FR9209

16V, 12A Synchronous Step-Down DC/DC Converter with Adjustable Current Limit, Programmable Frequency and Voltage Tracking

Description

The FR9209 is a synchronous step-down DC/DC converter with capacitor-current-sense constant on time (CCS-COT) mode control. The device provides 12A continuous load current capability. Adjustable switching frequency, 600kHz, 800kHz, or 1000kHz, the FR9209 provides both forced CCM or pulse skip mode to support high efficiency and reduce power loss.

The FR9209 fault protection includes cycle-by-cycle current limit, short circuit protection, UVLO, thermal shutdown, programmable soft-start function prevents inrush current at turn-on and internal power good function indicates the output is within its nominal voltage range.

The FR9209 use CCS constant on time control that provides fast transient response, the noise immunity and all kinds of very low ESR output capacitor for ensuring performance stabilization.

The FR9209 is offered in TQFN-21 (3mm×4mm) package, which provides good thermal conductance.

Features

- Low $R_{DS(ON)}$ Integrated Power MOSFET (15mΩ/5.5mΩ)
- Wide Input Voltage Range:
- 2.7V to 16V with External 5V VCC Bias
- 6 V to 16V with Internal Bias or External 5V VCC Bias
- Output Voltage Range: 0.6V to 5.5V
- Differential Output Voltage Remote Sense
- 12A Output Current
- CCS-COT Mode Enables Fast Transient Response
- Selectable Switching Frequency from 600kHz, 800kHz, and 1000kHz
- Input Under Voltage Lockout
- PGOOD Active Clamped Low Level during Power Failure
- Selectable Pulse Skip or Forced PWM Operation
- Programmable Soft-Start Time from 1ms
- Programmable Accurate Current Limit Level
- Hiccup Short Circuit Protection
- Over Temperature Protection with Auto Recovery
- Output Voltage Discharge
- Output Voltage Tracking
- Available in a TQFN-21 (3mm×4mm) Package

Pin Assignments

J16 Package: TQFN-21 (3mm×4mm)

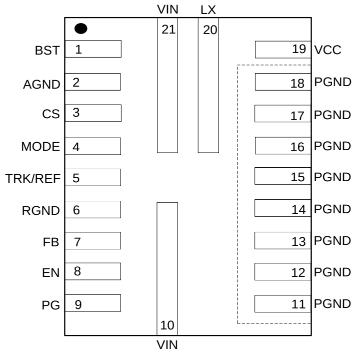


Figure 1. Pin Assignments of FR9209

Applications

- Telecom and Networking Systems
- Server, Cloud-Computing, Storage
- General Purpose Point-of-Load (POL)
- LCD Display, TV
- Distributed Power System
- Networking, XDSL Modem

Ordering Information

FR9209□

Package Type
J16: TQFN-21 (3mm×4mm)

Typical Application Circuit

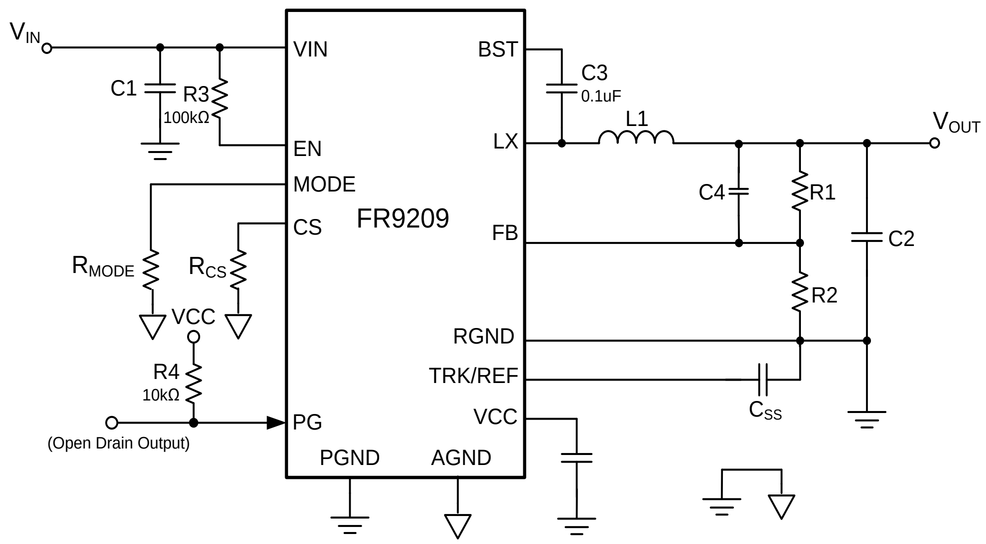


Figure 2. FR9209 Application Circuit

V_{IN}=12V, the recommended BOM list is as below.

V_{OUT}	C1	R1	R2	C4 (Note 1)	L1	C2
1.0V	220uF E-CAP + 10μF MLCCx3 + 1μF MLCCx2	6.81kΩ	10kΩ	10pF~100pF	0.56μH	47μF MLCC x6
1.2V	220uF E-CAP + 10μF MLCCx3 + 1μF MLCCx2	10kΩ	10kΩ	10pF~100pF	0.56μH	47μF MLCC x6
1.5V	220uF E-CAP + 10μF MLCCx3 + 1μF MLCCx2	15kΩ	10kΩ	10pF~100pF	0.56μH	47μF MLCC x6
1.8V	220uF E-CAP + 10μF MLCCx3 + 1μF MLCCx2	20kΩ	10kΩ	10pF~100pF	0.56μH	47μF MLCC x6
2.5V	220uF E-CAP + 10μF MLCCx3 + 1μF MLCCx2	32.4kΩ	10kΩ	0.1nF~0.5nF	1.5μH	47μF MLCC x6
3.3V	220uF E-CAP + 10μF MLCCx3 + 1μF MLCCx2	45.3kΩ	10kΩ	0.1nF~0.5nF	1.5μH	47μF MLCC x6
5.0V	220uF E-CAP + 10μF MLCCx3 + 1μF MLCCx2	73.2kΩ	10kΩ	0.1nF~0.5nF	2.2μH	47μF MLCC x6

Table 1. Recommended Component Values

Note 1: It can be fine-tuned according to different application conditions, for example PCB layout, C2 and R1.

Functional Pin Description

Pin Name	Pin No.	Pin Function
BST	**1**	High side gate drive boost pin. A capacitance between 100nF to 1μF must be connected from this pin to LX. It can boost the gate drive to fully turn on the internal high side NMOS.
AGND	**2**	Analog Ground. Connect AGND as the internal control circuit reference point.
CS	**3**	Current limit. Connect a resistor from CS to AGND to set the current limit trigger point
MODE	**4**	Operating mode selection. Connecting a resistor from MODE to AGND sets the FCCM or Skip mode operating and the switching frequency.
TRK/REF	**5**	External tracking voltage input. The output voltage tracks this input signal. Decouple with a ceramic capacitor as close to TRK/REF as possible. X7R or X5R grade dielectric ceramic capacitors are recommended for their stable temperature characteristics. It also selects the soft-start period.
RGND	**6**	Differential remote sense negative input. Connect this pin directly to the negative side of the voltage sense point. Short to GND if remote sense is not used.
FB	**7**	Voltage feedback input pin. Connect FB and VOUT with a resistive voltage divider. This IC senses feedback voltage via FB and regulates it at 0.6V.
EN	**8**	Enable input pin. Pull high to turn on IC, and pull low to turn off IC. Connect VIN with a 100kΩ resistor for self-startup.
PG	**9**	Power Good indicator. Open drain output when the output voltage is within 90% to 120% of regulator point.
VIN	**10,21**	Power supply input pin. Placed input capacitors as close as possible from VIN to GND to avoid noise influence.
PGND	**11-18**	Power ground. Connect internal Low-Side MOSFET. PGND is the reference ground of the regulated output voltage.
VCC	**19**	Internal 5.0V LDO output. A capacitor (typ.1μF) should be connected to PGND. Do not connect to external load.
LX	**20**	Power switching node. Connect an external inductor to this switching node.

Block Diagram

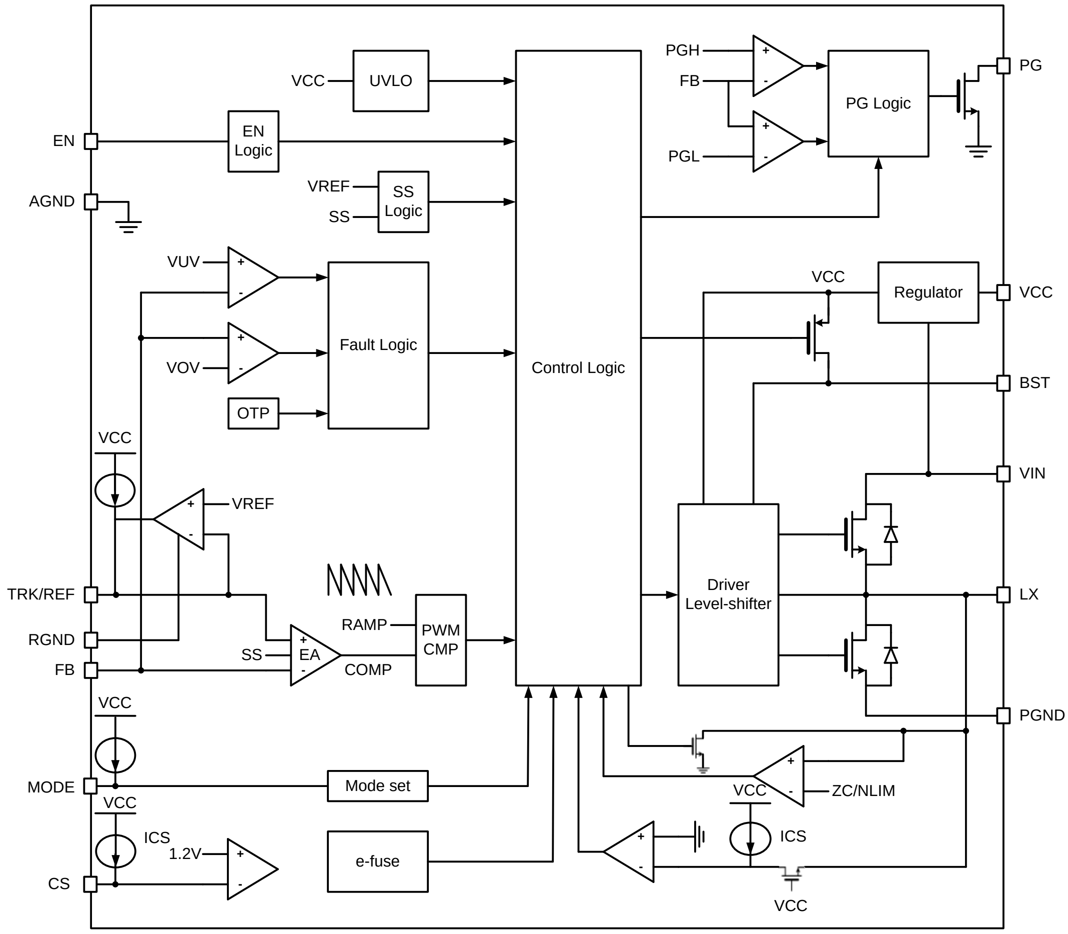


Figure 3. Block Diagram of FR9209

Absolute Maximum Ratings (Note 2)

- Supply Voltage V_{IN} -- -0.3V to +18V
- Enable Voltage $V_{\overline{SHDN}}$ -- -0.3V to +18V
- LX Voltage V_{LX} -- -0.3V to V_{IN} +0.3V
- Dynamic LX Voltage in 15nS Duration--- -5V to +23V
- BST Pin Voltage V_{BST} -- -0.3V to V_{LX} +6.5V
- All Other Pins Voltage -- -0.3V to +6V
- Maximum Junction Temperature (T_J) -- +150°C
- Storage Temperature (T_S) --- -65°C to +150°C
- Lead Temperature (Soldering, 10sec.) -- +260°C
- Package Thermal Resistance, (θ_{JA}) (Note 3)

  TQFN-21 (3mm×4mm) -- TBD°C/W
- Package Thermal Resistance, (θ_{JC})

  TQFN-21 (3mm×4mm) -- TBD°C/W

Note 2: Stresses beyond this listed under “Absolute Maximum Ratings" may cause permanent damage to the device.
Note 3: θ_{JA} is measured at 25°C ambient with the component mounted on a high effective thermal conductivity 4-layer board of JEDEC-51-7. The thermal resistance greatly varies with layout, copper thickness, number of layers and PCB size.

Recommended Operating Conditions

- Supply Voltage V_{IN} -- +6V to +16V
- Maximum Output Current --- 12A
- Maximum Output Current Limit --- 16A
- Maximum Peak Inductor Current --- 18A
- Operating Ambient Temperature Range -- -40°C to +85°C
- Operating Junction Temperature Range --- -40°C to +125°C

Electrical Characteristics

(V_{IN}=12V, T_A=-40°C~125°C, unless otherwise specified.)

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
V_{IN} Quiescent Current	I_{DDQ}	V_{EN}=2V, V_{FB}=0.62V		300		μA
V_{IN} Shutdown Supply Current	I_{SD}	EN=0V		0	10	μA
High-Side MOSFET Leakage Current	$I_{LX(leak\_HS)}$	V_{EN} = 0V, V_{LX} = 0V		0	10	μA
Low-Side MOSFET Leakage Current	$I_{LX(leak\_LS)}$	V_{EN} = 0V, V_{LX} = 12V		0	30	
High-Side MOSFET $R_{DS(ON)}$ (Note 4)	$R_{DS(ON)}$	V_{EN} = 2V T_A= 25°C		15		mΩ
Low-Side MOSFET $R_{DS(ON)}$ (Note 4)	$R_{DS(ON)}$	V_{EN} = 2V T_A= 25°C		5.5		mΩ
Output Current Limit	I_{LIM}		-15		15	%
Low-Side Negative Current Limit (Note 4)	$I_{LIM(NEG)}$			-2		A
Negative Current Limit Time-Out	$t_{NCL(Timer)}$			230		ns
Switching Frequency	F_{SW}	MODE = GND, I_{OUT}=0A,V_{OUT}=1V	480	600	720	kHz
		MODE = 30.1k, I_{OUT}=0A,V_{OUT}=1V	680	800	920	
		MODE = 60.4k, I_{OUT}=0A,V_{OUT}=1V	850	1000	1150	
Minimum On Time (Note 4)	$T_{ON(Min)}$			50		ns
Minimum Off Time (Note 4)	$T_{OFF(Min)}$			200		ns
OVP Threshold	V_{OVP}	V_{PG}=Low	112%	115%	118%	V_{REF}
UVP Threshold	V_{UVP}		77%	80%	83%	V_{REF}
Feedback Threshold Voltage	V_{REF}	T_J = -40°C to +125°C	594	600	606	mV
TRK/REF Sourcing Current	$I_{TRACK(Source)}$	$V_{TRK/REF}$ = 0V		42		μA
TRK/REF Sinking Current	$I_{TRACK(Sink)}$	$V_{TRK/REF}$ = 1V		12		μA
Soft-Start Time	T_{SS}	$C_{TRACK(min)}$ = 22nF, T_A= 25°C	0.75	1	1.25	ms

Electrical Characteristics (Continued)

(V_{IN}=12V, T_A=-40°C~125°C, unless otherwise specified.)

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
Feedback Input Current	I_{FB}	V_{FB} = REF		50	100	nA
Enable Input High Voltage	$V_{EN(H)}$	Rising	1.15	1.2	1.25	V
EN Input Current	I_{EN}	V_{EN}=2V		0		μA
EN Hysteresis	$V_{EN(HYS)}$			200		mV
Output Discharge Resistance	R_{DISCHG}			80	150	Ω
Input Supply Voltage UVLO Threshold Rising	$V_{UVLO(rise)}$	V_{CC}=5.0V	2.1	2.4	2.7	V
Input Supply Voltage UVLO Threshold Falling	$V_{UVLO(fall)}$		1.5	1.8	2.1	V
VCC Output Voltage UVLO Threshold Rising	$V_{CC(Rise)}$		4.15	4.3	4.45	V
VCC Output Voltage UVLO Threshold Falling	$V_{CC(Fall)}$		3.65	3.8	3.95	V
V_{CC} Voltage	Vcc			4.8		V
V_{CC} Load Regulation	V_{CC_Reg}	I_{VCC}=25mA		1		%
PG High Threshold	$V_{PG(H\_rise)}$	V_{FB} Rising	89.50%	92.50%	95.50%	V_{REF}
PG Low Threshold	$V_{PG(L\_rise)}$	V_{FB} Rising	112%	115%	118%	V_{REF}
	$V_{PG(L\_fall)}$	V_{FB} Falling	77%	80%	83%	V_{REF}
PG Low To High Delay	$V_{PG(Td)}$	T_A= 25°C	0.63	0.9	1.17	ms
PG Sink Current Capability	V_{PG}	IPG = 10mA			0.5	V
PG Leakage Current	I_{PG}	VPG = 5.0V			3	μA
PG Low-Level Output Voltage	V_{OL}	V_{IN}=0V, Pull PG up to 5.0V through a 100KΩ resistor T_A= 25°C		650	800	mV
	V_{OL}	V_{IN}=0V, Pull PG up to 5.0V through a 10KΩ resistor T_A= 25°C		750	900	mV
Thermal Shutdown Threshold (Note 4)	T_{SD}			160		°C
Thermal Shutdown Hysteresis(Note 4)	T_{HYS}			30		°C

Note 4: Not production tested.

Function Description

The FR9209 is a synchronous step-down DC/DC converter with capacitor-current-sense constant on time (CCS-COT) mode control. It has integrated High-Side (15mΩ, typ) and Low-Side (5.5mΩ, typ) power switches, and provides 12A continuous load current. It regulates input voltage from 6V to 16V, and down to an output voltage as low as 0.6V. Using CCS-COT control scheme provides fast transient response, which can minimize the component size without additional external compensation network.

Enable

The FR9209 EN pin provides digital control to turn on/turn off the regulator. When the voltage of EN exceeds the threshold voltage, the regulator starts the soft start function. If the EN pin voltage is below than the shutdown threshold voltage, the regulator will turn into the shutdown mode and the shutdown current will be smaller than 1μA. For auto start-up operation, connect EN to VIN through a 100kΩ resistor.

Soft Start

The FR9209 employs internal and programmable external soft start functions to reduce input inrush current during start up. When TRK/REF pin connects to C_{SS} capacitor to RGND, the C_{SS} capacitor will be charged by a 47μA current. the C_{SS} is recommended to be minimum of 22nF. The equation for the soft start time is shown as below:

$$T_{SS}(ms)=\frac{C_{SS}(nF)\times V_{FB}}{I_{SS}(\mu A)}$$

The V_{FB} voltage is 0.6V and the I_{SS} current is 47μA. (If a 22nF capacitor is connected from TRK/REF pin to RGND, the minimum value of internal soft start time is limited at 1ms.)

Input Under Voltage Lockout

When the FR9209 is power on, the internal circuits are held inactive until V_{IN} voltage exceeds the input UVLO threshold voltage. And the regulator will be disabled, the IC will shut down the internal circuit when V_{IN} is below the input UVLO threshold voltage. The hysteretic of the UVLO comparator is 600mV (typ).

Mode Selection

The FR9209 provides both forced CCM operation or pulse skip mode operation to support high efficiency and reduce power loss in a light-load condition. The FR9209 has three options for switching frequency selection, by connecting a resistor from the MODE pin to the AGND pin or VCC. ±5% tolerance resistor is recommended. (see Table 2)

Table 2. MODE Selection

MODE	Light-Load Mode	Switching Frequency
VCC	Pulse skip	600kHz
243kΩ to GND	Pulse skip	800kHz
121kΩ to GND	Pulse skip	1000kHz
GND	Forced CCM	600kHz
30.1kΩ to GND	Forced CCM	800kHz
60.4kΩ to GND	Forced CCM	1000kHz

Output Voltage Tracking and Reference

The FR9209 provides an analog input pin (TRK/REF) to track another power supply or accept external reference. When an external voltage signal is connected to TRK/REF, it acts as a reference for the FR9209 output voltage. The FB voltage follows this external voltage signal exactly; the soft-start settings are ignored. The TRK/REF input signal can be in the range of 0.3V to 1.4V. During the initial start-up, the TRK/REF needs to reach 600mV or above first to ensure proper operation. After that, it can be any value between 0.3V and 1.4V.

PG Signal Output

PG pin is an open-drain output and requires a pull up resistor. When the sensed output voltage is below 80% of nominal point, PG is actively held low in soft-start, standby and shutdown. It is released when the output voltage rises above 92.5% of nominal regulation point.

Function Description (Continued)

Output Voltage Discharge

When the FR9209 is disabled through EN, it enables the output voltage discharge mode. This causes both the High-Side MOSFET and the Low-Side MOSFET to latch off. A discharge MOSFET connected between LX and PGND is turned on to discharge the output voltage. The typical switch on resistance of this MOSFET is about 80Ω. Once the LX voltage drops below 0.1V REF, the discharge MOSFET is turned off.

Over-Voltage Protection (OVP)

The FR9209 monitors the output voltage by connecting FB to the tap of the output voltage feedback resistor divider to detect an overvoltage condition. This provides latch-off OVP mode. If the FB voltage exceeds 115% of the REF voltage, it enters latch-off OVP mode. The High-Side MOSFET latches off and PGOOD latches low until power recycle of V_{IN} or EN. Meanwhile, the Low-Side MOSFET remains on until it hits the low-side negative current limit (NOCP). Once it hits NOCP, the Low-Side MOSFET is momentarily turned off for 230ns and is then turned on again. It needs power recycle of the EN or VIN to clear the OVP fault. The OVP function is enabled after TRK/REF reaches 600mV.

Over Current Protection

The FR9209 over current protection function is implemented using cycle-by-cycle current limit architecture. The inductor current is monitored by Low-Side MOSFET. When the load current increases, the inductor current also increases. When the valley inductor current reaches the current limit threshold, the output voltage starts to drop. If the FR9209 detects over-current condition for consecutive 31 cycles, it enters hiccup mode. When the over current condition is removed, the output voltage returns to the regulated value.

The FR9209 employs programmable sets current limit threshold. A resistor, R_{CS}, connected from the CS pin to AGND. A ±1% tolerance resistor, RCS is highly recommended. The equation for the output current limit is shown as below:

$$R_{CS}(\Omega)=\frac{1.2\,(V)}{20(uA/A)\times\left[I_{LIMIT}(A)-\frac{V_{OUT}}{2\times F_{SW}\times L}(1-D)\right]}$$

$$D=\frac{V_{OUT}}{V_{IN}}$$

I_{LIMIT} is output current limit threshold.

Negative Inductor Current limit

When the Low-Side MOSFET detects a -2A current, the part turns off the Low-Side MOSFET for 230ns to limit the negative current.

Short Circuit Protection

The FR9209 provides short circuit protection function to prevent the device damage from short condition. When the short condition occurs and the feedback voltage drops lower than 0.48V, the oscillator frequency will be reduced naturally and hiccup mode will be triggered to prevent the inductor current increasing beyond the current limit. Once the short condition is removed, the frequency will return to normal.

Over Temperature Protection

The FR9209 incorporates an over temperature protection circuit to protect itself from overheating. When the junction temperature exceeds the thermal shutdown threshold temperature, the regulator will be shutdown. And the hysteretic of the over temperature protection is 30°C (typ).

Application Information

Output Voltage Setting

The output voltage V_{OUT} is set using a resistive divider from the output to FB. The FB pin regulated voltage is 0.6V. Thus the output voltage equation is:

$$V_{OUT}=0.6V\times\left(1+\frac{R1}{R2}\right)$$

Table 3 lists recommended values of R1 and R2 for most used output voltage.

Table 3. Recommended Resistance Values

V_{OUT}	R1	R2
1.0V	6.81kΩ	10kΩ
1.2V	10kΩ	10kΩ
1.5V	15kΩ	10kΩ
1.8V	20kΩ	10kΩ
2.5V	32.4kΩ	10kΩ
3.3V	45.3kΩ	10kΩ
5.0V	73.2kΩ	10kΩ

Place resistors R1 and R2 close to FB pin to prevent stray pickup.

Input Capacitor Selection

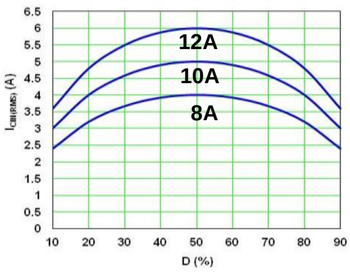
The use of the input capacitor is filtering the input voltage ripple and the MOSFETS switching spike voltage. Because the input current to the step-down converter is discontinuous, the input capacitor is required to supply the current to the converter to keep the DC input voltage. The capacitor voltage rating should be 1.25 to 1.5 times greater than the maximum input voltage. The input capacitor ripple current RMS value is calculated as:

$$I_{CIN(RMS)}=I_{OUT}\times\sqrt{D\times(1-D)}$$

$$D=\frac{V_{OUT}}{V_{IN}}$$

Where D is the duty cycle of the power MOSFET.

This function reaches the maximum value at D=0.5 and the equivalent RMS current is equal to $I_{OUT}/2$. The following diagram is the graphical representation of above equation.



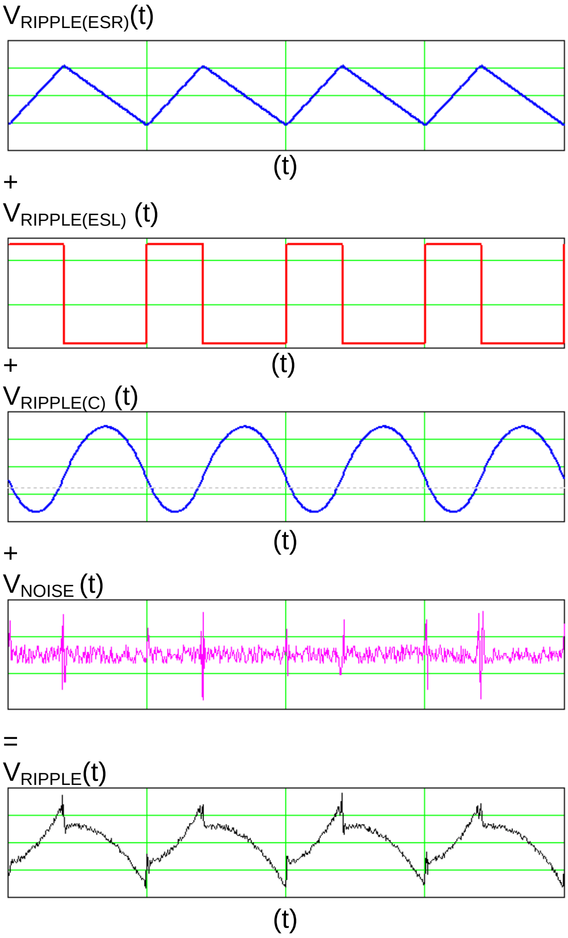
A low ESR capacitor is required to keep the noise minimum. Ceramic capacitors are better, but tantalum or low ESR electrolytic capacitors may also suffice. When using tantalum or electrolytic capacitors, a 0.1μF ceramic capacitor should be placed as close to the IC as possible.

Output Capacitor Selection

The output capacitor is used to keep the DC output voltage and supply the load transient current. When operating in constant current mode, the output ripple is determined by four components:

$$V_{RIPPLE}(t)=V_{RIPPLE(C)}(t)+V_{RIPPLE(ESR)}(t)$$
$$+V_{RIPPLE(ESL)}(t)+V_{NOISE}(t)$$

The following figures show the form of the ripple contributions.



Application Information (Continued)

$$V_{RIPPLE(ESR)}=\frac{V_{OUT}}{F_{OSC}\times L}\times\left(1-\frac{V_{OUT}}{V_{IN}}\right)\times ESR$$

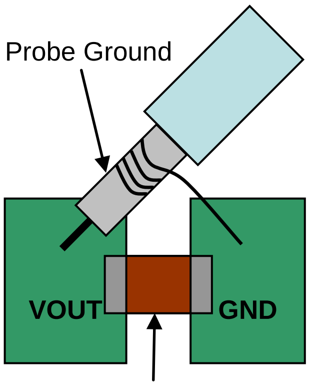
$$V_{RIPPLE(ESL)}=\frac{ESL}{L}\times V_{IN}$$

$$V_{RIPPLE(C)}=\frac{V_{OUT}}{8\times F_{OSC}{}^{2}\times L\times C_{OUT}}\times\left(1-\frac{V_{OUT}}{V_{IN}}\right)$$

Where F_{OSC} is the switching frequency, L is the inductance value, V_{IN} is the input voltage, ESR is the equivalent series resistance value of the output capacitor, ESL is the equivalent series inductance value of the output capacitor and the C_{OUT} is the output capacitor.

Low ESR capacitors are preferred to use. Ceramic, tantalum or low ESR electrolytic capacitors can be used depending on the output ripple requirement. When using the ceramic capacitors, the ESL component is usually negligible.

It is important to use the proper method to eliminate high frequency noise when measuring the output ripple. The figure shows how to locate the probe across the capacitor when measuring output ripple. Removing the scope probe plastic jacket in order to expose the ground at the tip of the probe. It gives a very short connection from the probe ground to the capacitor and eliminating noise.



Inductor Selection

The output inductor is used for storing energy and filtering output ripple current. But the trade-off condition often happens between maximum energy storage and the physical size of the inductor. The first consideration for selecting the output inductor is to make sure that the inductance is large enough to keep the converter in the continuous current mode.

That will lower ripple current and result in lower output ripple voltage. The ΔI_L is inductor peak-to-peak ripple current:

$$\Delta I_L=\frac{V_{OUT}}{F_{OSC}\times L}\times\left(1-\frac{V_{OUT}}{V_{IN}}\right)$$

A good compromise value between size and efficiency is to set the peak-to-peak inductor ripple current ΔI_L equal to 30% of the maximum load current. But setting the peak-to-peak inductor ripple current ΔI_L between 20%~50% of the maximum load current is also acceptable. Then the inductance can be calculated with the following equation:

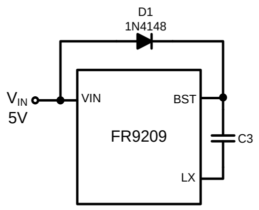
$$\Delta I_L=0.3\times I_{OUT(MAX)}$$

$$L=\frac{(V_{IN}-V_{OUT})\times V_{OUT}}{V_{IN}\times F_{OSC}\times\Delta I_L}$$

To guarantee the required output current, the inductor needs a saturation current rating and a thermal rating that exceeds IL (peak current). These are minimum requirements. To maintain control of inductor current in overload and short circuit conditions, some applications may desire current ratings up to the current limit value.

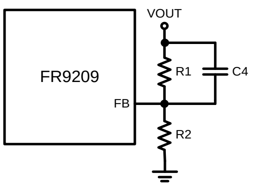
External Diode Selection

For 5V input applications, it is recommended to add an external boost diode. This helps improving the efficiency. The boost diode can be a low cost one such as 1N4148.



Feedforward Capacitor Selection

Internal compensation function allows users saving time in design and saving cost by reducing the number of external components. The use of a feedforward capacitor C4 in the feedback network is recommended to improve the transient response or higher phase margin.



Application Information (Continued)

For optimizing the feedforward capacitor, knowing the cross frequency is the first thing. The cross frequency (or the converter bandwidth) can be determined by using a network analyzer. When getting the cross frequency with no feedforward capacitor identified, the value of feedforward capacitor C4 can be calculated with the following equation:

$$C4=\frac{1}{2\pi\times F_{CROSS}}\times\sqrt{\frac{1}{R1}\times\left(\frac{1}{R1}+\frac{1}{R2}\right)}$$

Where F_{CROSS} is the cross frequency.

To reduce transient ripple, the feed forward capacitor value can be increased to push the cross frequency to higher region. Although this can improve transient response, it also decrease phase margin and cause more ringing. In the other hand, if more phase margin is desired, the feedforward capacitor value can be decreased to push the cross frequency to lower region. For the FR9209 applications, a 0.2nF feed forward capacitor is recommended.

PCB Layout Recommendation

The device's performance and stability is dramatically affected by PCB layout. It is recommended to follow these general guidelines shown as below:

1. Place the input capacitors and output capacitors as close to the device as possible. Trace to these capacitors should be as short and wide as possible to minimize parasitic inductance and resistance.
2. Place feedback resistors close to the FB pin.
3. Keep the sensitive signal (FB) away from the switching signal (LX).
4. Multi-layer PCB design is recommended.

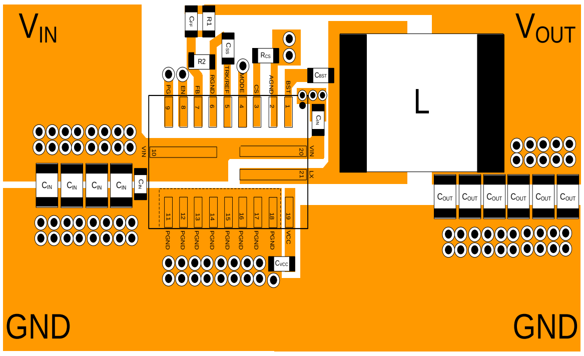
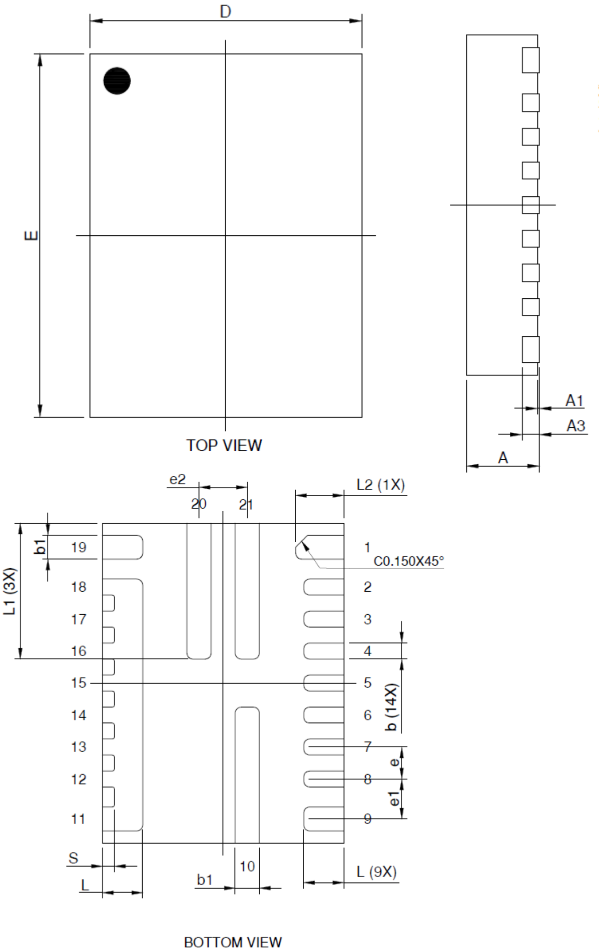


Figure 4. Recommended PCB Layout Diagram

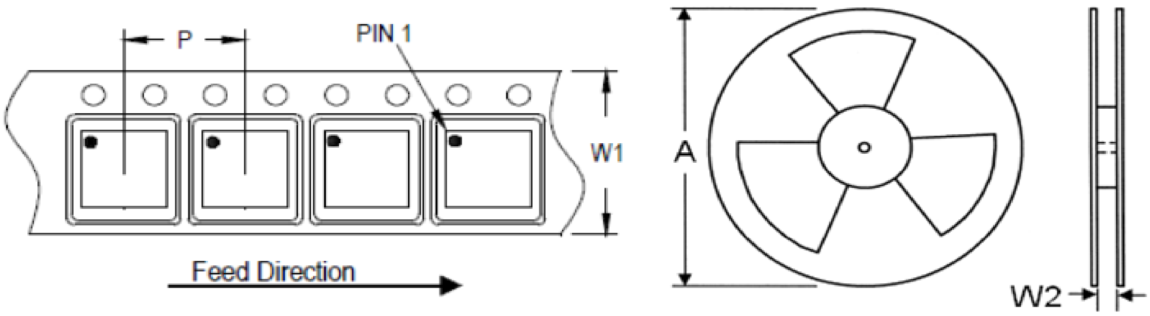
Outline Information

TQFN-21 (3mm×4mm) (pitch 0.4_0.5_0.6mm) Package (Unit: mm)



SYMBOLS	DIMENSION IN MILLIMETER		
	MIN.	NOM.	MAX.
A	0.80	0.85	0.90
A1	0.00	0.02	0.05
A3	0.203 REF		
b	0.15	0.20	0.25
b1	0.25	0.30	0.35
D	2.90	3.00	3.10
E	3.90	4.00	4.10
e	0.40 BSC		
e1	0.50 BSC		
e2	0.60 BSC		
L	0.45	0.50	0.55
L1	1.65	1.70	1.75
L2	0.55	0.60	0.65
S	0.150 REF		

Carrier Dimensions



Tape Size (W1) mm	Pocket Pitch (P) mm	Reel Size (A)		Reel Width (W2) mm	Empty Cavity Length mm	Units per Reel
		in	mm			
12	8	13	330	12.4	400~1000	3,000

Life Support Policy
Fitipower's products are not authorized for use as critical components in life support devices or other medical systems.