



UD05124

Advance

LINEAR INTEGRATED CIRCUIT

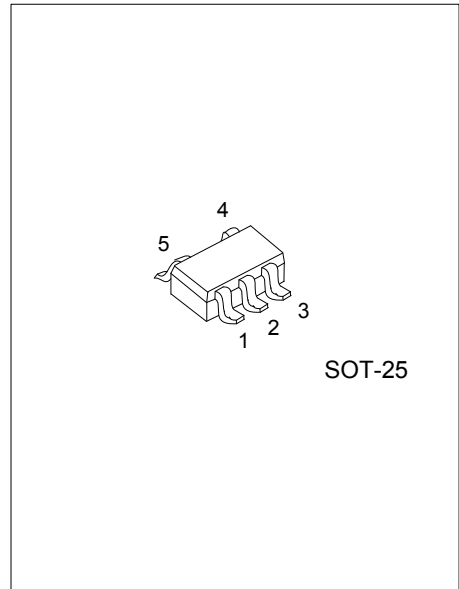
HIGH EFFICIENCY 1.5MHZ 1.2A SYNCHRONOUS STEP DOWN CONVERTER

DESCRIPTION

The UTC **UD05124** is a high efficiency, high frequency synchronous DC-DC step-down converter. The 100% duty cycle feature provides low dropout operation, extending battery life in portable systems.

The internal synchronous switch increases efficiency and eliminates the need for external schottky diode. At shutdown mode, the input supply current is less than 1 μ A.

The UTC **UD05124** fault protection includes over current protection, short circuit protection, UVLO and thermal shutdown. The internal soft-start function prevents inrush current at turn-on.



FEATURES

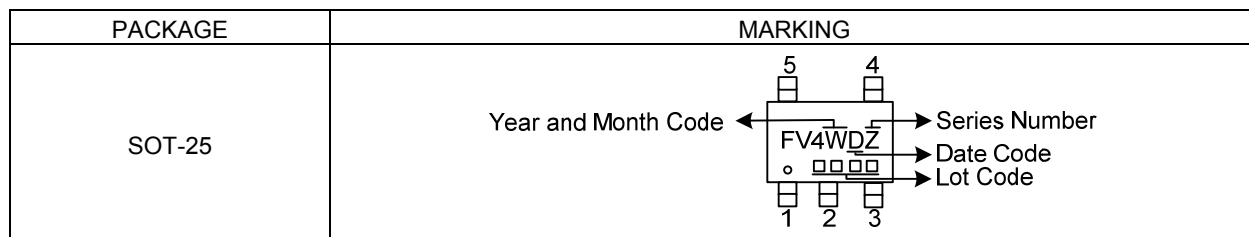
- * 2.5V ~ 6V Input Voltage Range
- * 0.6V Reference Voltage
- * 1.2A Output Current
- * Low R_{DS(ON)} for Internal Switch: 340 / 210m Ω (Top/Bottom)
- * 1.5MHz Switching Frequency
- * Internal 1ms Soft-Start Time
- * Internal Compensation Function
- * 100% Dropout Operation
- * Input Over Voltage Protection
- * Over Current Protection
- * Short Circuit Protection
- * Over Temperature Protection with Auto Recovery

ORDERING INFORMATION

Ordering Number		Package	Packing
Lead Free	Halogen Free		
UD05124L-AF5-R	UD05124G-AF5-R	SOT-25	Tape Reel

<p>UD05124G-AF5-R</p>	<p>(1) Packing Type</p> <p>(2) Package Type</p> <p>(3) Green Package</p>	<p>(1) R: Tape Reel</p> <p>(2) AF5: SOT-25</p> <p>(3) G: Halogen Free and Lead Free, L: Lead Free</p>
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MARKING



MARKING INFORMATION

W: Year and Month Code

YEAR & MONTH	Jan-20	Feb-20	Mar-20	Apr-20	May-20	Jun-20	Jul-20	Aug-20	Sep-20	Oct-20	Nov-20	Dec-20
CODE	D	E	F	G	H	I	J	K	L	M	N	O
YEAR & MONTH	Jan-21	Feb-21	Mar-21	Apr-21	May-21	Jun-21	Jul-21	Aug-21	Sep-21	Oct-21	Nov-21	Dec-21
CODE	P	a	R	S	T	U	V	W	X	Y	Z	D
YEAR & MONTH	Jan-22	Feb-22	Mar-22	Apr-22	May-22	Jun-22	Jul-22	Aug-22	Sep-22	Oct-22	Nov-22	Dec-22
CODE	e	f	g	h	j	k	m	n	q	r	t	Y
YEAR & MONTH	Jan-23	Feb-23	Mar-23	Apr-23	May-23	Jun-23	Jul-23	Aug-23	Sep-23	Oct-23	Nov-23	Dec-23
CODE	1	2	3	4	5	6	7	8	9	A	B	C

D: date Code

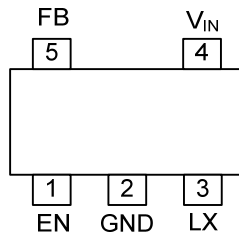
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DATE	13	14	15	16	17	18	19	20	21	22	23	24
CODE	D	E	F	G	H	I	J	K	L	M	N	P
DATE	25	26	27	28	29	30	31					
CODE	Q	R	S	T	U	V	W					

Z: Series Number (Note 1)

1	---●	2	--●-	3	--●●	4	-●---
5	-●-●	6	-●●-	7	-●●●	8	●----
9	●--●	A	●-●-	B	●-●●	C	●●---
D	●●-●	E	●●●-	F	●●●●	G	-----

Note: 1. Series No., the last digit of assembly lot No. (Follow binary system)

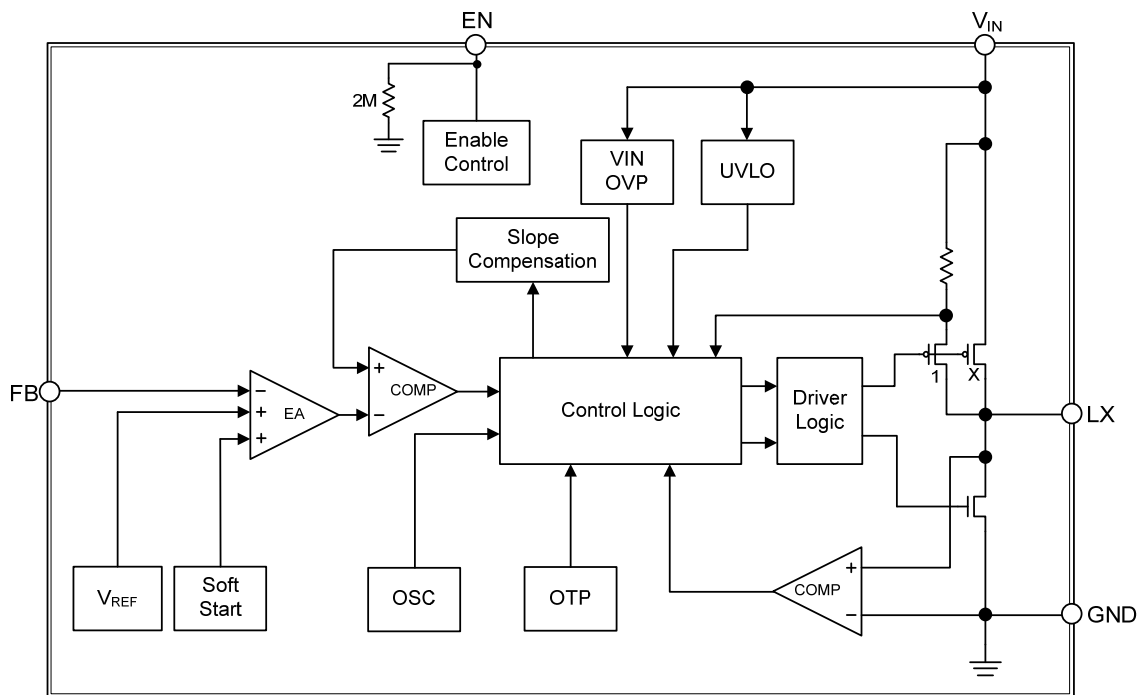
■ PIN CONFIGURATION



■ PIN DESCRIPTION

PIN NO.	PIN NAME	DESCRIPTION
1	EN	Enable control pin. Pull high to turn the IC on, and pull low to disable the IC. Don't leave this pin floating.
2	GND	Ground pin.
3	LX	Power switching node. Connect an external inductor to this switching node.
4	V _{IN}	Power supply input pin. Placed input capacitors as close as possible from V _{IN} to GND to avoid noise influence.
5	FB	Voltage feedback input pin. Connect FB and V _{OUT} with a resistive voltage divider. This IC senses feedback voltage via FB and regulates it at 0.6V.

■ BLOCK DIAGRAM



■ ABSOLUTE MAXIMUM RATING

PARAMETER	SYMBOL	RATINGS	UNIT
V _{IN} to GND		-0.3V ~ +6.5V	V
LX to GND		-0.3V to (V _{IN} +0.3V)	V
Dynamic LX Voltage in 20ns Duration		-4.5V ~ +7.5V	V
EN, FB to GND		-0.3V to V _{IN}	V
Junction Temperature	T _J	+150	°C
Storage Temperature	T _{STG}	-65 ~ +150	°C

Note: Absolute maximum ratings are those values beyond which the device could be permanently damaged. Absolute maximum ratings are stress ratings only and functional device operation is not implied.

■ RECOMMENDED OPERATING CONDITIONS

PARAMETER	SYMBOL	RATINGS	UNIT
Supply Voltage (V _{IN})	V _{IN}	+2.5 ~ +6	V
Operation Temperature Range	T _{OPR}	-40 ~ +85	°C

■ THERMAL DATA

PARAMETER	SYMBOL	RATINGS	UNIT
Junction to Ambient	θ _{JA}	250	°C/W
Junction to Case	θ _{JC}	130	°C/W

■ ELECTRICAL CHARACTERISTICS (V_{IN}=5V, V_{OUT}=2.5V, T_A=25°C, unless otherwise specified.)

PARAMETER	SYMBOL	TEST CONDITIONS	MIN	TYP	MAX	UNIT
Input Supply Voltage	V _{IN}		2.5		6.0	V
Input Over Voltage Protection	V _{IN OVP}			6.3		V
Shutdown Current	I _{SHDN}	EN=0V		0.1	1	μA
Quiescent Current	I _q	V _{FB} =0.65V, I _{OUT} =0A		30	50	μA
Reference Voltage	V _{REF}		0.588	0.6	0.612	V
FB Input Leakage Current	I _{FB}	V _{FB} =V _{IN}		0.01	1	μA
On-Resistance (Note)	R _{DS(ON)}	P-Channel MOSFET		340		mΩ
		N-Channel MOSFET		210		mΩ
P-Channel Current Limit (Note)	I _{LIM}			1.5		A
EN High-Level Input Voltage	V _{EN(H)}		1.5			V
EN Low-Level Input Voltage	V _{EN(L)}				0.4	V
EN Input Current	I _{EN}			2.5		μA
Under Voltage Lockout Voltage	UVLO			2.4		V
UVLO Hysteresis	V _{HYS}			0.3		V
Oscillation Frequency	F _{OSC}	I _{OUT} =200mA	1.2	1.5	1.8	MHz
Minimum On Time				50		ns
Maximum Duty Cycle			100			%
Internal Soft Start Time	T _{SS}			1		ms
LX Discharge Resistance				100		Ω
Thermal Shutdown Temperature (Note)	T _{SD}			150		°C

Note: Guarantee by design.

■ FUNCTION DESCRIPTION

The **UD05124** is a high efficiency, internal compensation and constant frequency current mode step-down synchronous DC/DC converter. It has integrated high-side (340mΩ, typ.) and low-side (210mΩ, typ.) power switches, and provides 1.2A continuous load current. It regulates input voltage from 2.5V to 6V, and down to an output voltage as low as 0.6V.

Enable

The **UD05124** EN pin provides digital control to turn on/off the regulator. When the voltage of EN exceeds the threshold voltage, the regulator will start the soft start function. If the EN pin voltage is below 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.

Soft Start

The **UD05124** employs internal soft start function to reduce input inrush current during start up. The internal soft start time will be 1ms.

Under Voltage Lockout

When the **UD05124** is power on, the internal circuits will be held inactive until V_{IN} voltage exceeds the UVLO threshold voltage. And the regulator will be disabled when V_{IN} is below the UVLO threshold voltage. The hysteresis of the UVLO comparator is 200mV (typ).

Input Over Voltage Protection

The **UD05124** supports input over voltage protection. When input voltage exceeds the input over voltage threshold, the regulator will be shutdown unless the input over voltage is removed.

Over Current Protection

The **UD05124** over current protection function is implemented by using cycle-by-cycle current limit architecture. The inductor current is monitored by measuring the high-side MOSFET series sense resistor voltage. When the load current increases, the inductor current will also increase. When the peak inductor current reaches the current limit threshold, the output voltage will start to drop. When the over current condition is removed, the output voltage will return to the regulated value.

Short Circuit Protection

The **UD05124** provides short circuit protection function to prevent the device damaged from short condition. When the short condition occurs and the feedback voltage drops lower than 40% of the regulation level, the oscillator frequency will be reduced and hiccup mode will be triggered to prevent the **UD05124** from overheating during the extended short condition. Once the short condition is removed, the frequency and current limit will return to normal.

Over Temperature Protection

The **UD05124** 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 hysteresis of the over temperature protection is 30°C (typ).

■ APPLICATION INFORMATION

Output Voltage Setting

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

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

Table 1 lists recommended values of R1 and R2 for most used output voltage.

Table 1. Recommended Resistance Values

V_{OUT}	R1	R2
3.3V	453k Ω	100k Ω
2.5V	316k Ω	100k Ω
1.8V	200k Ω	100k Ω
1.5V	150k Ω	100k Ω
1.2V	100k Ω	100k Ω

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 $I_{OUT}/2$.

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.

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.

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

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

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

■ APPLICATION INFORMATION (Cont.)

Where FOSC is the switching frequency, L is the inductance value, VIN 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 COUT 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 requirements. 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.

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:

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

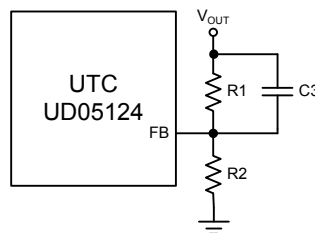
$$L = \frac{(V_{IN} - V_{OUT}) \times V_{OUT}}{V_{IN} \times F_{OSC} \times \Delta I_L}$$

To guarantee sufficient output current, peak inductor current must be lower than the **UD05124** high-side MOSFET current limit.

$$I_{PEAK} = I_{OUT(MAX)} + \frac{\Delta I_L}{2}$$

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 C3 in the feedback network is recommended to improve transient response or higher phase margin.



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 C3 can be calculated with the following equation:

$$C3 = \frac{1}{2\pi \times F_{CROSS}} \times \sqrt{\frac{1}{R1} \times \left(\frac{1}{R1} + \frac{1}{R2}\right)}$$

Where F_{CROSS} is the cross frequency.

To reduce transient ripple, the feedforward capacitor value can be increased to push the cross frequency to higher region. Although this can improve transient response, it also decreases phase margin and causes 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. In general, the feedforward capacitor range is between 10pF to 330pF.

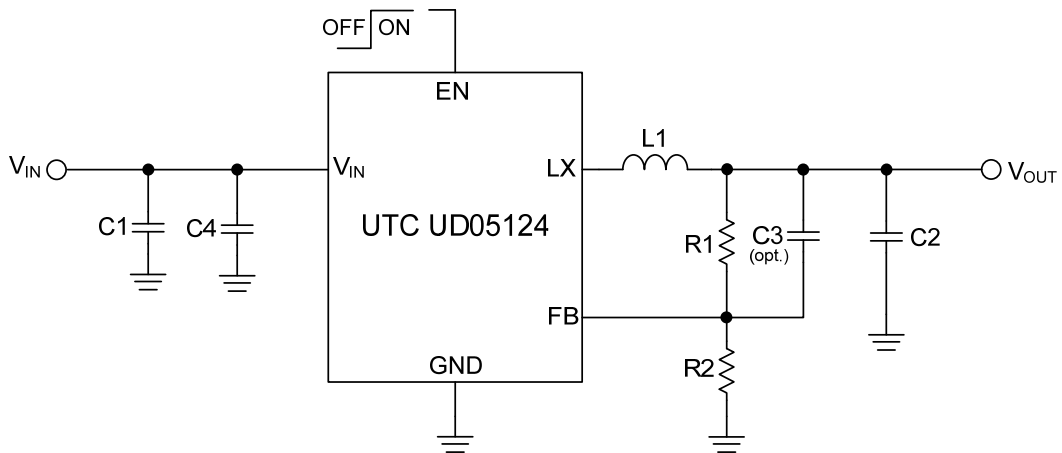
■ APPLICATION INFORMATION (Cont.)

PCB Layout Recommendation

The device's performance and stability are 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. The traces which connect 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.

■ TYPICAL APPLICATION CIRCUIT



Note: $V_{IN}=5V$, the recommended BOM list is as below.

Table 2. Recommended Component Values

V_{OUT}	C1	C4	R1	R2	L1	C2
3.3V	4.7 μ F MLCC	0.1 μ F MLCC	453k Ω	100k Ω	2.2 μ H	10 μ F MLCC
2.5V	4.7 μ F MLCC	0.1 μ F MLCC	316k Ω	100k Ω	2.2 μ H	10 μ F MLCC
1.8V	4.7 μ F MLCC	0.1 μ F MLCC	200k Ω	100k Ω	2.2 μ H	10 μ F MLCC
1.5V	4.7 μ F MLCC	0.1 μ F MLCC	150k Ω	100k Ω	1.8 μ H	10 μ F MLCC
1.2V	4.7 μ F MLCC	0.1 μ F MLCC	100k Ω	100k Ω	1.8 μ H	10 μ F MLCC
1.05V	4.7 μ F MLCC	0.1 μ F MLCC	75k Ω	100k Ω	1.5 μ H	10 μ F MLCC

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