Triple DC-DC Converter for AMOLED

General Description

The RT4703 is a triple channels DC-DC converter which is designed to provide the power of AMOLED. It integrates step up and inverting DC-DC converters to provide the positive and negative output voltage required by AMOLED.

For the portable application, board space and efficiency are always major concerns. The high switching frequency of the RT4703 allows the use of low inductance inductor to save the board space. VO1, VO2 and VO3 output voltage can be programmed by external MCU through CTRL pin. The positive output voltage range of VO1 is 4.6V to 5.0V and VO3 is 6.8V to 7.8V. The negative VO2 voltage range is -1.4V to -5.4V. The RT4703 is available in a WL-CSP-20B 1.76x2.06 (BSC) package to achieve optimized solution for PCB space.

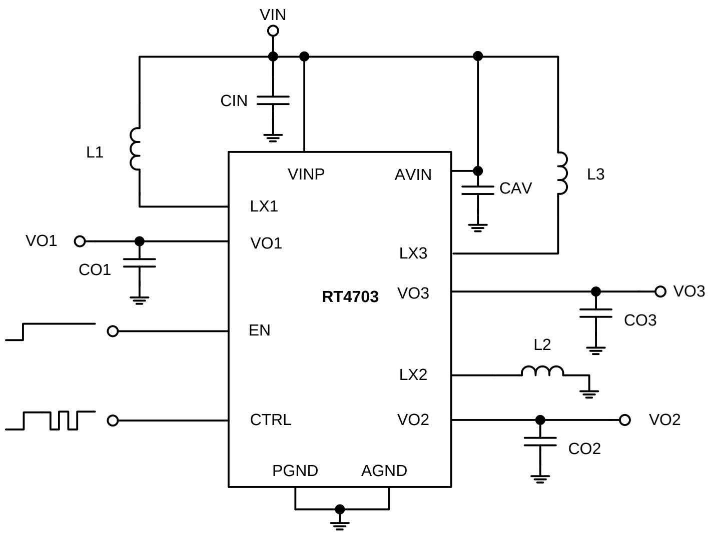
Applications

- AMOLED Panel
- Mobile Phone
- Portable Instrument

Features

- **2.9V to 4.8V Supply Voltage Range**
- **Boost Converter to Supply Positive VO1 (ELVDD) Voltage from 4.6V to 5.0V**
- **Inverting Converter to Supply Negative VO2 (ELVSS) Voltage from –1.4V to –5.4V**
- **Boost Converter to Supply Positive VO3 (AVDD) Voltage from 6.8V to 7.8V**
- **Maximum Output Current up to 455mA for AMOLED Positive & Negative Power Supply**
- **Maximum Output Current up to 150mA for AVDD Output Supply**
- **PWM Mode @1.36MHz Switching Frequency**
- **High Output Voltage Accuracy**
- **Excellent Line and Load Transient**
- **Excellent Line and Load Regulation**
- **Programmable VO2 Transition Time**
- **Programmable Output Discharge / Hi-z Function**
- **Low Quiescent Current < 1μA in Shutdown Mode**
- **UVLO, OCP, SCP, OTP Protection**
- **Available in 20-Ball WL-CSP Package**

Simplified Application Circuit



Ordering Information

RT4703□

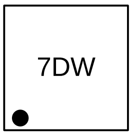
Package Type
WSC : WL-CSP-20B 1.76x2.06 (BSC)

Note :

Richtek products are :

- RoHS compliant and compatible with the current requirements of IPC/JEDEC J-STD-020.
- Suitable for use in SnPb or Pb-free soldering processes.

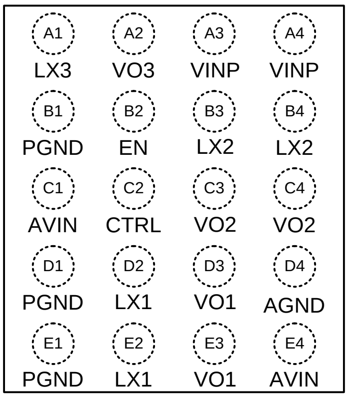
Marking Information



7D : Product Code
W : Date Code

Pin Configuration

(TOP VIEW)

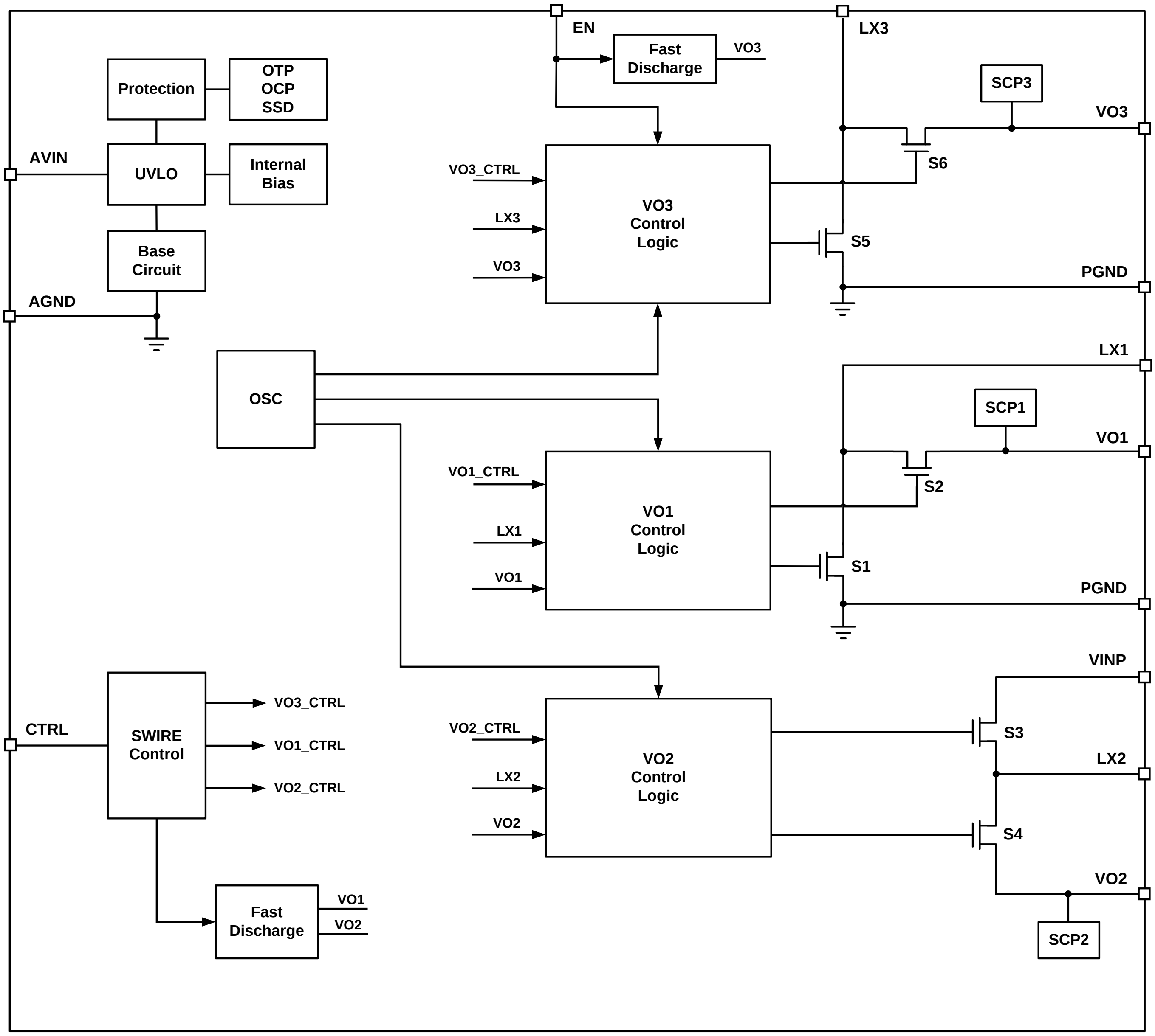


WL-CSP-20B 1.76x2.06 (BSC)

Functional Pin Description

Pin No.	Pin Name	Pin Function
A1	LX3	VO3 boost switching node.
A2	VO3	VO3 (AVDD) output voltage.
A3, A4	VINP	Power input voltage.
B1, D1, E1	PGND	Power ground.
B2	EN	VO3 enable pin.
B3, B4	LX2	VO2 buck-boost switching node.
C1, E4	AVIN	Analog input voltage.
C2	CTRL	Enable VO1 and VO2, programming voltage by SWIRE.
C3, C4	VO2	VO2 (ELVSS) output voltage.
D2, E2	LX1	VO1 boost switching node.
D3, E3	VO1	VO1 (ELVDD) output voltage.
D4	AGND	Analog ground.

Functional Block Diagram



Operation

The RT4703 is a triple channels DC-DC converter which is designed to provide the power of AMOLED that can support the input voltage range from 2.9V to 4.8V. The VO1&VO2 output current can be up to 455mA, and the VO3 output current can be up to 150mA. The VO1 positive output voltage is from the DC-DC boost converter and is programmable from 4.6V to 5.0V. The VO2 negative output voltage is from the DC-DC inverting Buck-Boost converter and the negative output voltage range is –1.4V to –5.4V. The VO3 positive output voltage is from the DC-DC Boost converter and the output voltage range is 6.8V to 7.8V. VO1, VO2 and VO3 can be programmed by external MCU through CTRL pin. The output voltage VO3 will be enabled when EN goes high. When CTRL voltage goes high, VO1 will be enabled with an internal soft-start process first, then VO2 will begin its soft-start process after VO1 is ready.

Absolute Maximum Ratings (Note 1)

- VINP, AVIN, VO1, EN, CTRL, LX1 ---------- –0.3V to 6V
- VO3, LX3 ---------- –0.3V to 10V
- VO2 ---------- –6V to 0.3V
- LX2 ---------- –6V to VINP
- Power Dissipation, P_D @ T_A = 25°C
  WL-CSP-20B 1.76x2.06 ---------- 2.88W
- Package Thermal Resistance (Note 2)
  WL-CSP-20B 1.76x2.06, θ_{JA} ---------- 34.7 °C/W
- Lead Temperature (Soldering, 10 sec.) ---------- 260°C
- Junction Temperature ---------- 150°C
- Storage Temperature Range ---------- –65°C to 150°C
- ESD Susceptibility (Note 3)
  HBM (Human Body Model) ---------- 2kV
  CDM (Charge Device Model) ---------- 500V

Recommended Operating Conditions (Note 4)

- Supply Input Voltage Range ---------- 2.9V to 4.8V
- Ambient Temperature Range ---------- –40°C to 85°C
- Junction Temperature Range ---------- –40°C to 125°C

Electrical Characteristics

(V_{IN} = 3.7V, V_{O1} = 4.6V, V_{O2} = –4.0V, V_{O3} = 7V, C_{IN} = 10μFx3, C_{O1} = 22μF x 3, C_{O2} = 22μF x 2, C_{O3} = 22μF, L1 = L2 = 4.7μH, L3 = 10μH, T_A = 25°C, unless otherwise specified)

Parameter	Symbol	Test Conditions	Min	Typ.	Max	Unit
Power Supply						
Input Voltage Range	V_{IN}		2.9	3.7	4.8	V
Under Voltage Lockout High	UVLO_H	V_{IN} rising	2.35	2.5	2.6	V
Under Voltage Lockout Hysteresis	UVLO_Hyst	V_{IN} hysteresis	---	100	---	mV
Shutdown Current	I_{SHDN}	EN = L, CTRL = L	--	--	1	μA
Logic Threshold Voltage High	V_{IH}		1.2	--	V_{IN}	V
Logic Threshold Voltage Low	V_{IL}		0	--	0.4	V
Operating Section						
Switching Frequency	Freq_12	PWM mode	1.305	1.36	1.415	MHz
	Freq_3		1.305	1.45	1.595	
VO1 Maximum Duty	DMAX_1		--	87	--	%
VO2 Maximum Duty	DMAX_2		--	87	--	%
Over-Temperature Protection	T_{OTP}	(Note 5)	--	140	--	°C

Parameter	Symbol	Test Conditions	Min	Typ.	Max	Unit
Over-Temperature Protection Hysteresis	T_{OTP_HYST}	(Note 5)	--	15	--	°C
VO1 Positive Output						
Positive Output Voltage	V_{O1}		4.6	4.6	5.0	V
Output Voltage Accuracy	V_{O1_ACC}	V_{O1} = 4.6V, no load	–0.8	--	+0.8	%
Maximum Output Current	I_{O1_TYP}		320	--	--	mA
	I_{O1_HBM}	$V_{IN} \geq$ 3.3V, V_{O1} = 4.6V, $V_{O2} \geq$ –5V	450	--	--	
Line Regulation	V_{O1_LINE}	V_{IN} = 2.9 to 4.8V, I_{OP} = 150mA, (Note 5)	--	--	0.01	%/V
Load Regulation	V_{O1_LOAD}	I_{O1} = 1mA to 320mA, (Note 5)	--	--	0.4	%/A
Output Voltage Ripple	V_{O1_RIPPLE}	I_{O1} = 0mA to 100mA, (Note 5)	--	--	Δ10	mV
		I_{O1} = 0mA to 200mA, (Note 5)	--	--	Δ15	mV
Output Voltage Fluctuation	V_{O1_FLUCT}	I_{O1} = 0mA to 320mA, (Note 5)	--	--	Δ5	mV
High-Side MOS On-Resistance	R_{DSON1_H}	ILX1-H = 100mA	--	200	--	mΩ
Low-Side MOS On-Resistance	R_{DSON1_L}	ILX1-L = 100mA	--	200	--	mΩ
Current Limit	I_{OCP1}		1	1.1	1.2	A
Short Circuit Protection Level	SCP1		--	90	--	%
Fast Discharge Resistance	R_{DIS1}	V_{O1} = 0.5V	--	20	--	Ω
High-Z leakage current	I_{O1_leak}	V_{O1} = 4.6V	--	0.1	--	μA
VO2 Negative Output						
Negative Output Voltage	V_{O2}		–5.4	–4	–1.4	V
Output Voltage Accuracy	V_{O2_ACC}	V_{O2} = –1.4V to –5.4V, no load	--	--	±30	mV
Maximum Output Current	I_{O2_TYP}		320	--	--	mA
	I_{O2_HBM}	$V_{IN} \geq$ 3.3V, V_{O1} = 4.6V, $V_{O2} \geq$ –5V	455	--	--	
Line Regulation	V_{O2_LINE}	V_{IN} = 2.9 to 4.8V, I_{O2} = 150mA, (Note 5)	--	--	0.02	%/V
Load Regulation	V_{O2_LOAD}	I_{O2} = 1mA to 320mA, (Note 5)	--	--	0.4	%/A
Output Voltage Ripple	V_{O2_RIPPLE}	I_{O2} = 0mA to 100mA, (Note 5)	--	--	Δ10	mV
		I_{O2} = 0mA to 200mA, (Note 5)	--	--	Δ15	mV
Output Voltage Fluctuation	V_{O2_FLUCT}	I_{O2} = 0mA to 320mA, (Note 5)	--	--	Δ5	mV
High-Side MOS On-Resistance	R_{DSON2_H}	ILX2-H = 100mA	--	165	--	mΩ
Low-Side MOS On-Resistance	R_{DSON2_L}	ILX2-L = 100mA	--	100	--	mΩ
Current Limit	I_{OCP2}		1.9	2	2.1	A
Short Circuit Protection Level	SCP2		--	80	--	%
Fast Discharge Resistance	R_{DIS2}		--	25	--	Ω
High-Z leakage current	I_{O2_leak}	V_{O2} = –4V	--	0.1	--	μA
VO3 Positive Output						
Output Voltage	V_{O3}		6.8	7	7.8	V
Output Voltage Accuracy	V_{O3_ACC}	V_{O3} = 7V, no load	–1	--	1	%
Maximum Output Current	I_{O3_MAX}		150	--	--	mA

Parameter	Symbol	Test Conditions	Min	Typ.	Max	Unit
Line Regulation	V_{O3_LINE}	V_{IN} = 2.9 to 4.8V, I_{O3} = 50mA, (Note 5)	--	--	0.01	%/V
Load Regulation	V_{O3_LOAD}	I_{O3} = 1 to 150mA (Note 5)	--	--	0.4	%/A
Output Voltage Ripple	V_{O3_RIPPLE}	I_{O3} = 0 to 50mA (Note 5)	--	--	Δ10	mV
		I_{O3} = 0 to 100mA (Note 5)	--	--	Δ15	mV
Output Voltage Fluctuation	V_{O3_FLUCT}	I_{O3}= 0 to 150mA (Note 5)	--	--	Δ5	mV
High-side MOS On-Resistance	R_{DSON3_H}	ILX3-H = 100mA	--	700	--	mΩ
Low-side MOS On-Resistance	R_{DSON3_L}	ILX3-L = 100mA	--	370	--	mΩ
Current Limit	I_{OCP3}		0.9	1	1.1	A
Short Circuit Protection Level	SCP3		--	90	--	%
Discharge Resistor Value	R_{DIS_3}	V_{O3} = 0.5V	--	175	--	Ω
Logic Input (CTRL)						
Initial Waiting Time	t_{WAIT_INT}	EN = H	--	200	--	μs
		EN = L	--	600	--	μs
Enable High Delay Time	t_{EN_DLY}		--	10	13	ms
SWIRE Turn-off Detection Time	t_{OFF_DLY}		50	--	90	μs
SWIRE High	t_{ON}		2	10	20	μs
SWIRE Low	t_{OFF}		2	10	20	μs
SWIRE signal stop	t_{STOP}		100	--	--	μs
Input High Threshold Voltage	V_{IH_CTRL}		1.2	--	VIN	V
Input Low Threshold Voltage	V_{IL_CTRL}		0	--	0.4	V
Pull Down Resistor	R_{CTRL}		--	150	--	kΩ
Wake up delay	t_{wkp}		--	--	1	μs
SWIRE Rising Time	t_R		--	--	200	ns
SWIRE Falling Time	t_F		--	--	200	ns

Note 1. Stresses beyond those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions may affect device reliability.

Note 2. θ_{JA} is measured under natural convection (still air) at T_A = 25°C with the component mounted on a high effective-thermal-conductivity four-layer test board on a JEDEC 51-7 thermal measurement standard. θ_{JC} is measured at the exposed pad of the package.

Note 3. Devices are ESD sensitive. Handling precaution is recommended.

Note 4. The device is not guaranteed to function outside its operating conditions.

Note 5. Spec. is guaranteed by design.

Typical Application Circuit

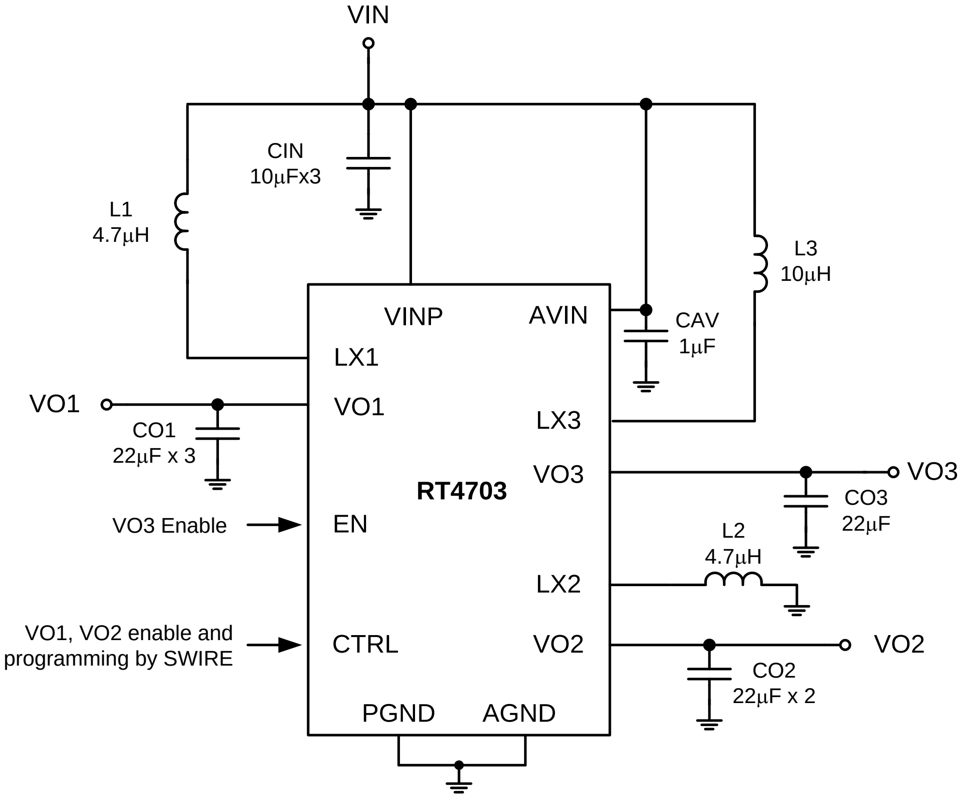
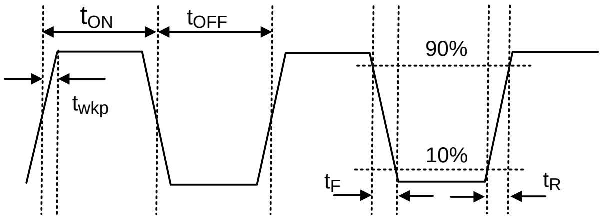


Table 1. Component List of Evaluation Board

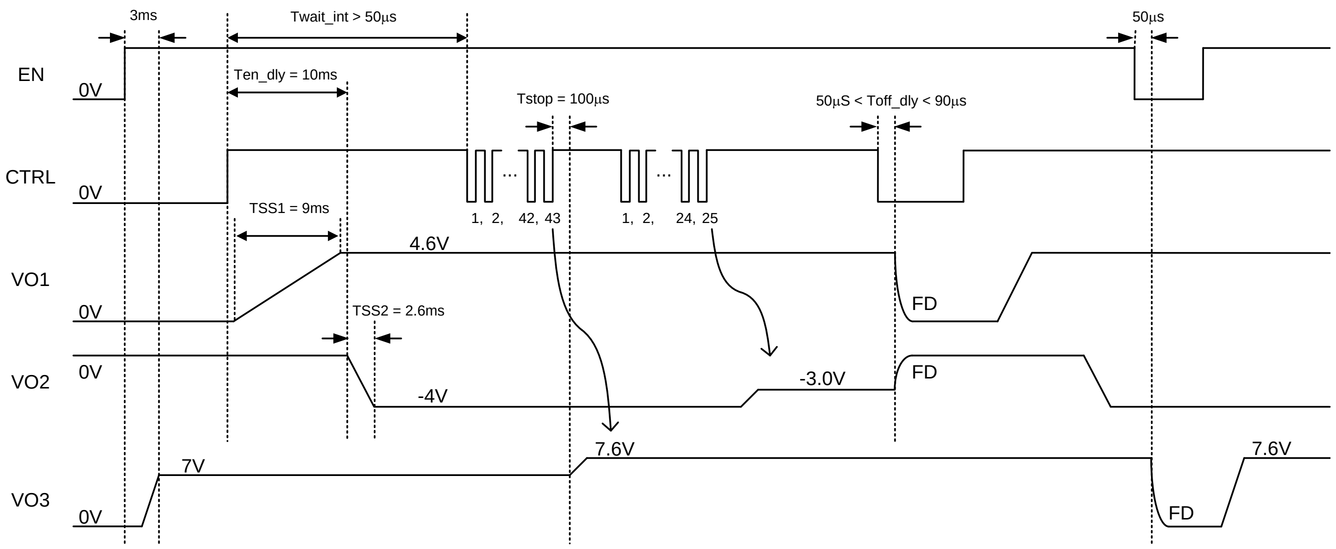
<table>
<tr><th>Reference</th><th>Qty.</th><th>Part Number</th><th>Description</th><th>Package</th><th>Supplier</th></tr>
<tr><td>CIN</td><td>3</td><td>CL10A106MQ8NNNC</td><td>10μF/6.3V/X5R</td><td>1.6 x 0.8 x 0.8mm</td><td>SEMCO</td></tr>
<tr><td>CAV</td><td>1</td><td>C1608X5R1E105K080AC</td><td>1μF/25V/X5R</td><td>1.6 x 0.8 x 0.8mm</td><td>TDK</td></tr>
<tr><td>CO1</td><td>3</td><td rowspan="2">CL10A226MP8NUNE</td><td rowspan="4">22μF/10V/X5R</td><td rowspan="4">1.6 x 0.8 x 0.8mm</td><td rowspan="2">SEMCO</td></tr>
<tr><td rowspan="2">CO2</td><td rowspan="2">2</td></tr>
<tr><td rowspan="2">GRM187R61A226ME15</td><td rowspan="2">muRata</td></tr>
<tr><td>CO3</td><td>1</td></tr>
<tr><td rowspan="2">L1</td><td rowspan="2">1</td><td>DFE252010F-4R7M=P2</td><td rowspan="2">4.7μH</td><td rowspan="2">2.5 x 2.0 x 1.0mm</td><td>muRata</td></tr>
<tr><td>GLULK4R701A</td><td>ALPS</td></tr>
<tr><td>L2</td><td>1</td><td>DFE322512F-4R7M</td><td>4.7μH</td><td>3.2 x 2.5 x 1.2mm</td><td>muRata</td></tr>
<tr><td>L3</td><td>1</td><td>DFE252010F-100M=P2</td><td>10μH</td><td>2.5 x 2.0 x 1.0mm</td><td>muRata</td></tr>
</table>

Time Diagram

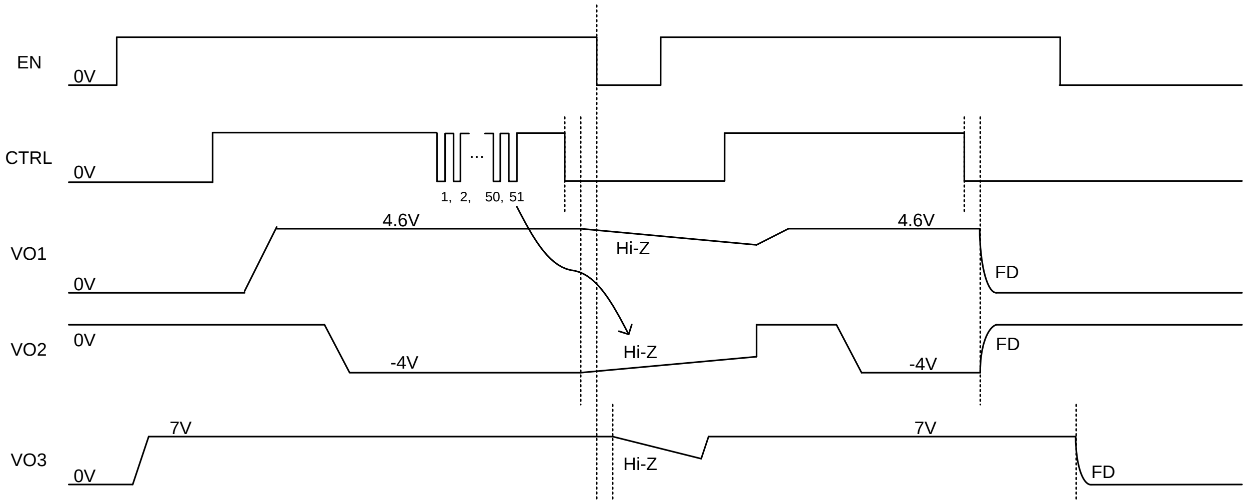
CTRL (SWIRE) Interface



Power Sequence

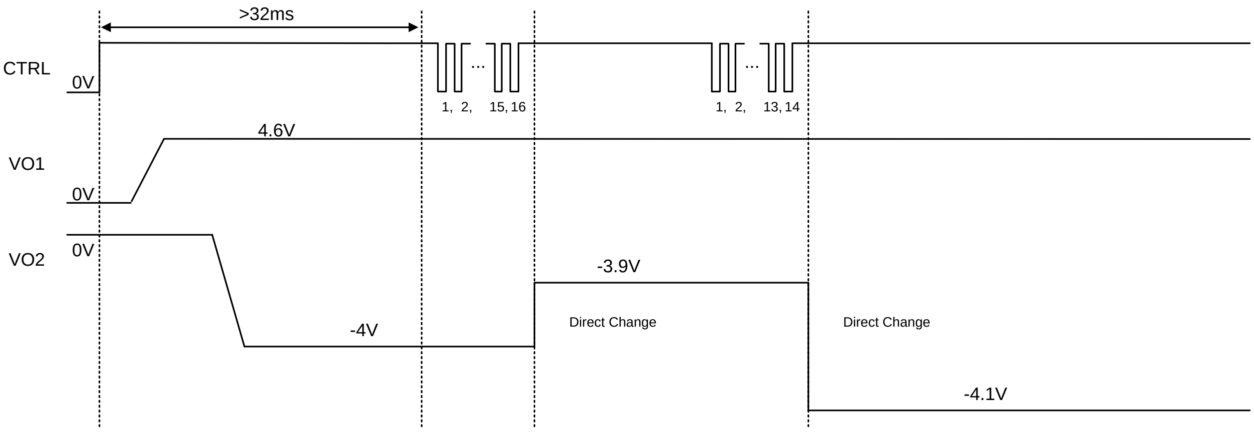


Fast Discharge (FD ON) & Hi-Z (FD OFF)

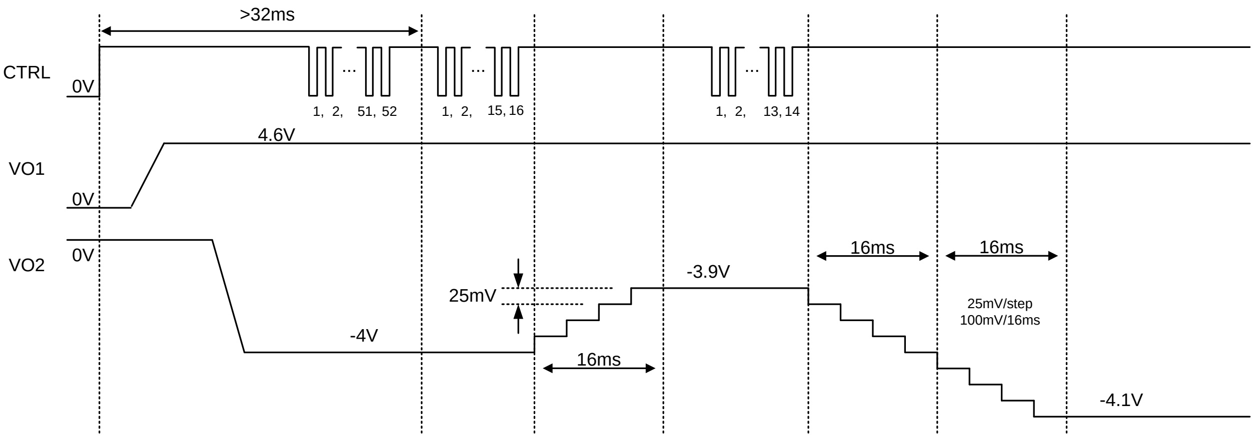


Control of VO2 transition Time (CT)

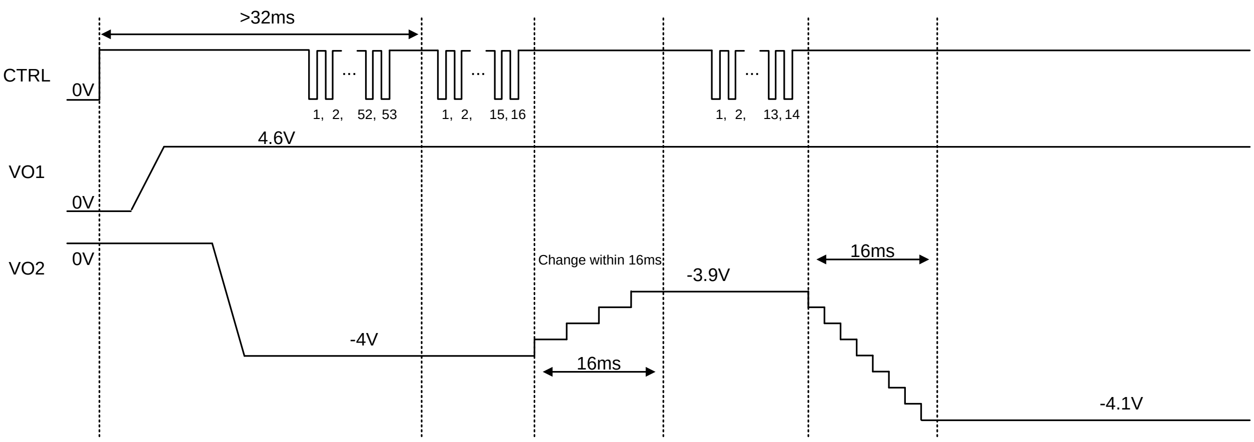
CTRL = 0 / No pulse CT = Direct Change



CTRL = 52 pulses CT = 25mV/step, 100mV/16ms

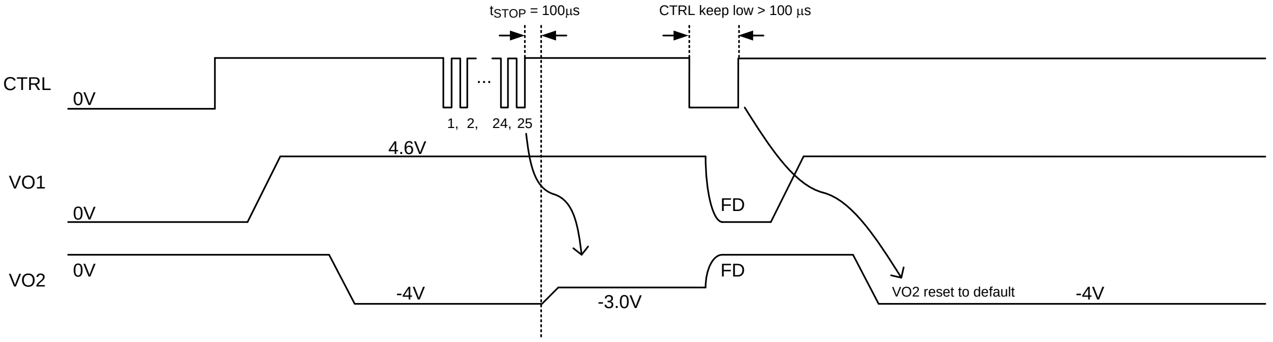


CTRL = 53 pulses CT = Change within 16ms

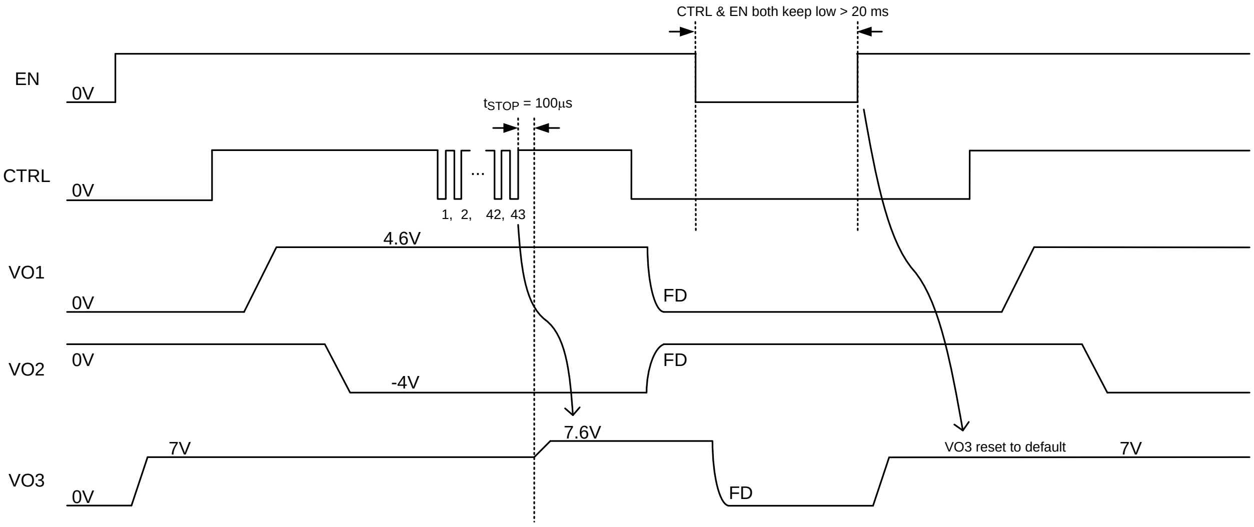


Reset CTRL setting to default

Reset VO1, VO2 voltage and VO2 transition time (CT) setting after CTRL keep low more than 100μs.



Reset VO3 voltage setting after CTRL and EN both keep low over 20ms.



Reset FD and slew rate setting on the rising edge of CTRL

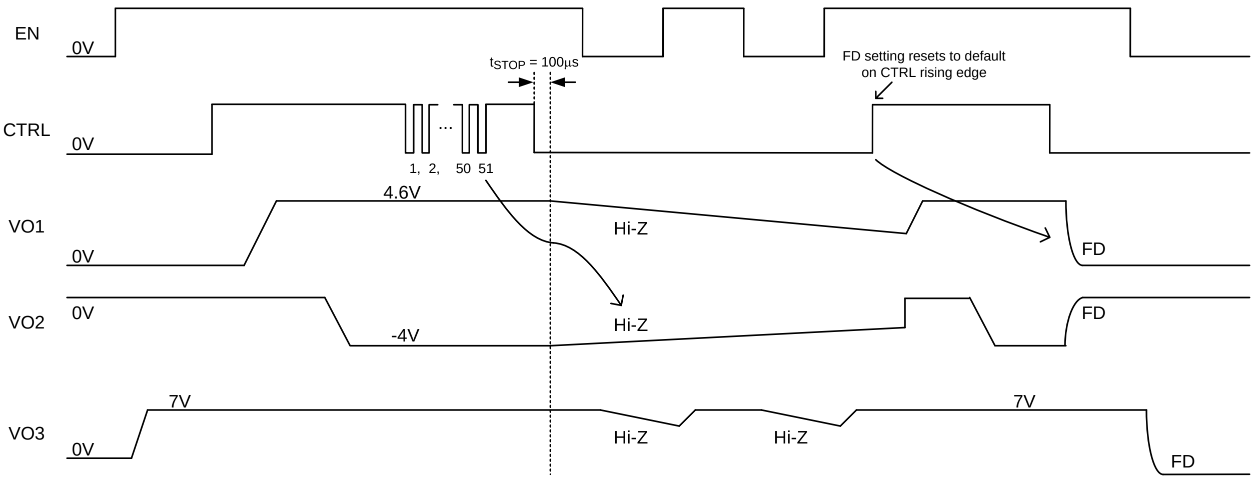
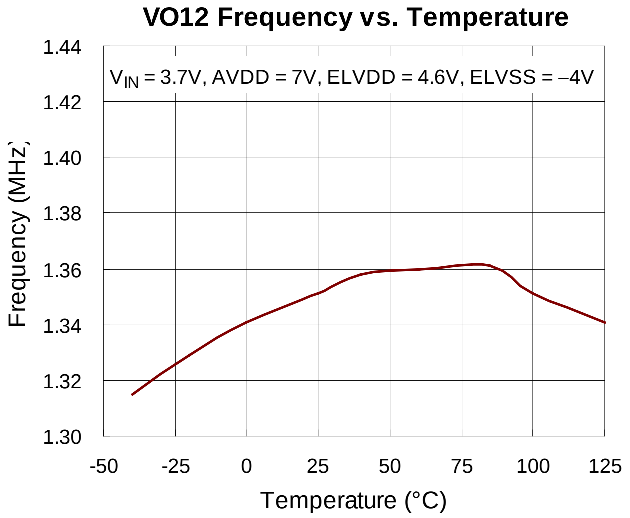
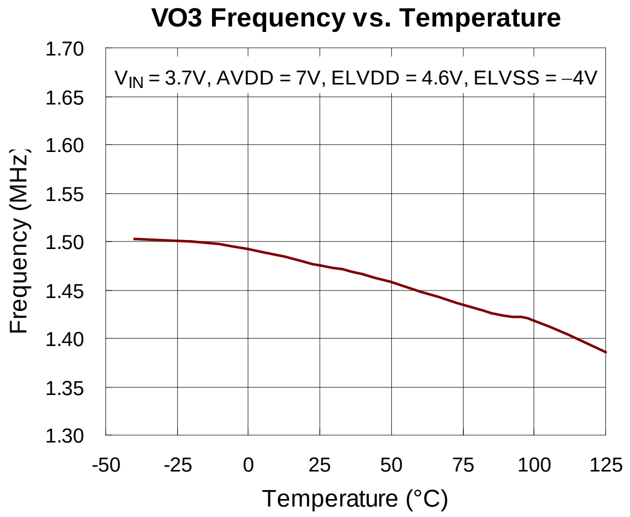


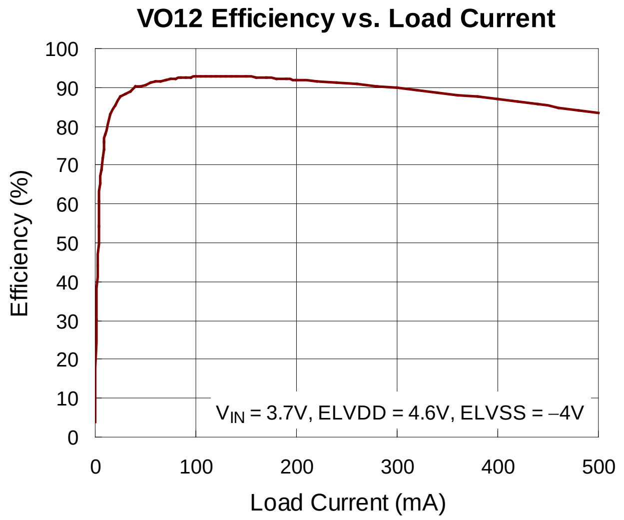
Table 2. Selection Table with CTRL (SWIRE) Pulse

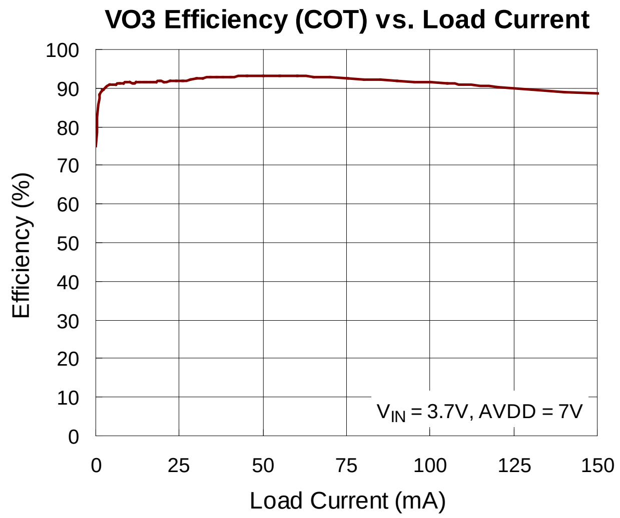
CTRL Pulse	VO2	CTRL Pulse	VO3
0 / Default	**-4.0 V**	**0 / Default**	**7.0 V**
1	-5.4 V	42	7.8 V
2	-5.3 V	43	7.6 V
3	-5.2 V	44	7.5 V
4	-5.1 V	45	7.4 V
5	-5.0 V	46	7.3 V
6	-4.9 V	47	7.2 V
7	-4.8 V	48	7.0 V
8	-4.7 V	49	6.8 V
9	-4.6 V	**CTRL Pulse**	**FD**
10	-4.5 V	**0 / Default**	**ON**
11	-4.4 V	50	ON
12	-4.3 V	51	OFF
13	-4.2 V	**CTRL Pulse**	**CT**
14	-4.1 V	**0 / Default**	**Direct Change**
15	-4.0 V	52	25mV/step
16	-3.9 V	53	Change in 16ms
17	-3.8 V	**CTRL Pulse**	**VO1**
18	-3.7 V	**0 / Default**	**4.6 V**
19	-3.6 V	54	4.7 V
20	-3.5 V	55	4.8 V
21	-3.4 V	56	4.9 V
22	-3.3 V	57	5.0 V
23	-3.2 V	**CTRL Pulse**	
24	-3.1 V	58	Reserve
25	-3.0 V	59	Reserve
26	-2.9 V	**CTRL Pulse**	**LX3 Slew Rate**
27	-2.8 V	60 / Default	4.7 V/ns
28	-2.7 V	61	4.2 V/ns
29	-2.6 V	62	3.7 V/ns
30	-2.5 V	63	3.2 V/ns
31	-2.4 V	**CTRL Pulse**	**LX1 Slew Rate**
32	-2.3 V	64 / Default	2.8 V/ns
33	-2.2 V	65	2.5 V/ns
34	-2.1 V	66	2.2 V/ns
35	-2.0 V	67	1.9 V/ns
36	-1.9 V	**CTRL Pulse**	**LX2 Slew Rate**
37	-1.8 V	68 / Default	4.0 V/ns
38	-1.7 V	69	3.5 V/ns
39	-1.6 V	70	3.0 V/ns
40	-1.5 V	71	2.5 V/ns
41	-1.4 V	--	--
		--	--
		--	--
		--	--
		--	--

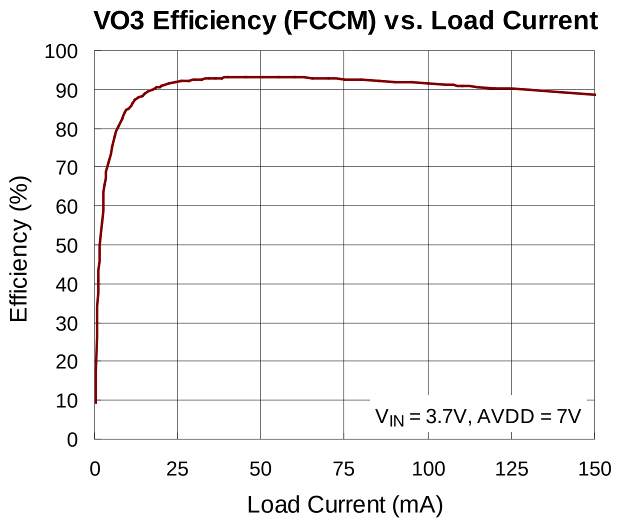
Typical Operating Characteristics

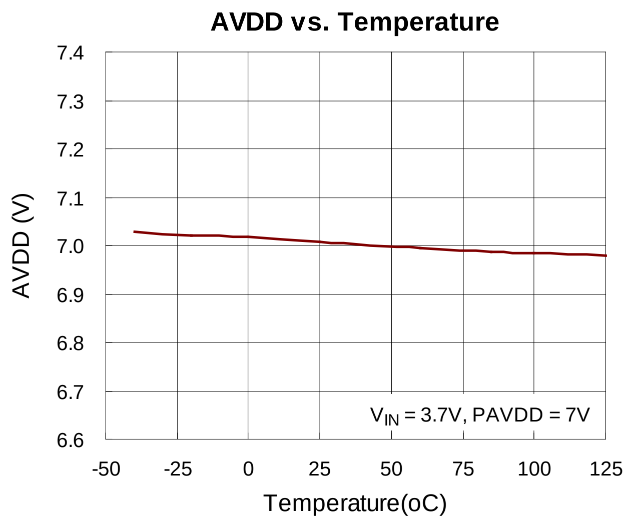


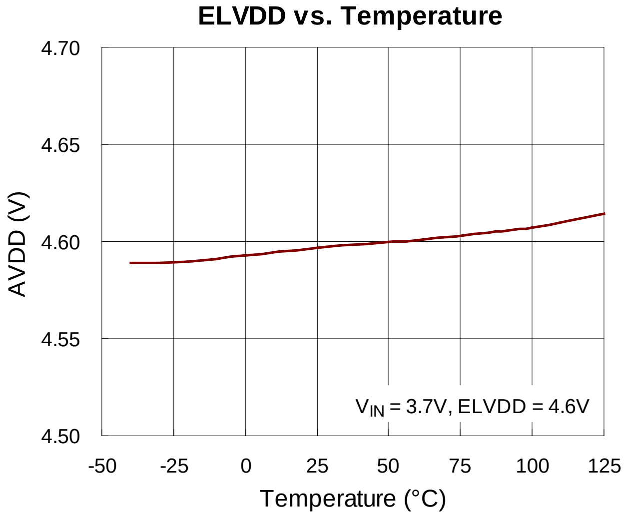


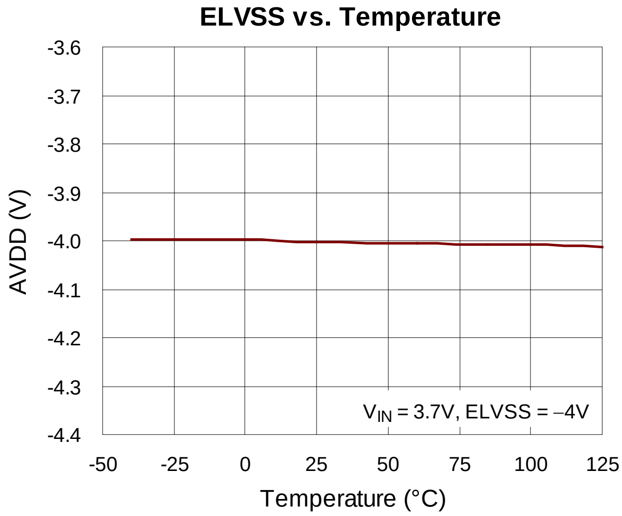


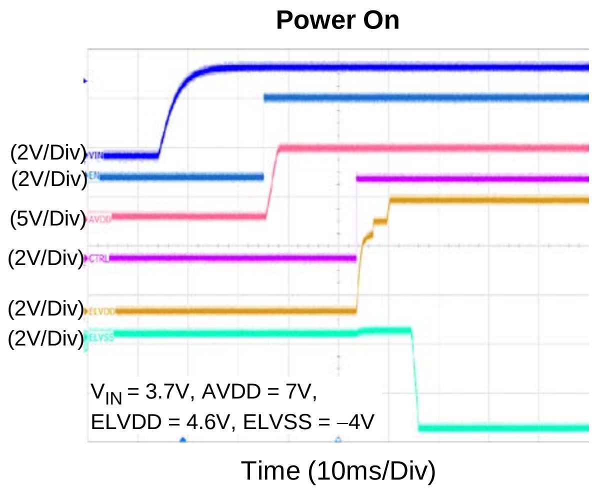


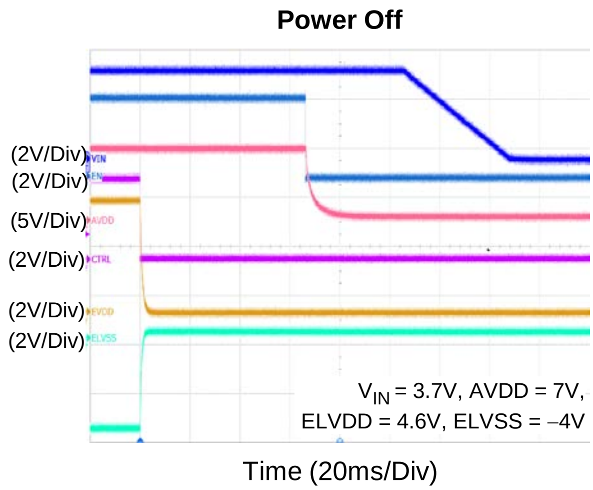





ELVDD vs. Temperature
AVDD (V)
4.70
4.65
4.60
4.55
4.50
-50 -25 0 25 50 75 100 125
V_{IN} = 3.7V, ELVDD = 4.6V
Temperature (°C)


ELVSS vs. Temperature
AVDD (V)
-3.6
-3.7
-3.8
-3.9
-4.0
-4.1
-4.2
-4.3
-4.4
-50 -25 0 25 50 75 100 125
V_{IN} = 3.7V, ELVSS = –4V
Temperature (°C)


Power On
(2V/Div)
(2V/Div)
(5V/Div)
(2V/Div)
(2V/Div)
(2V/Div)
V_{IN} = 3.7V, AVDD = 7V,
ELVDD = 4.6V, ELVSS = –4V
Time (10ms/Div)


Power Off
(2V/Div)
(2V/Div)
(5V/Div)
(2V/Div)
(2V/Div)
(2V/Div)
V_{IN} = 3.7V, AVDD = 7V,
ELVDD = 4.6V, ELVSS = –4V
Time (20ms/Div)

Application Information

The RT4703 is a triple channels DC-DC converter, which integrates dual step up converter and an inverting converter to provide the positive and negative output voltage required by AMOLED. The positive (VO1), negative (VO2) and positive (VO3) voltage can be programmed by external MCU through single wire protocol (CTRL pin). The RT4703 protection function includes Over Temperature Protection (OTP), Over Current Protection (OCP) and Short Circuit Protection (SCP).

Under Voltage Lockout (UVLO)

To prevent abnormal operation of the IC in low input voltage condition, an under voltage lockout is included, which shuts down the device at voltage lower than 2.4V. All functions will be turned off in this state.

Soft-Start

The RT4703 employs an internal soft-start feature to avoid high inrush currents during start-up.

Fast Discharge Function

VO1, VO2 and VO3 use an embedded discharge function to discharge the remaining output voltage to 0V rapidly, preventing phenomena such as residual image on the display during shutdown.

Over Temperature Protection (OTP)

The RT4703 includes an Over Temperature Protection (OTP) feature to prevent excessive power dissipation from overheating the device. The OTP will shut down switching operation when junction temperature exceeds 140°C, Once the junction temperature cools down by approximately 15°C, the converter resumes operation.

To maintain continuous operation, prevent the maximum junction temperature from rising above 125°C.

Over Current Protection (OCP)

The RT4703 includes a current sensing circuitry which monitors the inductor current during each ON period. If the current value becomes greater than the current limit, the switch that pertains to inductor charging will turn off, forcing the inductor to stop charging state and begin to discharge.

Short Circuit Protection (SCP)

The RT4703 has an advanced short circuit protection mechanism which prevents damage the device from unexpected applications. When the output becomes shorted to ground over 1ms, the device is in shutdown mode. VO1, VO2 can only re-start normal operation after triggering the CTRL pin. VO3 can only re-start after triggering the EN pin.

Star-Up Short Detection (SSD)

The RT4703 has a star-up short detection mechanism which detects the condition of AMOLED panel. If the VO1 and VO2 is in low resistance at start-up period, then VO1 and VO2 will be shut down.

Input Capacitor Selection

Each channels input ceramic capacitors with 10μF capacitance are suggested. However, to achieve best performance with the RT4703, larger capacitance can be used. For better voltage filtering, select ceramic capacitors with low ESR, X5R and X7R types which are suitable because of their performance in wider voltage and temperature ranges.

Boost Inductor Selection

The inductance depends on the maximum input current. As a general rule, the inductor ripple current range is 20% to 40% of the maximum input current. If 40% is selected as an example, the inductor ripple current can be calculated according to the following equations :

$$I_{IN(MAX)} = \frac{V_{OUT} \times I_{OUT(MAX)}}{\eta \times V_{IN}}$$

$$\Delta I_L = 0.4 \times I_{IN(MAX)}$$

Where η is the efficiency of the boost converter, $I_{IN(MAX)}$ is the maximum input current, and ΔI_L is the inductor ripple current. The input peak current then can be obtained by adding the maximum input current with half of the inductor ripple current as shown in the following equation :

$$I_{PEAK} = 1.2 \times I_{IN(MAX)}$$

Note that the saturated current of the inductor must be greater than I_{PEAK}.

The inductance can eventually be determined according to the following equation:

$$L = \frac{\eta \times (V_{IN})^2 \times (V_{OUT} - V_{IN})}{0.4 \times (V_{OUT})^2 \times I_{OUT(MAX)} \times f_{OSC}}$$

where f_{OSC} is the switching frequency. For better system performance, a shielded inductor is preferred to avoid EMI problems.

Boost Output Capacitor Selection

The output ripple voltage is an important index for estimating IC performance. This portion consists of two parts. One is the product of ripple current with the ESR of the output capacitor, while the other part is formed by the charging and discharging process of the output capacitor. As shown in Figure 1, ΔV_{OUT1} can be evaluated based on the ideal energy equalization. According to the definition of Q, the ΔV_{OUT1} value can be calculated as the following equation :

$$Q = I_{OUT} \times D \times \frac{1}{f_{SOC}} = C_{OUT} \times \Delta V_{OUT1}$$

$$\Delta V_{OUT1} = \frac{I_{OUT} \times D}{f_{SOC} \times C_{OUT}}$$

where f_{OSC} is the switching frequency and D is the duty cycle.

Finally, taking ESR into consideration, the overall output ripple voltage can be determined by the following equation :

$$\Delta V_{OUT} = \Delta V_{ESR} + \Delta V_{OUT1} = \Delta V_{ESR} + \frac{I_{OUT} \times D}{f_{OSC} \times C_{OUT}}$$

where $\Delta V_{ESR} = I_{Crms} \times R_{CESR}$

The output capacitor, C_{OUT}, should be selected accordingly.

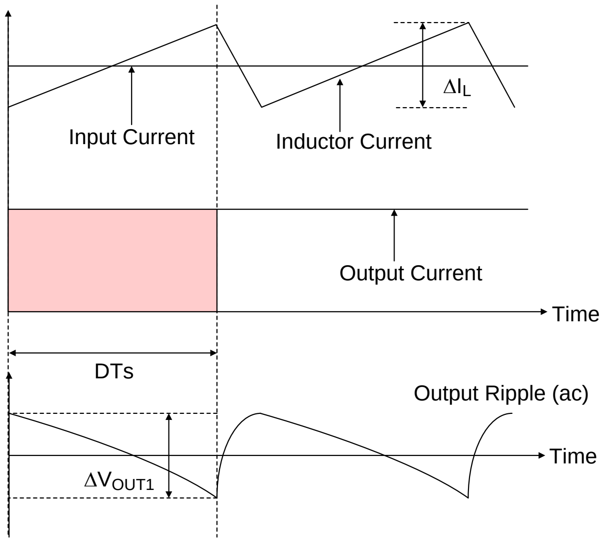


Figure 1. Output Ripple Voltage without ESR

Buck-boost Inductor Selection

The first step in design procedure is to verify whether the maximum possible output current of the buck-boost converter supports the specific application requirements. To simplify the calculation, the fastest approach is to estimate converter efficiency by taking the efficiency numbers from provided efficiency curves or to use a worst case assumption for the expected efficiency, e.g., 80%. The calculation must be performed for the minimum assumed input voltage where the peak switch current is the highest. The inductor and internal switch has to be able to handle this current.

- Converter Duty Cycle :

$$D = \frac{-V_{OUT}}{V_{IN} \times \eta - V_{OUT}}$$

- Maximum output current :

$$I_{OUT} = \left(I_{PEAK} - \frac{V_{IN} \times D}{2 \times f_{OSC} \times L} \right) \times (1-D)$$

- Inductor peak current :

$$I_{PEAK} = \frac{I_{OUT}}{1-D} + \frac{V_{IN} \times D}{2 \times f_{OSC} \times L}$$

As for inductance, we are going to derive the transition point, where the converter toggles from CCM to DCM. We need to define the point at which the inductor current ripple touches zero, and as the power switch SW is immediately reactivated, the current ramps up again. Figure 2 portrays the input current activity of the buck-boost converter.

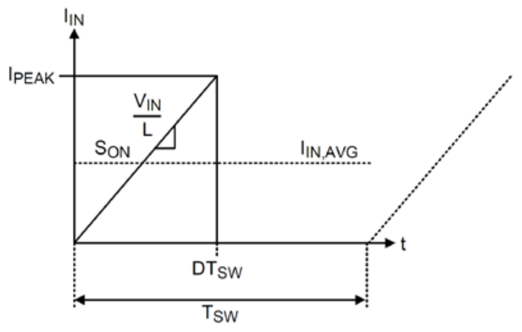


Figure 2. The Buck-Boost Input Signature in BCM

The inductance can eventually be determined according to the following equation :

$$L_{critical} = \frac{|V_{OUT}| \times \eta}{2 \times f_{OSC} \times I_{OUT}} \times \left(\frac{V_{IN}}{V_{IN} + |V_{OUT}|}\right)^2$$

Buck-Boost Output Capacitor Selection

For the best output voltage filtering, low ESR ceramic capacitors are recommended. Output capacitors with sufficient capacitors with sufficient voltage ratings is for adequate for most applications. Additional capacitors can be added to improve load transient response.

To calculate the output voltage ripple, the following equations can be used:

$$\Delta V = \frac{D \times |V_{OUT}|}{f_{OSC} \times R_{LOAD} \times C_{OUT}} + \Delta V_{ESR}$$

where $\Delta V_{ESR} = \Delta I_C \times R_{C\_ESR} = I_{PEAK} \times R_{C\_ESR}$

ΔV_{ESR} can be neglected in many cases since ceramic capacitors provides very low ESR.

Thermal Considerations

The junction temperature should never exceed the absolute maximum junction temperature $T_{J(MAX)}$, listed under Absolute Maximum Ratings, to avoid permanent damage to the device. The maximum allowable power dissipation depends on the thermal resistance of the IC package, the PCB layout, the rate of surrounding airflow, and the difference between the junction and ambient temperatures. The maximum power dissipation can be calculated using the following formula:

$P_{D(MAX)} = (T_{J(MAX)} - T_A) / \theta_{JA}$

where $T_{J(MAX)}$ is the maximum junction temperature, T_A is the ambient temperature, and θ_{JA} is the junction-to-ambient thermal resistance.

For continuous operation, the maximum operating junction temperature indicated under Recommended Operating Conditions is 125°C. The junction-to-ambient thermal resistance, θ_{JA}, is highly package dependent. For a WL-CSP-20B 1.76x2.06 package, the thermal resistance, θ_{JA}, is 34.7°C/W on a standard JEDEC 51-7 high effective-thermal-conductivity four-layer test board. The maximum power dissipation at T_A = 25°C can be calculated as below :

$P_{D(MAX)}$ = (125°C − 25°C) / (34.7°C/W) = 2.88W for a WL-CSP-20B 1.76x2.06 package.

The maximum power dissipation depends on the operating ambient temperature for the fixed $T_{J(MAX)}$ and the thermal resistance, θ_{JA}. The derating curves in Figure 3 allows the designer to see the effect of rising ambient temperature on the maximum power dissipation.

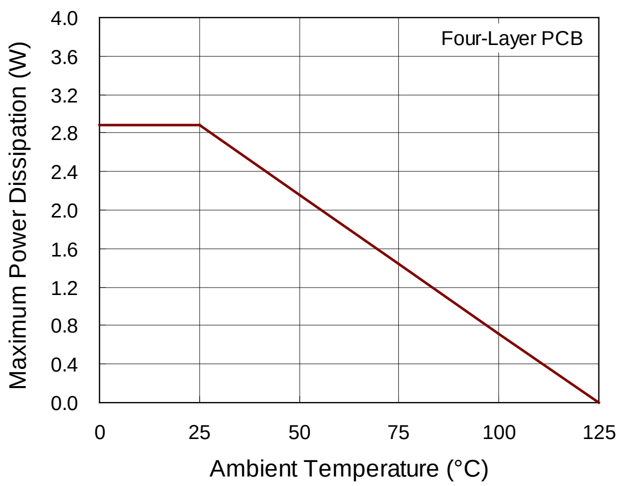


Figure 3. Derating Curve of Maximum Power Dissipation

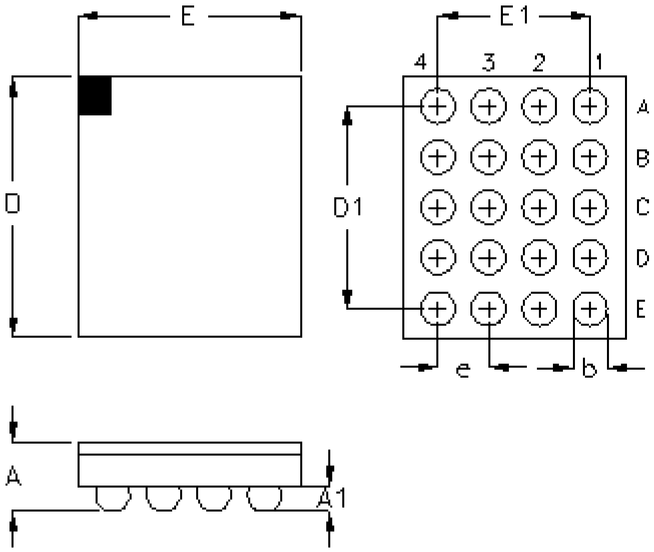
Layout Consideration

For the best performance of the RT4703, the following PCB layout guidelines should be strictly followed.

- For good regulation, place the power components as close to the IC as possible. The traces should be wide and short, especially for the high current output loop.

- The input and output bypass capacitor should be placed as close to the IC as possible and connected to the ground plane of the PCB.
- Minimize the size of the LX1, LX2, LX3 nodes and keep the traces wide and short. Care should be taken to avoid running traces that carry any noise-sensitive signals near LX or high-current traces.
- Separate power ground (PGND) and analog ground (AGND). Connect the AGND and the PGND islands at a single end. Make sure that there are no other connections between these separate ground planes.
- Connect the exposed pad to a strong ground plane for maximum thermal dissipation.

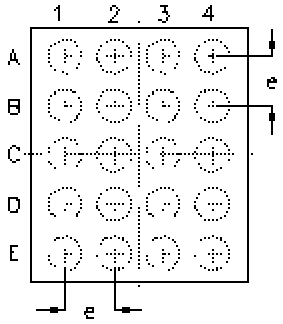
Outline Dimension

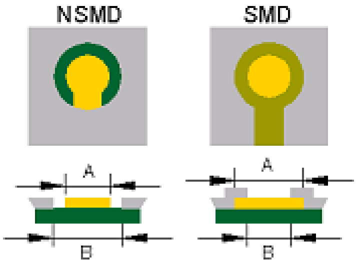


Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	0.500	0.600	0.020	0.024
A1	0.170	0.230	0.007	0.009
b	0.240	0.300	0.009	0.012
D	2.020	2.100	0.080	0.083
D1	1.600		0.063	
E	1.720	1.800	0.068	0.071
E1	1.200		0.047	
e	0.400		0.016	
UBM	0.240		0.009	

WL-CSP-20B 1.76x2.06 (BSC)

Footprint Information





Package	Number of Pin	Type	Footprint Dimension (mm)			Tolerance
			e	A	B	
WL-CSP1.76x2.06-20(BSC)	20	NSMD	0.400	0.240	0.340	±0.025
		SMD		0.270	0.240	

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