AS3504x

25uA Quiescent, 2.25MHz, 600mA Step-Down DCDC

From Santa Clara, United States of America

Leading Performance: 2.25MHz Low noise, 2.3-5.5V Input, 0.8-3.3V Output (0.1V step)

Features

• High Efficiency Step Down Converter

• Output Current up to 600mA

• Wide Vin Range from 2.3V to 5.5V

• 2.25MHz Fixed Frequency Low Noise Operation

• Power Save Mode at Light Load Currents

• Voltage Positioning in PFM mode +1.5%

• Low Quiescent Current: Typ. 25uA

• Low Dropout operation: 100% Duty Cycle

• Soft Start

• Under-voltage Lockout

• Available packages: SOT-23-5, DFN1616-06B, DFN(PLP)1216-6F

Applications

• Cellular Telephones

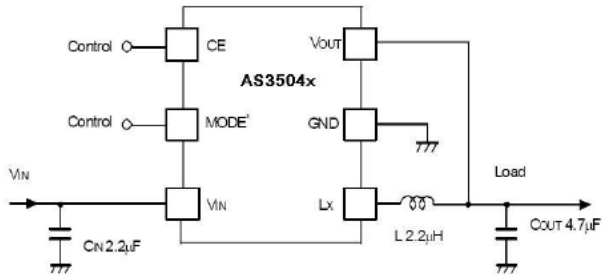
• PDA, Pocket PCs

• Wireless and DSL Modems

• Low Power DSP Supply

• Portable Media Players

Typical Application



Overview

The AS3504x Series are low supply current 600mA step-down DC/DC Converters with synchronous rectifier. Each of these ICs consists of an oscillator, a reference voltage unit, an error amplifier, a switching control circuit, a mode control circuit circuit(Ver.A, D), a soft-start circuit, a "latch type" protection circuit, an under voltage lockout (UVLO) circuit, and switching transistors. A low ripple, high efficiency synchronous rectifier step-down DC/DC converter can be easily composed of this IC with only and inductor and capacitors. Since packages are SOT-23-5, DFN1616-6B, DFN(PLP)1216-6F, high density mounting on boards is possible.

As protection circuits, the AS3504x Series contain a current limit circuit which limits the Lx peak current in each clock cycle, and a latch protection circuit which latches the built-in driver to the OFF state if the load current exceeds the limit value or the output short continues for a specified time (the protection delay time). The latch protective circuit can be released by once putting the IC into the standby mode with the CE pin and then into the active mode, or, by turning the power off and back on. Setting the supply voltage lower than the UVLO detector threshold can also release the latch protective circuit.

In terms of the output voltage, since the feedback resistances are built-in, the voltage is fixed internally. 0.1V step output can be set by laser-trim and +/-1.5% or +/18mv tolerance depending on the output voltage is guaranteed. By inputting a signal to a MODE pin, the AS3504x Series can be switched between PWM/VFM auto switching control and Forced PWM control. PWM/VFM auto switching control switches to high-efficiency VFM mode in low output current. Forced PWM control switches to fixed-frequency Force PWM mode for reducing noise in low output current.

Pin Description

- **AS3504Nxx1B,1C : SOT-23-5**

Pin No.	Symbol	Description
1	V_{OUT}	Output Pin
2	GND	Ground Pin
3	L_X	L_X Switching Pin
4	V_{IN}	Input Pin
5	CE	Chip Enable Pin ("H" Active)

- **AS3504Lxx1A,1D : DFN1616-6B**

Pin No.	Symbol	Description
1	CE	Chip Enable Pin ("H" Active)
2	MODE	Mode Control Pin ("H" forced PWM, "L" PWM/VFM automatic shift)
3	V_{IN}	Input Pin
4	L_X	L_X Switching Pin
5	GND	Ground Pin
6	V_{OUT}	Output Pin

*) Tab is GND level. (They are connected to the reverse side of this IC.)
The tab is better to be connected to the GND, but leaving it open is also acceptable.

- **AS3504Kxx1A,1D : DFN(PLP)1216-6F**

Pin No.	Symbol	Description
1	V_{IN}	Input Pin
2	MODE	Mode Control Pin ("H" forced PWM, "L" PWM/VFM automatic shift)
3	CE	Chip Enable Pin ("H" Active)
4	V_{OUT}	Output Pin
5	GND	Ground Pin
6	L_X	L_X Switching Pin

Electrical Characteristics AS3504xxxxA, AS3504xxxxD (Ta=25 C)

Symbol	Item	Conditions		Min.	Typ.	Max.	Unit
V_{IN}	Operating Input Voltage	V_{OUT} ≥1.0		2.3		5.5	V
		V_{OUT} <1.0		2.3		4.5	
V_{OUT}	Output Voltage	V_{IN}=V_{CE}=3.6V or V_{SET}+1V	V_{OUT}≥1.2V	×0.985		×1.015	V
			V_{OUT}<1.2V	-0.018		+0.018	
$\Delta V_{OUT}/\Delta T$	Output Voltage Temperature Coefficient	-40°C ≦Ta ≦85°C			±40		ppm/°C
fosc	Oscillator Frequency	V_{IN}=V_{CE}=3.6V or V_{SET}+1V		1.95	2.25	2.55	MHz
I_{DD1}	Supply Current 1	V_{IN}=V_{CE}=5.5V, V_{OUT}=V_{SET}×0.8			400	800	μA
I_{DD2}	Supply Current 2	V_{IN}=V_{CE}=V_{OUT}=5.5V	V_{MODE}=0V		25	40	μA
			V_{MODE}=5.5V		400	800	
Istandby	Standby Current	V_{IN}=5.5V,V_{CE}=0V			0	5	μA
I_{CEH}	CE "H" Input Voltage	V_{IN}=V_{CE}=5.5V		-1	0	1	μA
I_{CEL}	CE "L" Input Voltage	V_{IN}=5.5V,V_{CE}=0V		-1	0	1	μA
I_{MODEH}	Mode "H" Input Current	V_{IN}=V_{MODE}=5.5V		-1	0	1	μA
I_{MODEL}	Mode "L" Input Current	V_{IN}=5.5V, V_{MODE}=0V		-1	0	1	μA
I_{VOUTH}	V_{OUT} "H" Input Current*1	V_{IN}=V_{OUT}=5.5V,V_{CE}=0V		-1	0	1	μA
I_{VOUTL}	V_{OUT} "L" Input Current	V_{IN}=5.5V,V_{CE}=V_{OUT}=0V		-1	0	1	μA
$I_{LXLEAKH}$	Lx Leakage Current "H"	V_{IN}=V_{LX}=5.5V,V_{CE}=0V		-1	0	5	μA
$I_{LXLEAKL}$	Lx Leakage Current "L"	V_{IN}=5.5V,V_{CE}=V_{LX}=0V		-5	0	1	μA
V_{CEH}	CE "H" Input Voltage	V_{IN}=5.5V		1.0			V
V_{CEL}	CE "L" Input Voltage	V_{IN}=2.3V				0.4	V
V_{MODEH}	Mode "H" Input Voltage	V_{IN}=V_{CE}=5.5V		1.0			V
V_{MODEL}	Mode "L" Input Voltage	V_{IN}=V_{CE}=2.3V				0.4	V
R_{LOW}	Nch On Resistance*2	V_{IN}=3.6V,V_{CE}=0V			30		Ω
R_{ONP}	On Resistance of Pch Tr.	V_{IN}=3.6V, I_{LX}=−100mA			0.34		Ω
R_{ONN}	On Resistance of Nch Tr.	V_{IN}=3.6V, I_{LX}=−100mA			0.43		Ω
Maxduty	Oscillator Maximum Duty Cycle			100			%
tstart	Soft-start Time	V_{IN}=V_{CE}=3.6V or V_{SET}+1V			150	310	μs
I_{Lxlim}	Lx Current Limit	V_{IN}=V_{CE}=3.6V or V_{SET}+1V		700	900		mA
tprot	Protection Delay Time	V_{IN}=V_{CE}=3.6V or V_{SET}+1V		0.5	1.5	5	ms
V_{UVLO1}	UVLO Detector Threshold	V_{IN}=V_{CE}		1.9	2.0	2.1	V
V_{UVLO2}	UVLO Released Voltage	V_{IN}=V_{CE}		2.0	2.1	2.2	V

Test circuit is "OPEN LOOP" and AGND=PGND=0V unless otherwise specified.
*1) without auto discharge version only
*2) with auto discharge version only

Electrical Characteristics AS3504xxxxB, AS3504xxxxC (Ta=25 C)

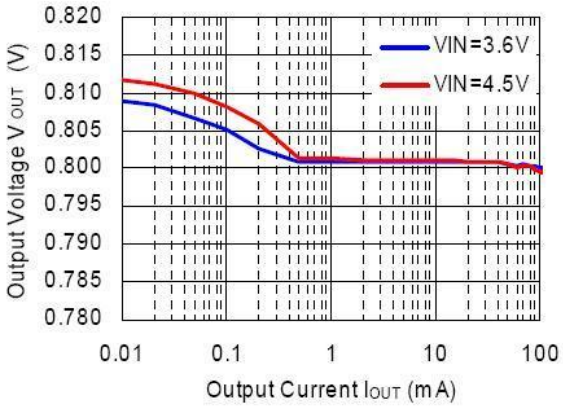
Symbol	Item	Conditions		Min.	Typ.	Max.	Unit
V_{IN}	Operating Input Voltage	V_{OUT} ≥1.0		2.3		5.5	V
		V_{OUT} <1.0		2.3		4.5	
V_{OUT}	Output Voltage	V_{IN}=V_{CE}=3.6V or V_{SET}+1V	V_{OUT} ≥1.2V	×0.985		×1.015	V
			V_{OUT} < 1.2V	-0.018		+0.018	
$\Delta V_{OUT}/\Delta T$	Output Voltage Temperature Coefficient	-40°C ≦ Ta ≦85°C			±40		ppm/°C
fosc	Oscillator Frequency	V_{IN}=V_{CE}=3.6V or V_{SET}+1V		1.95	2.25	2.55	MHz
I_{DD1}	Supply Current 1	V_{IN}=V_{CE}=5.5V, V_{OUT}=V_{SET}×0.8			400	800	μA
I_{DD2}	Supply Current 2	V_{IN}=V_{CE}=V_{OUT}=5.5V	RP504xxxxB		40	60	μA
			RP504xxxxC		500	840	
Istandby	Standby Current	V_{IN}=5.5V,V_{CE}=0V			0	5	μA
I_{CEH}	CE "H" Input Voltage	V_{IN}=V_{CE}=5.5V		-1	0	1	μA
I_{CEL}	CE "L" Input Voltage	V_{IN}=5.5V,V_{CE}=0V		-1	0	1	μA
I_{VOUTH}	V_{OUT} "H" Input Current	V_{IN}=V_{OUT}=5.5V,V_{CE}=0V		-1	0	1	μA
I_{VOUTL}	V_{OUT} "L" Input Current	V_{IN}=5.5V,V_{CE}=V_{OUT}=0V		-1	0	1	μA
$I_{LXLEAKH}$	Lx Leakage Current "H"	V_{IN}=V_{LX}=5.5V,V_{CE}=0V		-1	0	5	μA
$I_{LXLEAKL}$	Lx Leakage Current "L"	V_{IN}=5.5V,V_{CE}=V_{LX}=0V		-5	0	1	μA
V_{CEH}	CE "H" Input Voltage	V_{IN}=5.5V		1.0			V
V_{CEL}	CE "L" Input Voltage	V_{IN}=2.3V				0.4	V
R_{ONP}	On Resistance of Pch Tr.	V_{IN}=3.6V, I_{LX}=−100mA			0.34		Ω
R_{ONN}	On Resistance of Nch Tr.	V_{IN}=3.6V, I_{LX}=−100mA			0.43		Ω
Maxduty	Oscillator Maximum Duty Cycle			100			%
tstart	Soft-start Time	V_{IN}=V_{CE}=3.6V or V_{SET}+1V			150	310	μs
I_{LXlim}	Lx Current Limit	V_{IN}=V_{CE}=3.6V or V_{SET}+1V		700	900		mA
tprot	Protection Delay Time	V_{IN}=V_{CE}=3.6V or V_{SET}+1V		0.5	1.5	5	ms
V_{UVLO1}	UVLO Detector Threshold	V_{IN}=V_{CE}		1.9	2.0	2.1	V
V_{UVLO2}	UVLO Released Voltage	V_{IN}=V_{CE}		2.0	2.1	2.2	V

Test circuit is "OPEN LOOP" and AGND=PGND=0V unless otherwise specified.

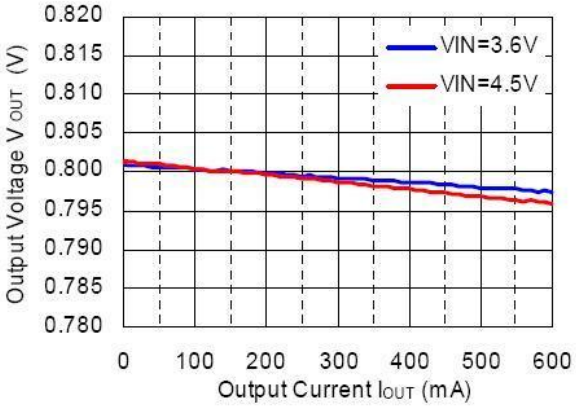
Typical Characteristics

1) Output Voltage vs. Output Current

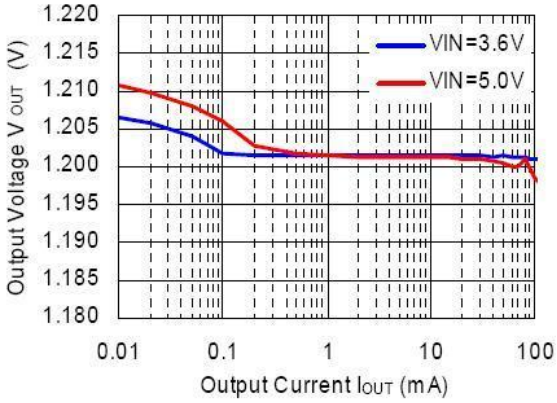
AS3504x V_{OUT}=0.8V
MODE="L"PWM/VFM automatic shift



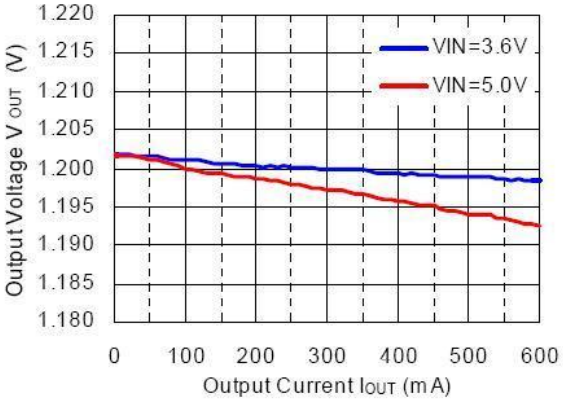
AS3504x V_{OUT}=0.8V
MODE="H" forced PWM



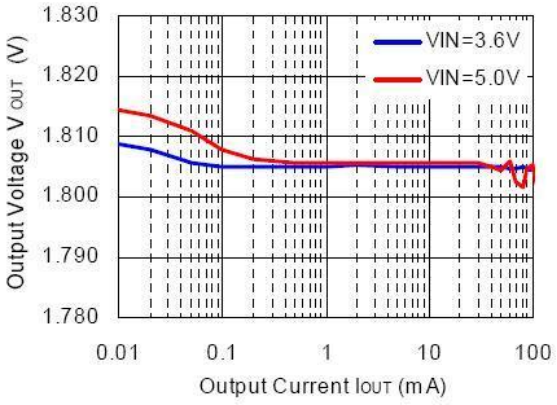
AS3504x V_{OUT}=1.2V
MODE="L"PWM/VFM automatic shift



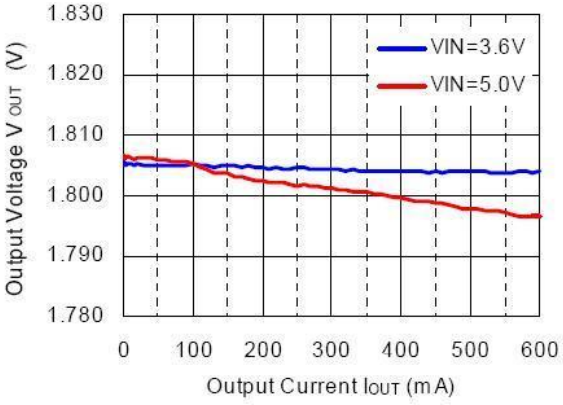
AS3504x V_{OUT}=1.2V
MODE="H" forced PWM



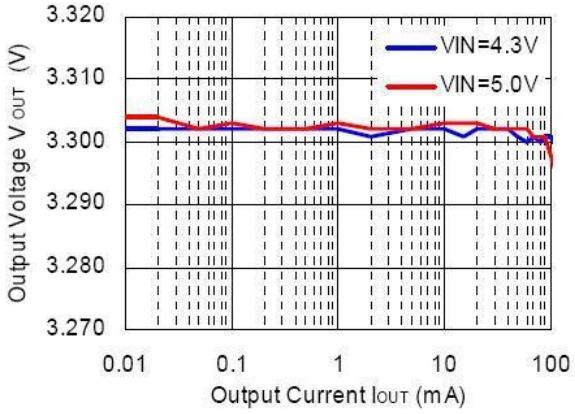
AS3504x V_{OUT}=1.8V
MODE="L"PWM/VFM automatic shift



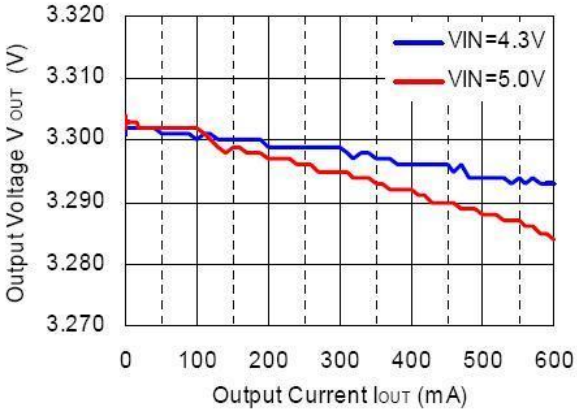
AS3504x V_{OUT}=1.8V
MODE="H" forced PWM



AS3504x V_{OUT}=3.3V
MODE="L"PWM/VFM automatic shift

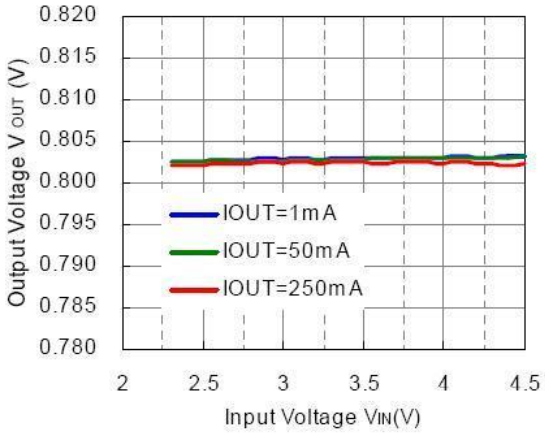


AS3504x V_{OUT}=3.3V
MODE="H" forced PWM

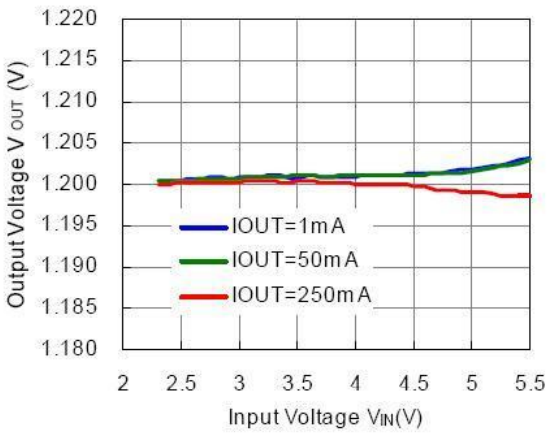


2) Output Voltage vs. Input Voltage

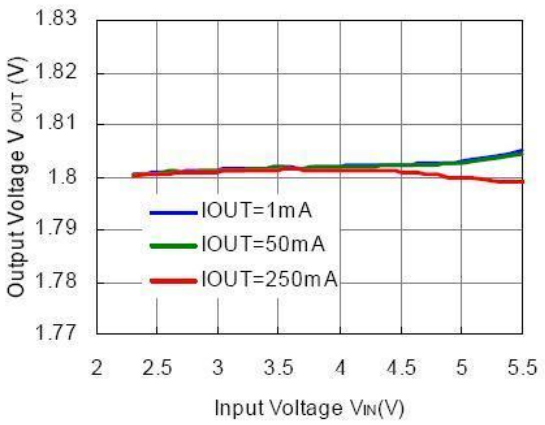
AS3504x V_{OUT}=0.8V
MODE="H" forced PWM



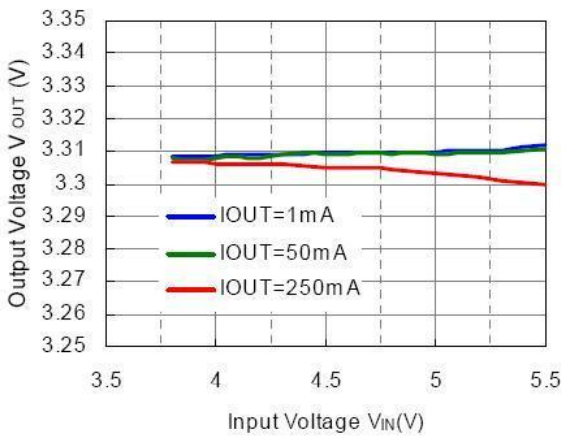
AS3504x V_{OUT}=1.2V
MODE="H" forced PWM



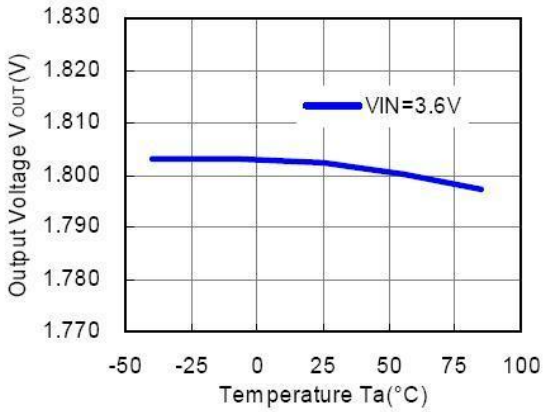
AS3504x V_{OUT}=1.8V
MODE="H" forced PWM



AS3504x V_{OUT}=3.3V
MODE="H" forced PWM

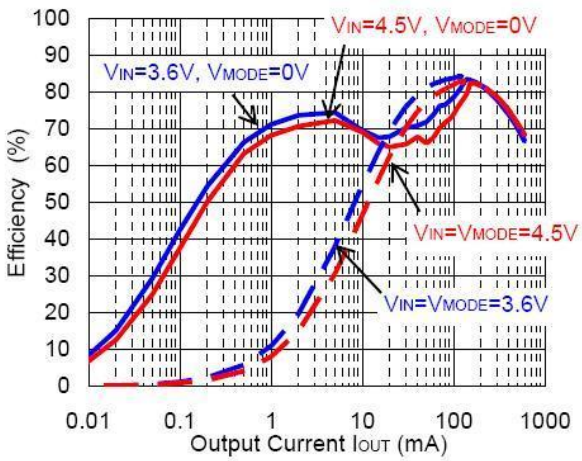


3) Output Voltage vs. Temperature

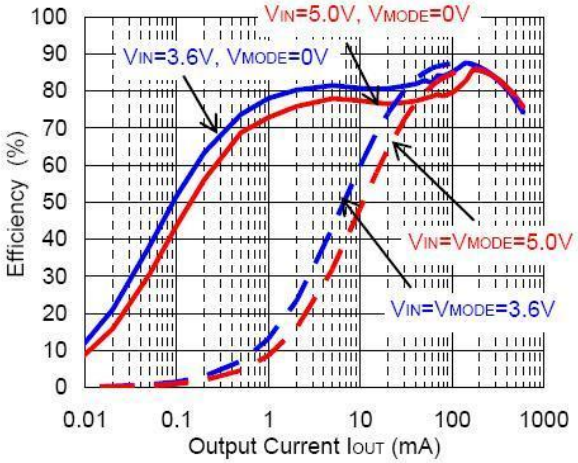


4) Efficiency vs. Output Current

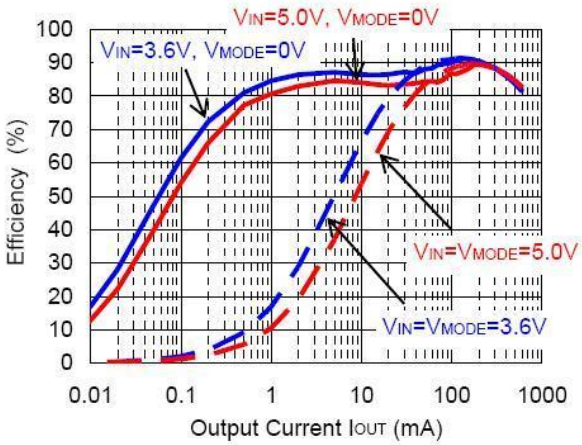
AS3504x V_{OUT}=0.8V



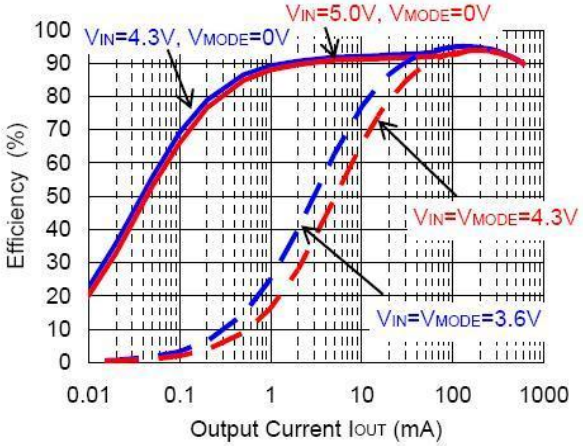
AS3504x V_{OUT}=1.2V



AS3504x V_{OUT}=1.8V

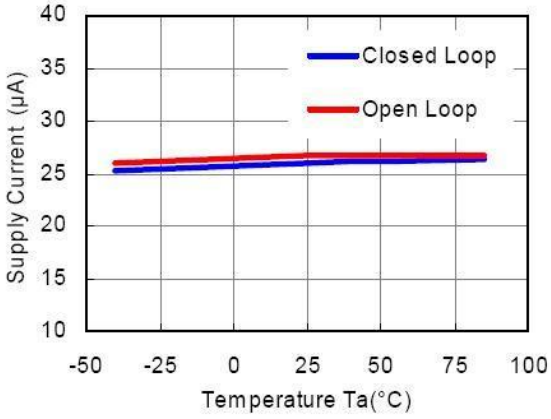


AS3504x V_{OUT}=3.3V



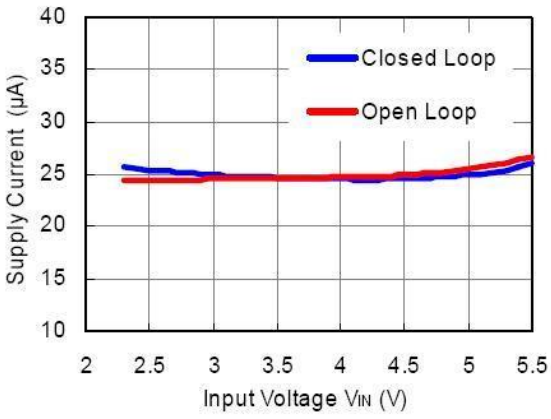
5) Supply Current vs. Temperature

AS3504x V_{OUT}=1.8V(V_{IN}=5.5V)
MODE="L"PWM/VFM automatic shift



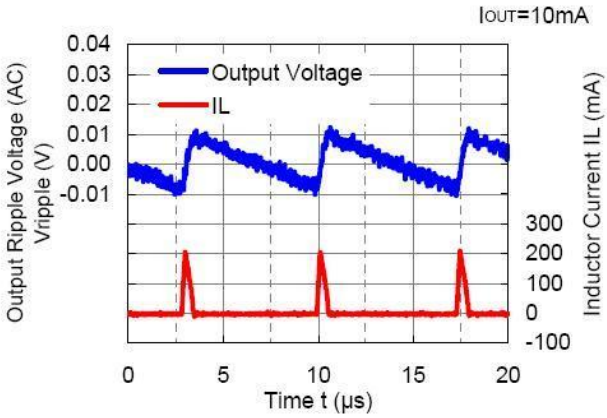
6) Supply Current vs. Input Voltage

AS3504x V_{OUT}=1.8V
MODE="L"PWM/VFM automatic shift

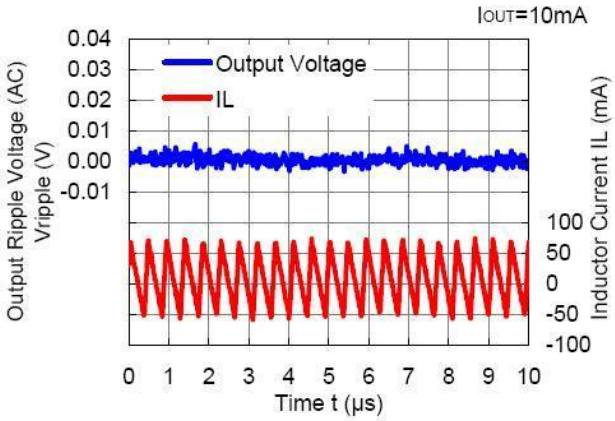


7) Output Ripple Voltage Vripple

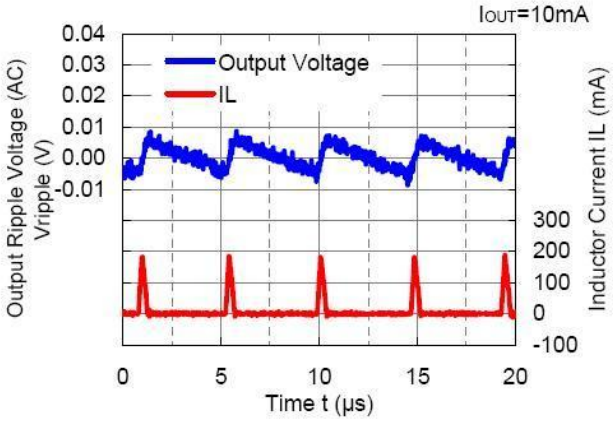
AS3504x V_{OUT}=0.8V(V_{IN}=3.6V)
MODE="L"PWM/VFM automatic shift



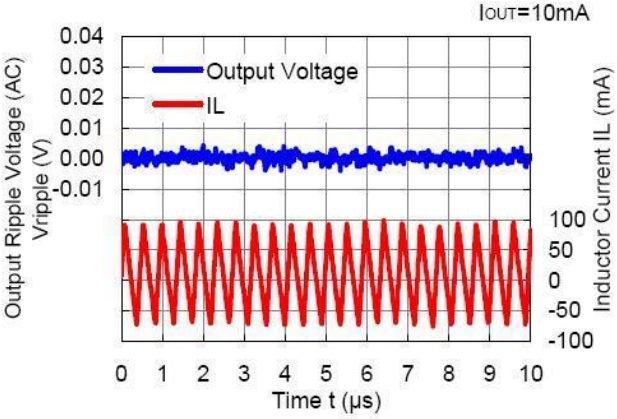
AS3504x V_{OUT}=0.8V(V_{IN}=3.6V)
MODE="H" forced PWM



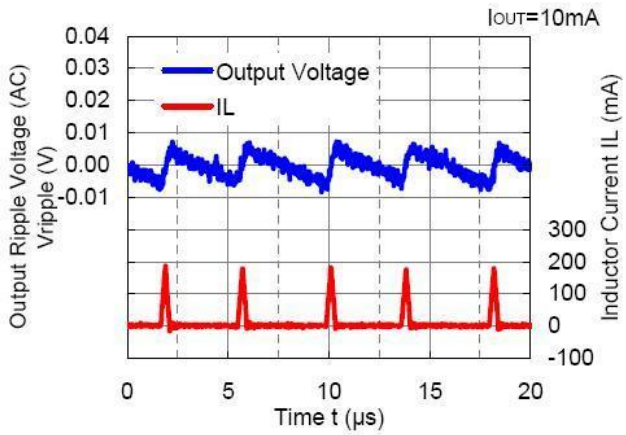
AS3504x V_{OUT}=1.2V(V_{IN}=3.6V)
MODE="L"PWM/VFM automatic shift



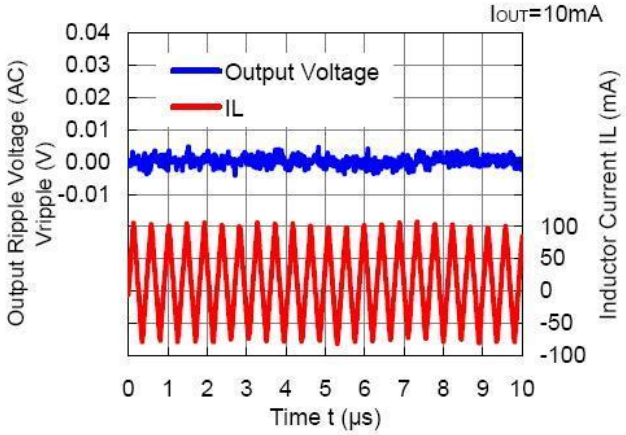
AS3504x V_{OUT}=1.2V(V_{IN}=3.6V)
MODE="H" forced PWM



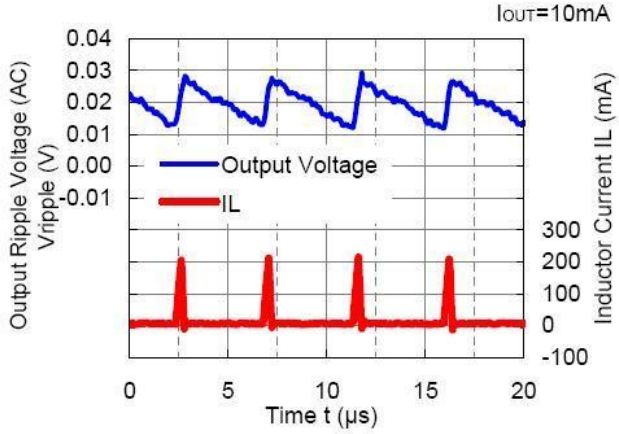
AS3504x V_{OUT}=1.8V(V_{IN}=3.6V)
MODE="L"PWM/VFM automatic shift



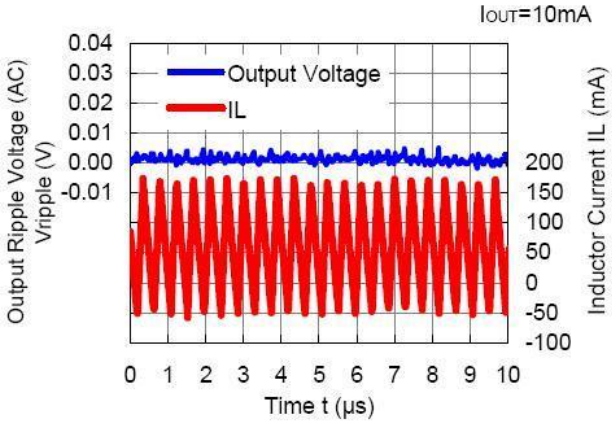
AS3504x V_{OUT}=1.8V(V_{IN}=3.6V)
MODE="H" forced PWM



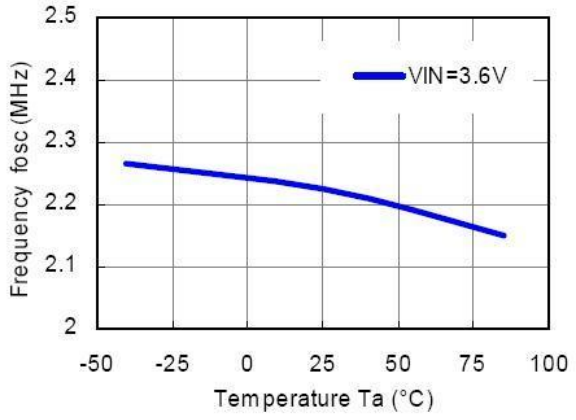
AS3504x V_{OUT}=3.3V(V_{IN}=5.0V)
MODE="L"PWM/VFM automatic shift



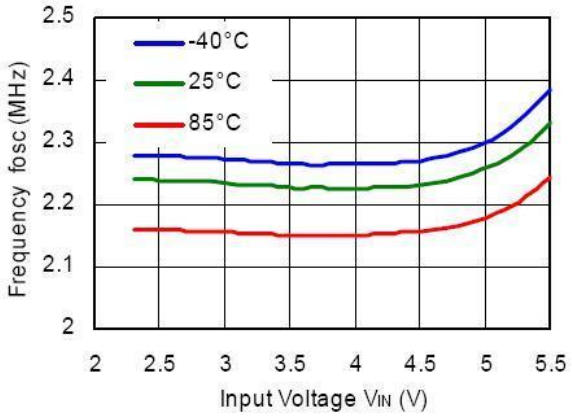
AS3504x V_{OUT}=3.3V(V_{IN}=5.0V)
MODE="H" forced PWM



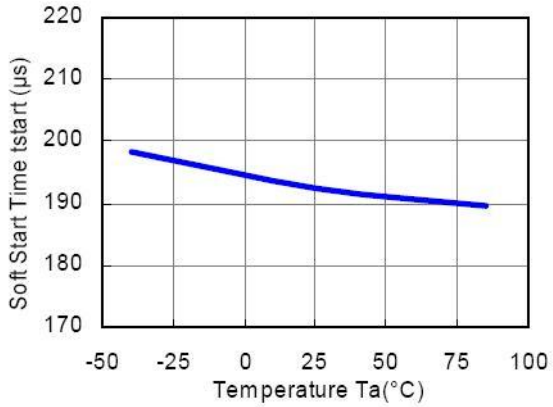
8) Frequency vs. Temperature



9) Frequency vs. Input Voltage

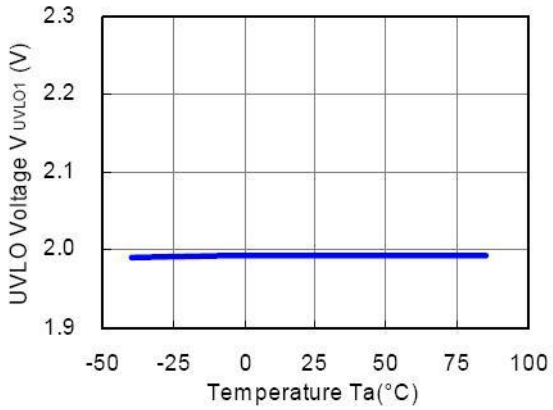


10) Soft Start Time vs. Temperature

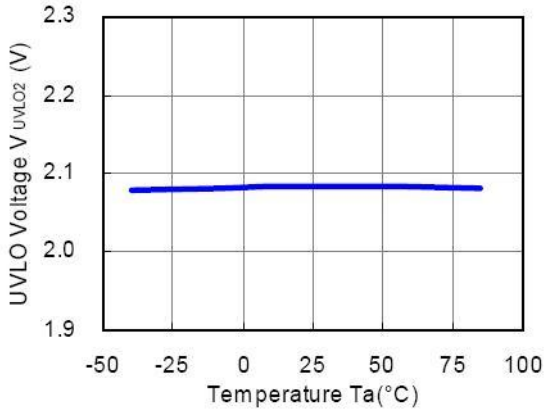


11) UVLO Detector Threshold / Released Voltage vs. Temperature

UVLO Detector Threshold Voltage

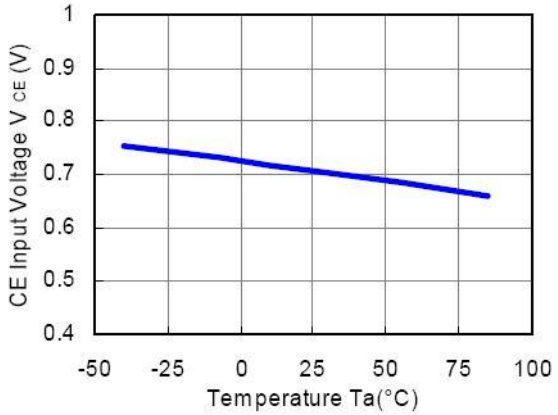


UVLO Released Voltage

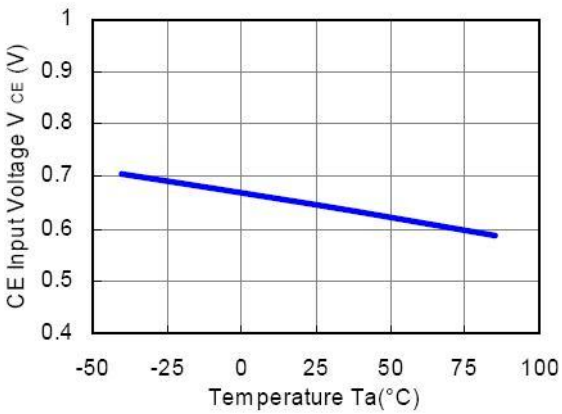


12) CE Input Voltage vs. Temperature

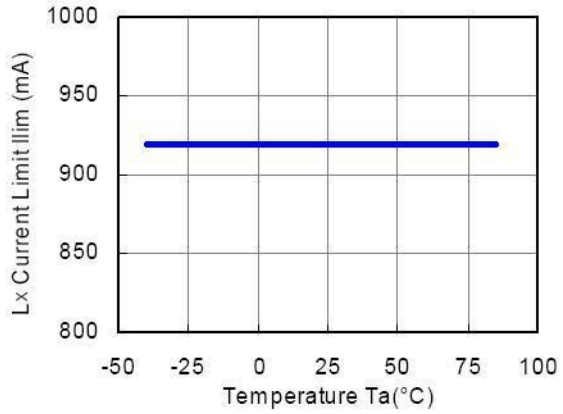
CE"H" Input Voltage(V_{IN}=5.5V)



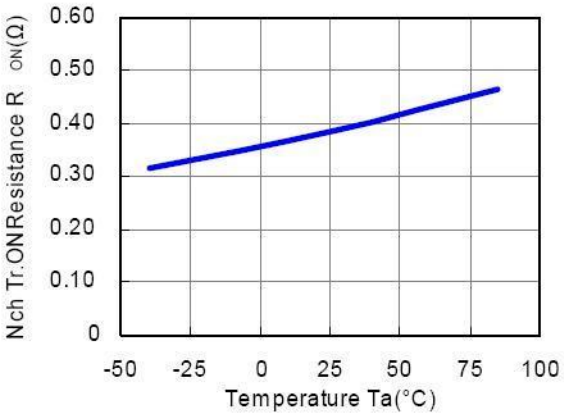
CE"H" Input Voltage (V_{IN}=2.3V)



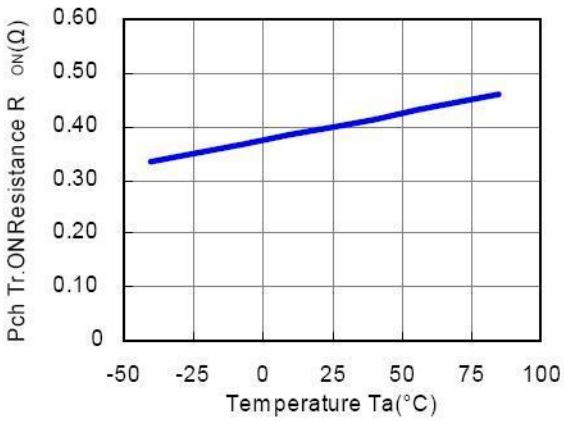
13) L_X Current Limit vs. Temperature



14) Nch Tr. ON Resistance vs. Temperature

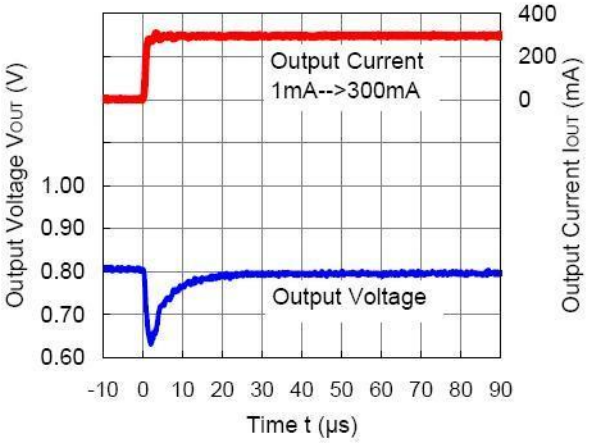


15) Pch Tr. ON Resistance vs. Temperature

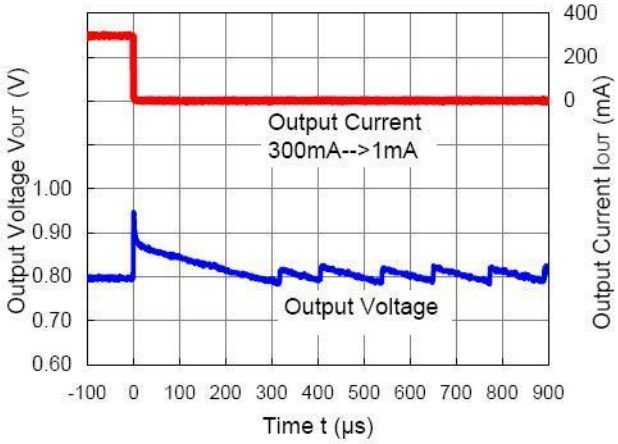


16) Load Transient Response

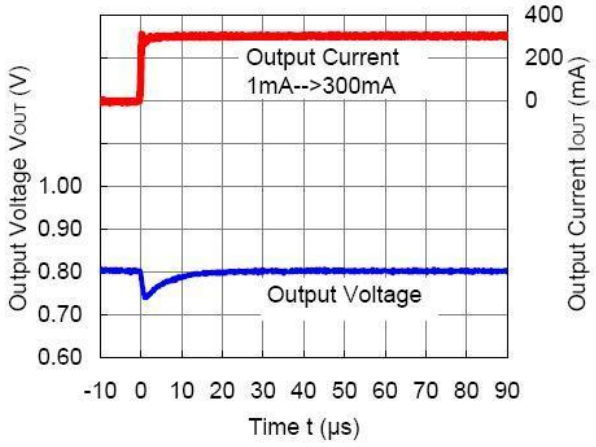
AS3504x081x (VIN=3.6V)
MODE="L"PWM/VFM automatic shift



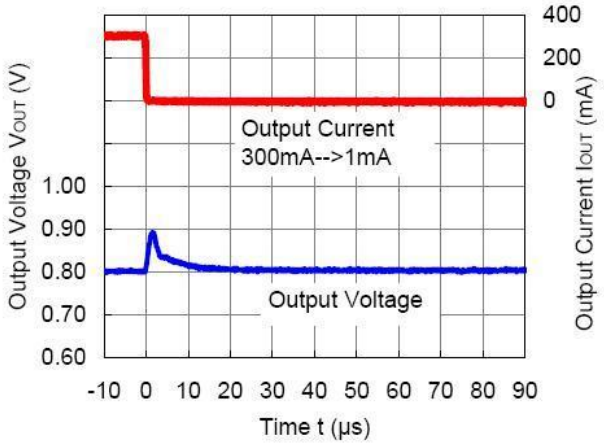
AS3504x081x (VIN=3.6V)
MODE="L"PWM/VFM automatic shift



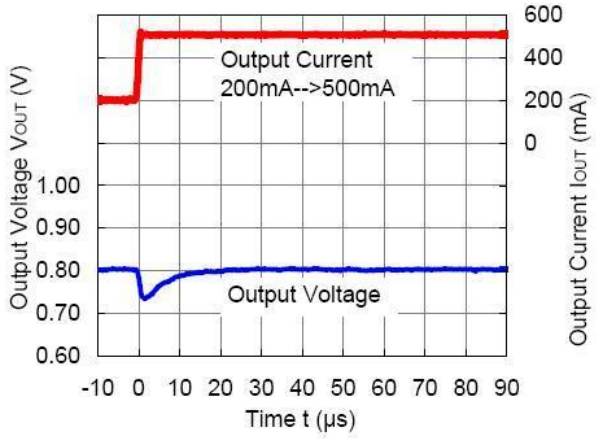
AS3504x081x (V_{IN}=3.6V)
MODE="H" forced PWM



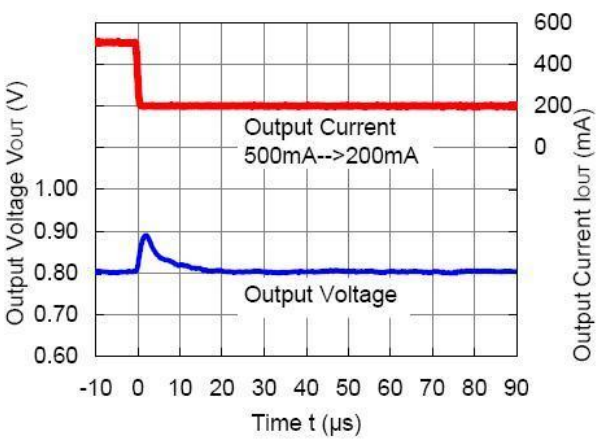
AS3504x081x (V_{IN}=3.6V)
MODE="H" forced PWM



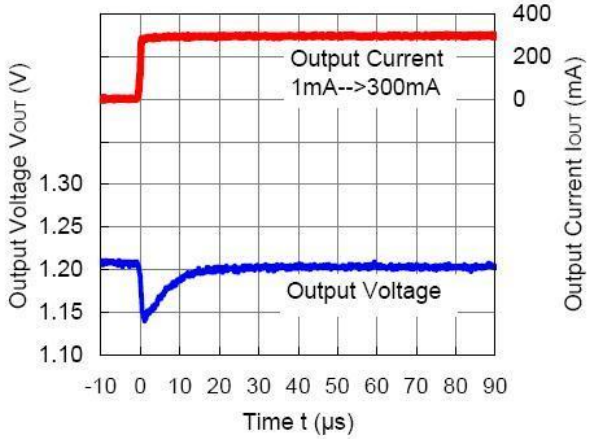
AS3504x081x (V_{IN}=3.6V)



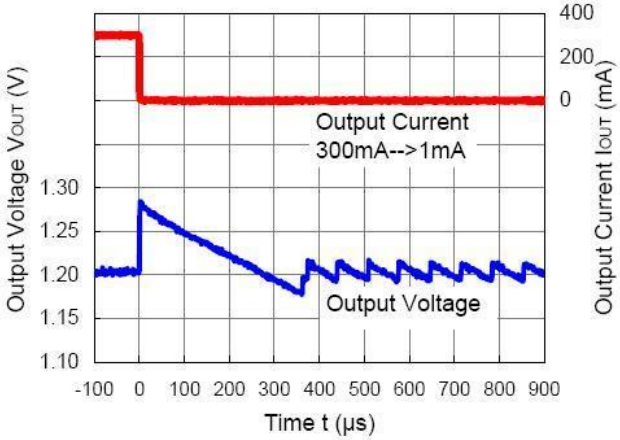
AS3504x081x (V_{IN}=3.6V)



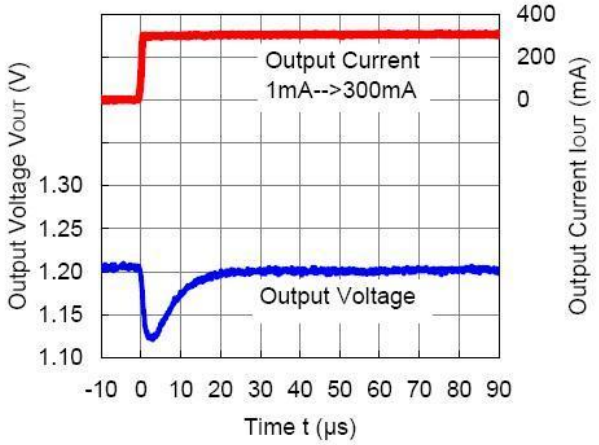
AS3504x121x (V_{IN}=3.6V)
MODE="L"PWM/VFM automatic shift



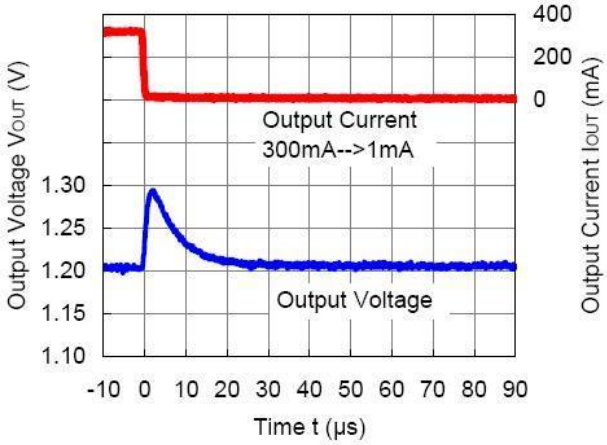
AS3504x121x (V_{IN}=3.6V)
MODE="L"PWM/VFM automatic shift



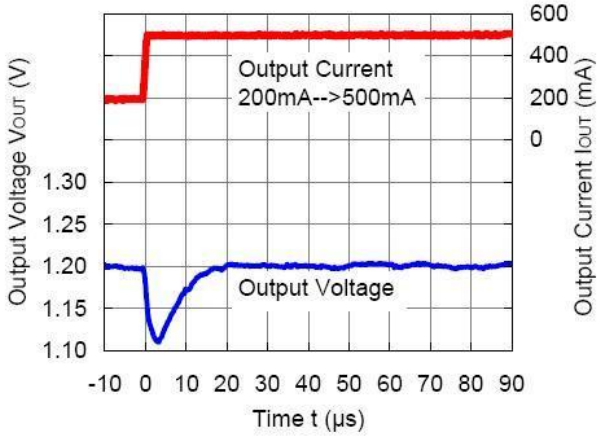
AS3504x121x (V_{IN}=3.6V)
MODE="H" forced PWM



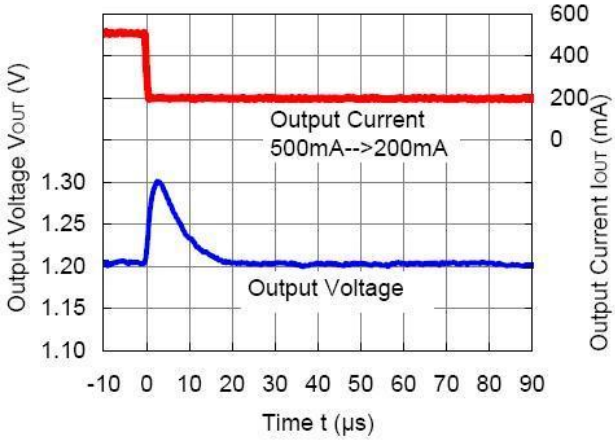
AS3504x121x (V_{IN}=3.6V)
MODE="H" forced PWM



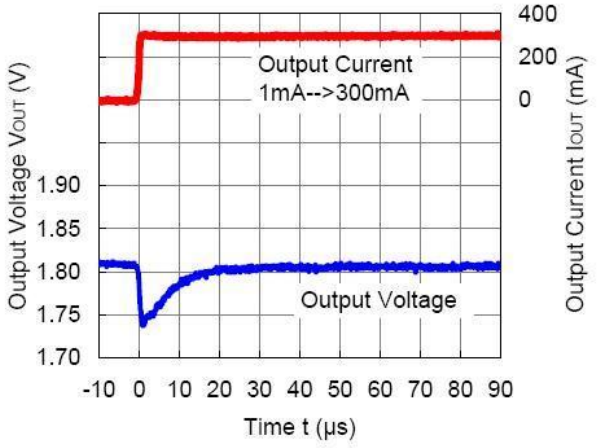
AS3504x121x (V_{IN}=3.6V)



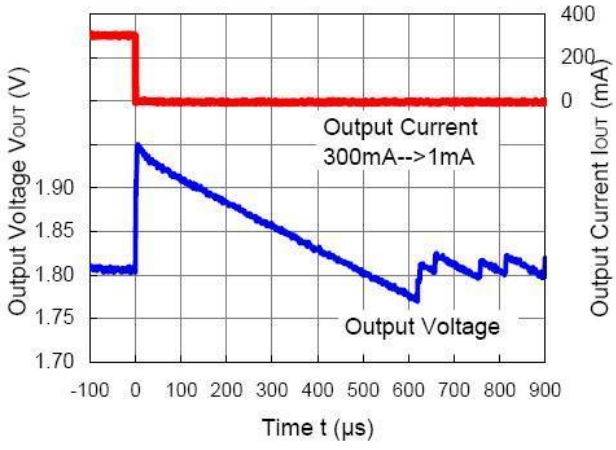
AS3504x121x (V_{IN}=3.6V)



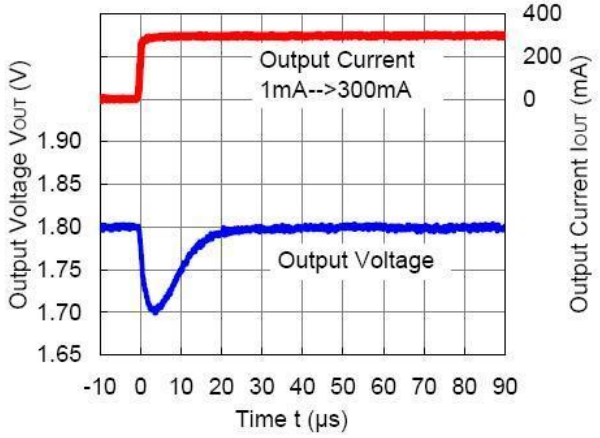
AS3504x181x (V_{IN}=3.6V)
MODE="L"PWM/VFM automatic shift



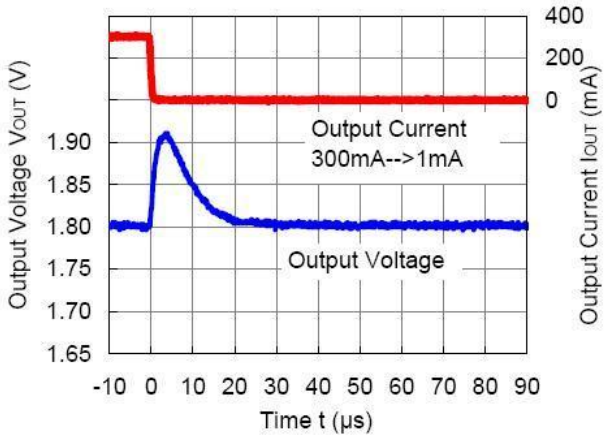
AS3504x181x (V_{IN}=3.6V)
MODE="L"PWM/VFM automatic shift



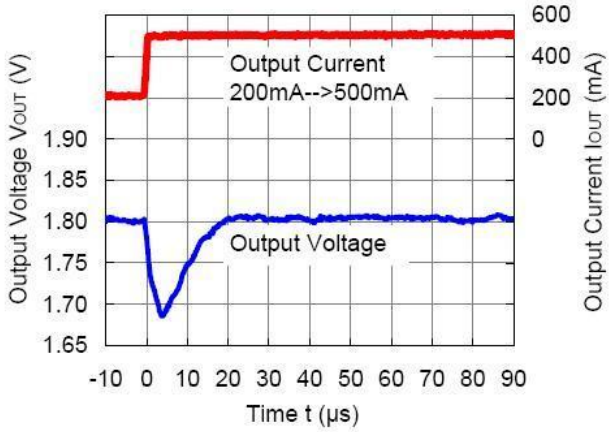
AS3504x181x (V_{IN}=3.6V)
MODE="H" forced PWM



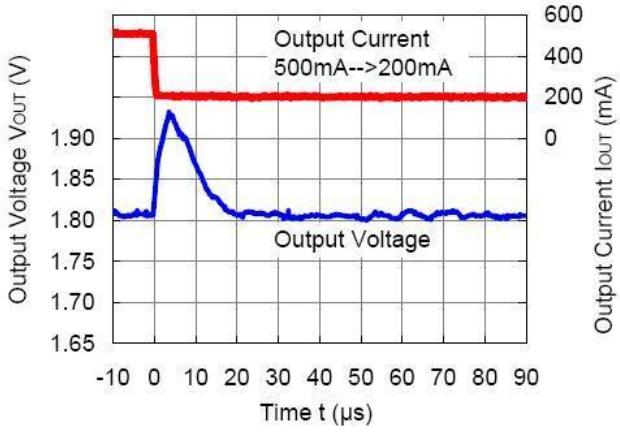
AS3504x181x (V_{IN}=3.6V)
MODE="H" forced PWM



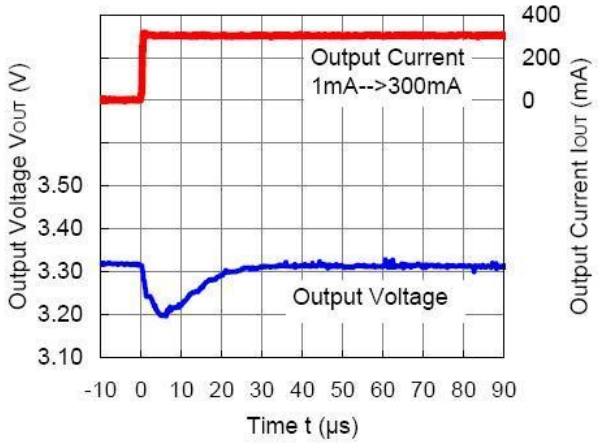
AS3504x181x (V_{IN}=3.6V)



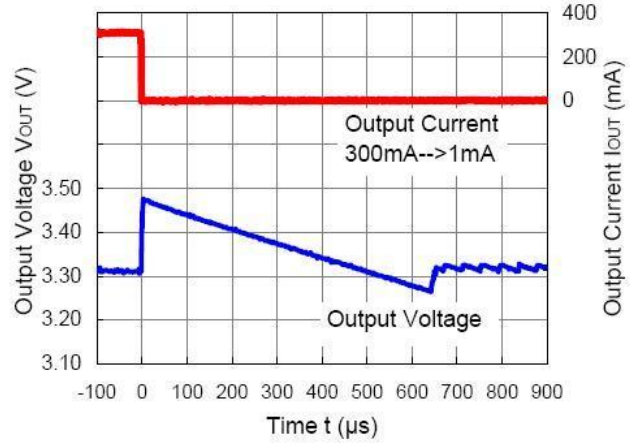
AS3504x181x (V_{IN}=3.6V)



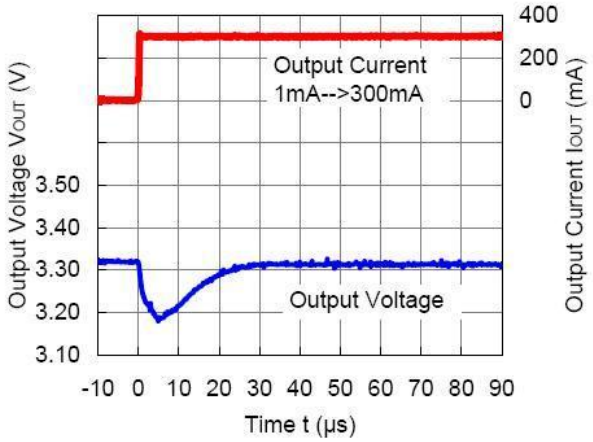
AS3504x331x (V_{IN}=5.0V)
MODE="L"PWM/VFM automatic shift



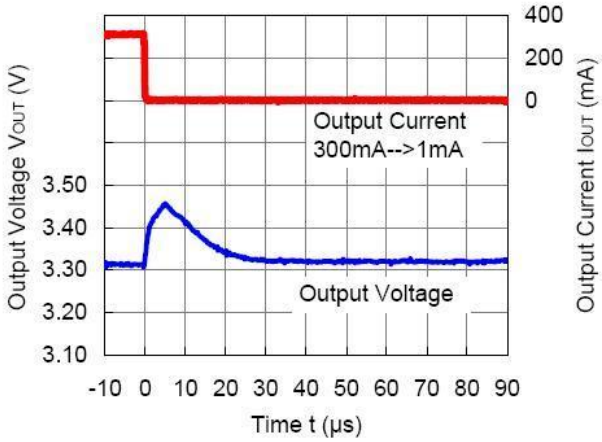
AS3504x331x (V_{IN}=5.0V)
MODE="L"PWM/VFM automatic shift



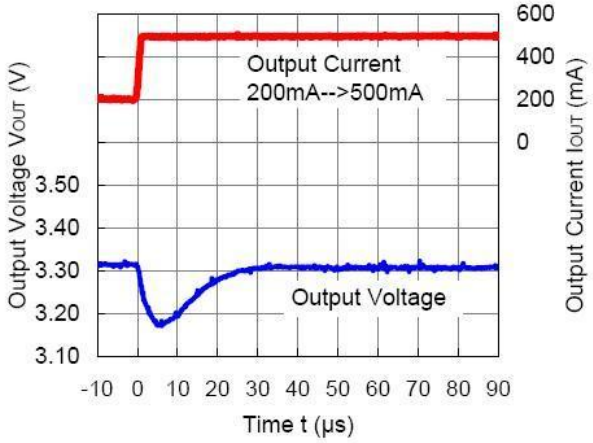
AS3504x331x (V_{IN}=5.0V)
MODE="H" forced PWM



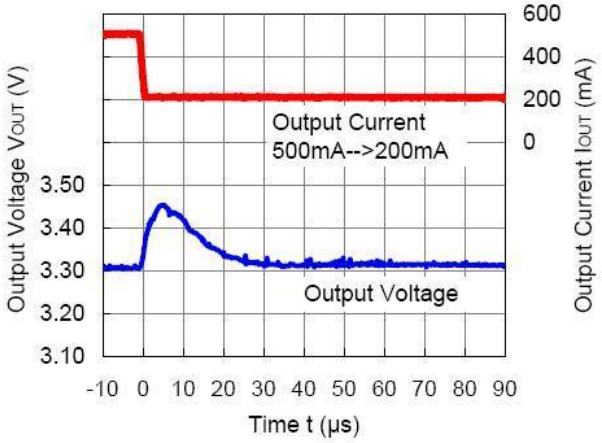
AS3504x331x (V_{IN}=5.0V)
MODE="H" forced PWM



AS3504x331x (V_{IN}=5.0V)

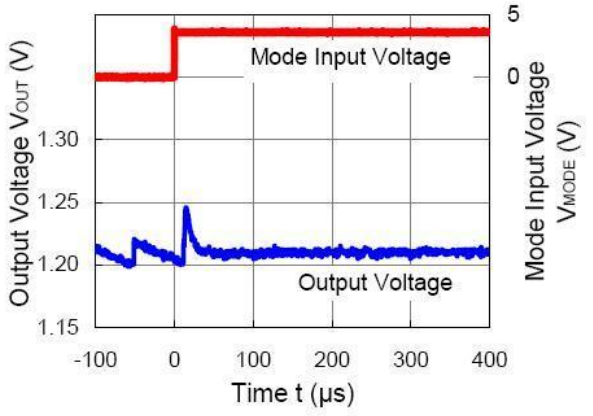


AS3504x331x (V_{IN}=5.0V)

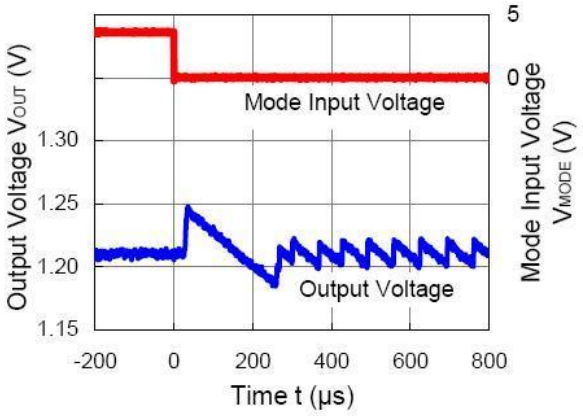


17) Mode Switching Waveform

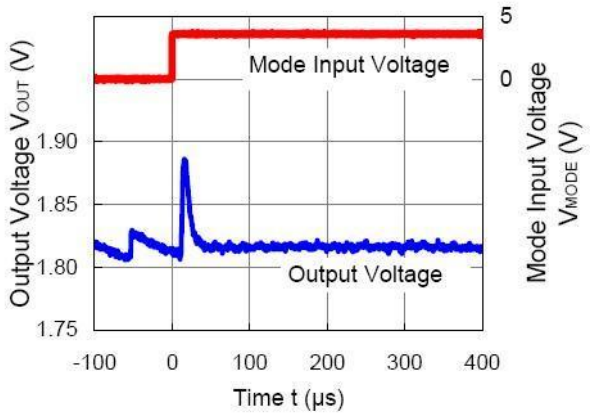
AS3504x (V_{IN}=1.2V, I_{OUT}=1mA)
MODE="L" --> MODE="H"



AS3504x (V_{IN}=1.2V, I_{OUT}=1mA)
MODE="H" --> MODE="L"



AS3504x (V_{IN}=1.8V, I_{OUT}=1mA)
MODE="L" --> MODE="H"



AS3504x (V_{IN}=1.8V, I_{OUT}=1mA)
MODE="H" --> MODE="L"