°

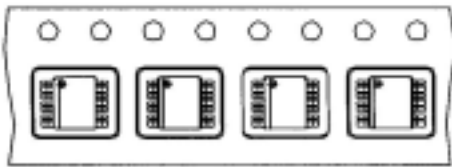
NOTE:

1. CONTROLLING DIMENSION: MILLIMETERS
2. LEAD FRAME MATERIAL: OLIN C7025/EFTEC 64T
3. DIMENSION "D" DOES NOT INCLUDE MOLD FLASH, TIE BAR BURRS AND GATE BURRS. MOLD FLASH, TIE BAR BURRS AND GATE BURRS SHALL NOT EXCEED 0.006" [0.15 MILLIMETERS] PER END. DIMENSION "E1" DOES NOT INCLUDE INTERLEAD FLASH. INTERLEAD FLASH SHALL NOT EXCEED 0.010" [0.25 MILLIMETERS] PER SIDE.
4. DIMENSION "b" DOES NOT INCLUDE DAMBAR PROTRUSION. ALLOWABLE DAMBAR PROTRUSION SHALL BE 0.003" [0.08 MILLIMETERS] TOTAL IN EXCESS OF THE "b" DIMENSION AT MAXIMUM MATERIAL CONDITION. DAMBAR CANNOT BE LOCATED ON THE LOWER RADIUS OR THE FOOT. MINIMUM SPACE BETWEEN PROTRUSION AND AN ADJACENT LEAD TO BE 0.0028" [0.07 MILLIMETERS].
5. TOLERANCE: ± 0.010 [0.25 MILLIMETERS] UNLESS OTHERWISE SPECIFIED.
6. OTHERWISE DIMENSION FOLLOW ACCEPTABLE SPEC.
7. REFERENCE DOCUMENT: JEDEC SPEC MO-153.





**TAPE AND REEL (CONT.)**



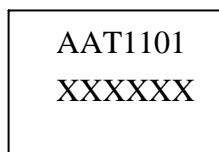
TSSOP 14L / 16L

**NOTE:**

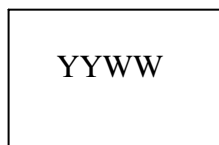
1. 10 SPROCKET HOLE PITCH CUMULATIVE TOLERANCE  $\pm 0.2$  MILLIMETERS.
2. CAMBER NOT TO EXCEED 1 MILLIMETER IN 100 MILLIMETERS.
3. MATERIAL: ANTI-STATIC BLACK ADVANTEK POLYSTYRENE.
4.  $A_0$  AND  $B_0$  MEASURED ON A PLANE 0.3 MILLIMETERS ABOVE THE BOTTOM OF THE POCKET.
5.  $K_0$  MEASURED FROM A PLANE ON THE INSIDE BOTTOM OF THE POCKET TO THE TOP SURFACE OF THE CARRIER.
6. POCKET POSITION RELATIVE TO SPROCKET HOLE MEASURED AS TRUE POSITION OF POCKET, NOT POCKET HOLE.

**PART MARKING**

**TSSOP16 TOP MARKING**



**TSSOP16 BACK MARKING**





**ORDERING INFORMATION**

