0.9A, Low Noise, Low Dropout Linear Regulator

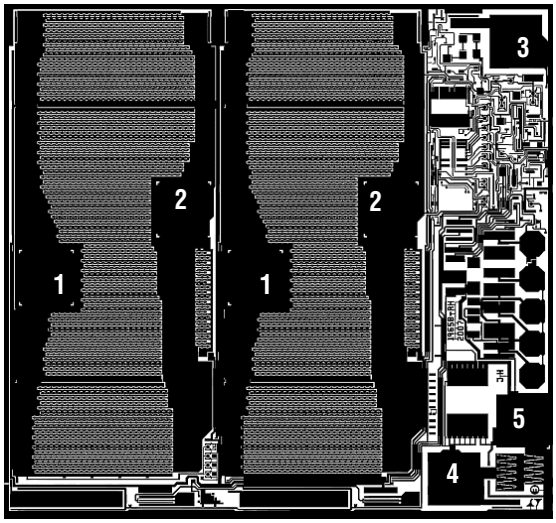
FEATURES

- **Output Current: 0.9A**
- **500µA Quiescent Current**
- Adjustable Output from 1.2V to 19.5V
- No Protection Diodes Needed
- < 1µA Quiescent Current in Shutdown
- Total Ionizing Dose (TID) Tolerance, per TM1019.8,
- MIL-STD-883 up to:
  - 200kRad (Si), per Condition A, at 50Rads(Si)/sec
  - 100kRad (Si), per Condition D, at 10mRads(Si)/sec
  - ELDRS Pass 100kRad(Si)
- MIL-PRF-38535 Class V Compliant

DESCRIPTION

The RH1965MK is a 0.9A low noise, low dropout linear regulator with a PNP pass transistor, requiring only a single supply for operation. Operating quiescent current is 500µA, reducing to less than 1µA in shutdown. Output voltage ranges from 1.2V to 19.5V. A small 10µF capacitor on the output with an ESR of less than 1Ω is adequate to ensure stability. Applications with large output load transients require a larger output capacitor value to minimize output voltage change. Input circuitry ensures output safe operating area with current limiting and thermal shutdown protection. The rated dropout of an RH1965-based part is dependent on the internal bond wire length/resistance. Linear Technology dice element evaluations are based on parts rated for 0.9A output current that are assembled in 4-Lead TO-3 can packages.

DICE PINOUT



71mils × 66mils,
Backside metal: Alloyed gold (K) layer
Backside potential: GND

PAD FUNCTION

1. OUT
2. IN
3. $\overline{\text{SHDN}}$
4. ADJ
5. GND

DIE CROSS REFERENCE

LTC® Finished Part Number	Order Part Number
RH1965MK	RH1965MK DICE
RH1965MK	RH1965MK DWF*

Please refer to LTC standard product data sheet for other applicable product information.
***DWF = DICE in wafer form.**

ABSOLUTE MAXIMUM RATINGS

(Note 1)

IN Pin Voltage .....±22V
OUT Pin Voltage.....±22V
Input to Output Differential Voltage (Note 2).....±22V
ADJ Pin Voltage .....±9V
$\overline{SHDN}$ Pin Voltage .....±22V
Output Short-Circuit Duration ..... Indefinite
Operating Junction Temperature
Range (Notes 3, 5, 13)..... –55°C to 125°C
Storage Temperature Range..... –65°C to 150°C

TABLE 1: DICE/DWF ELECTRICAL TEST LIMITS T_A = 25°C (Notes 3, 14, 15, 16)

PARAMETER	CONDITIONS	MIN	MAX	UNITS
ADJ Pin Voltage (Notes 4, 5)	V_{IN} = 2.1V, I_{LOAD} = 1mA	1.182	1.218	V
Line Regulation	ΔV_{IN} = 2.1V to 20V, I_{LOAD} = 1mA (Note 4)		5	mV
Load Regulation	V_{IN} = 2.3V, ΔI_{LOAD} = 1mA to 50mA (Note 4)		7	mV
Dropout Voltage $V_{IN} = V_{OUT(NOMINAL)}$ (Notes 6, 7, 12)	I_{LOAD} = 1mA I_{LOAD} = 50mA		0.08 0.16	V V
GND Pin Current $V_{IN} = V_{OUT(NOMINAL)}$ + 1V (Notes 6, 8)	I_{LOAD} = 0mA I_{LOAD} = 1mA I_{LOAD} = 100mA		0.7 1 4.5	mA mA mA
ADJ Pin Bias Current (Notes 4, 9)			4.5	µA
Shutdown Threshold	V_{OUT} = Off to On V_{OUT} = On to Off	 0.43	1.2	V V
$\overline{SHDN}$ Pin Current (Note 10)	$V_{\overline{SHDN}}$ = 0V $V_{\overline{SHDN}}$ = 20V		1 10	µA µA
Quiescent Current in Shutdown	V_{IN} = 6V, $V_{\overline{SHDN}}$ = 0V		1	µA
Input Reverse-Leakage Current	V_{IN} = –20V, V_{OUT} = 0V		1	mA
Reverse-Output Current (Note 11)	V_{OUT} = 1.2V, V_{IN} = 0V (Note 4)		400	µA

TABLE 2: ELECTRICAL CHARACTERISTICS (Preirradiation) (Notes 3, 15, 16)

PARAMETER	CONDITIONS	T_A = 25°C MIN	T_A = 25°C MAX	SUB-GROUP	–55°C < T_A < 125°C MIN	–55°C < T_A < 125°C MAX	SUB-GROUP	UNITS
Minimum Input Voltage (Notes 4, 12)	I_{LOAD} = 0.9A		2.3	1		2.3	2, 3	V
ADJ Pin Voltage (Notes 4, 5)	V_{IN} = 2.1V, I_{LOAD} = 1mA	1.182	1.218	1	1.164	1.236	2, 3	V
Line Regulation	ΔV_{IN} = 2.1V to 20V, I_{LOAD} = 1mA (Note 4)		6	1		8	2, 3	mV
Load Regulation	V_{IN} = 2.3V, ΔI_{LOAD} = 1mA to 0.9A (Note 4)		8	1		16	2, 3	mV
Dropout Voltage $V_{IN} = V_{OUT(NOMINAL)}$ (Notes 6, 7, 12)	I_{LOAD} = 1mA I_{LOAD} = 100mA I_{LOAD} = 500mA I_{LOAD} = 0.9A		80 185 300 435	1 1 1 1		140 295 430 600	2, 3 2, 3 2, 3 2, 3	mV mV mV mV
GND Pin Current $V_{IN} = V_{OUT(NOMINAL)} + 1V$ (Notes 6, 8)	I_{LOAD} = 0mA I_{LOAD} = 1mA I_{LOAD} = 100mA I_{LOAD} = 500mA I_{LOAD} = 0.9A		0.85 1.1 4.6 16.5 30	1 1 1 1 1		1.1 1.5 5.5 20 38	2, 3 2, 3 2, 3 2, 3 2, 3	mA mA mA mA mA
Output Voltage Noise	V_{OUT}= 2.5V, C_{OUT} = 10µF, I_{LOAD} = 0.9A, BW = 10Hz to 100kHz	TYP = 40		1				μV_{RMS}
ADJ Pin Bias Current (Notes 4, 9)			4.5	1		4.5		µA
Shutdown Threshold	V_{OUT} = Off to On V_{OUT} = On to Off	 0.37	1.5	1	 0.2	2	2, 3	V V
$\overline{SHDN}$ Pin Current (Note 10)	$V_{\overline{SHDN}}$ = 0V $V_{\overline{SHDN}}$ = 20V		1 10	1				µA µA
Quiescent Current in Shutdown	V_{IN} = 6V, $V_{\overline{SHDN}}$ = 0V		1	1				µA
Ripple Rejection	$V_{IN} – V_{OUT}$ = 1.5V (AVG), V_{RIPPLE} = 0.5V_{P-P}, f_{RIPPLE} = 120Hz, I_{LOAD} = 0.75A	57		1				dB
Current Limit (Note 6)	$V_{IN} = V_{OUT(NOMINAL)} + 1V$, ΔV_{OUT} = –0.1V	1.0		1	1.0		2, 3	A
Input Reverse-Leakage Current	V_{IN} = –20V, V_{OUT} = 0V		1	1				mA
Reverse-Output Current (Note 11)	V_{OUT} = 1.2V, V_{IN} = 0V (Note 4)		400	1				µA

TABLE 3: ELECTRICAL CHARACTERISTICS (Postirradiation) T_A = 25°C (Notes 3, 15, 16)

PARAMETER	CONDITIONS	10kRads (Si) MIN	10kRads (Si) MAX	20kRads (Si) MIN	20kRads (Si) MAX	50kRads (Si) MIN	50kRads (Si) MAX	100kRads (Si) MIN	100kRads (Si) MAX	200kRads (Si) MIN	200kRads (Si) MAX	UNITS
Minimum Input Voltage (Notes 4, 12)	I_{LOAD} = 0.9A		2.3		2.3		2.3		2.3		2.3	V
ADJ Pin Voltage (Notes 4, 5)	V_{IN} = 2.1V, I_{LOAD} = 1mA	1.176	1.224	1.176	1.224	1.176	1.224	1.176	1.224	1.176	1.224	V
Line Regulation (Note 4)	ΔV_{IN} = 2.1V to 20V, I_{LOAD} = 1mA		6		6		6		6		6	mV
Load Regulation	V_{IN} = 2.3V, ΔI_{LOAD} = 1mA to 0.9A (Note 4)		8		8		9		10		12	mV
Dropout Voltage (Notes 6, 7, 12)	I_{LOAD} = 1mA I_{LOAD} = 100mA I_{LOAD} = 500mA I_{LOAD} = 0.9A		80 185 300 435		80 185 300 440		80 186 305 450		80 188 310 455		80 190 320 465	mV mV mV mV
GND Pin Current V_{IN} = $V_{OUT(NOMINAL)}$ + 1V (Notes 6, 8)	I_{LOAD} = 0mA I_{LOAD} = 1mA I_{LOAD} = 100mA I_{LOAD} = 500mA I_{LOAD} = 0.9A		0.85 1.1 4.8 17 31		0.85 1.1 4.9 18 32		0.85 1.1 5.2 19 34		0.85 1.1 6 21 38		0.85 1.1 7 25 45	mA mA mA mA mA
Output Voltage Noise	V_{OUT} = 2.5V, C_{OUT} = 10µF, I_{LOAD} = 0.9A, BW = 10Hz to 100kHz	TYP = 40		TYP = 40		TYP = 40		TYP = 40		TYP = 40		μV_{RMS}
ADJ Pin Bias Current (Notes 4, 9)			4.5		4.5		4.5		4.5		4.5	µA
Shutdown Threshold	V_{OUT} = Off to On V_{OUT} = On to Off	 0.37	1.5	 0.37	1.5	 0.37	1.5	 0.37	1.5	 0.37	1.5	V V
$\overline{SHDN}$ Pin Current (Note 10)	$V_{\overline{SHDN}}$ = 0V $V_{\overline{SHDN}}$ = 20V		1 10		1 10		1 10		1 10		1 10	µA µA
Quiescent Current in Shutdown	V_{IN} = 6V, $V_{\overline{SHDN}}$ = 0V		1		1		1		1		1	µA
Ripple Rejection	V_{IN} = 2.7V + 0.5V_{P-P}, V_{OUT} = 1.2V f_{RIPPLE} = 120Hz, I_{LOAD} = 0.75A	56		55		54		52		50		dB
Current Limit	V_{IN} = $V_{OUT(NOMINAL)}$ + 1V, ΔV_{OUT} = –0.1V	1.0		1.0		1.0		1.0		1.0		A
Input Reverse-Leakage Current	V_{IN} = –20V, V_{OUT} = 0V		1		1		1		1		1	mA
Reverse-Output Current (Note 11)	V_{OUT} = 1.2V, V_{IN} = 0V (Note 4)		400		400		400		400		400	µA

Note 1: Stresses beyond those listed under Absolute Maximum Ratings may cause permanent damage to the device. Exposure to any Absolute Maximum Rating condition for extended periods may affect device reliability and lifetime.

Note 2: Absolute maximum input to output differential voltage is not achievable with all combinations of rated IN pin and OUT pin voltages. With the IN pin at 22V, the OUT pin may not be pulled below 0V. The total measured voltage from IN to OUT must not exceed ±22V.

Note 3: The RH1965MK DICE is tested and specified under pulse load conditions such that $T_J \cong T_A$.

Note 4: The RH1965MK DICE is tested and specified for these conditions with the ADJ pin connected to the output.

Note 5: Maximum junction temperature limits operating conditions. The regulated output voltage specification does not apply for all possible combinations of input voltage and output current. Limit the output current range if operating at the maximum input voltage. Limit the input-to-output voltage differential if operating at the maximum output current.

Note 6: To satisfy minimum input voltage requirements, the RH1965MK DICE is tested and specified for these conditions with an external resistor divider (bottom 4.02k, top 4.32k) for an output voltage of 2.5V. The external resistor divider adds 300µA of output DC load current. This external current is not factored into GND pin current.

Note 7: Dropout voltage is the minimum input-to-output voltage differential needed to maintain regulation at a specified output current. In dropout, the output voltage equals: (V_{IN} – $V_{DROPOUT}$).

ELECTRICAL CHARACTERISTICS

Note 8: GND pin current is tested with $V_{IN} = V_{OUT(NOMINAL)} + 1V$ and a current source load. GND pin current increases slightly in dropout.

Note 9: ADJ pin bias current flows into the ADJ pin.

Note 10: $\overline{SHDN}$ pin current flows into the $\overline{SHDN}$ pin.

Note 11: Reverse-output current is tested with the IN pin grounded and the OUT pin forced to 1.2V. This current flows into the OUT pin and out of the GND pin.

Note 12: The minimum input voltage specification limits the dropout voltage under some output voltage/load conditions

Note 13: This IC includes overtemperature protection that is intended to protect the device during momentary overload conditions. Junction temperature exceeds the maximum junction temperature when overtemperature protection is active. Continuous operation above the specified maximum operating junction temperature may impair device reliability.

Note 14: Dice are probe tested at 25°C to the limits shown in Table 1. Except for high current tests, dice are tested under low current conditions which assure full load current specifications when assembled.

Note 15: Dice that are not qualified by Linear Technology with a can sample are guaranteed to meet specifications of Table 1 only. Dice qualified by Linear Technology with a can sample meet specifications in all tables.

Note 16: Please refer to the LT1965 standard product data sheet for Typical Performance Characteristics, Pin Functions, Applications Information, and Typical Applications.

TABLE 4. POST BURN-IN ENDPOINTS AND DELTA LIMIT REQUIREMENTS $T_A = 25°C$

PARAMETER	CONDITIONS	ENDPOINT LIMITS MIN	ENDPOINT LIMITS MAX	DELTA LIMITS MIN	DELTA LIMITS MAX	UNITS
ADJ Pin Voltage (Notes 4, 5)	$V_{IN} = 2.1V$, $I_{LOAD} = 1mA$	1.182	1.218	–0.010	0.010	V
ADJ Pin Bias Current (Notes 4, 9)			4.5	–0.4	0.4	µA

TABLE 5. ELECTRICAL TEST REQUIREMENTS

MIL-STD-883 TEST REQUIREMENTS	SUBGROUP
Final Electrical Test Requirements (Method 5004)	1*, 2, 3
Group A Test Requirements (Method 5005)	1, 2, 3
Group B and D for Class S, End Point Electrical Parameters (Method 5005)	1, 2, 3

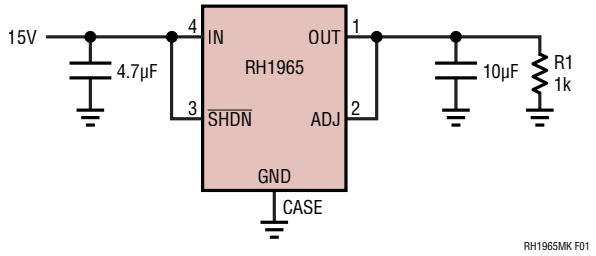
*PDA applies to subgroup 1. See PDA Test Notes.

PDA Test Notes

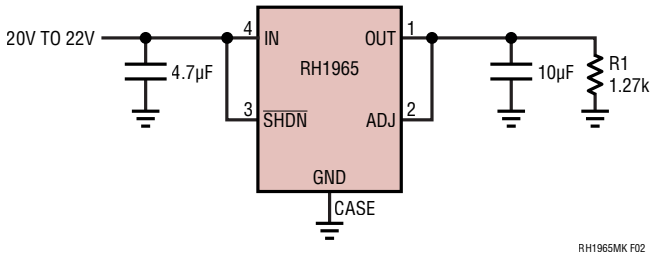
The PDA is specified as 5% based on failures from group A, subgroup 1, tests after cooldown as the final electrical test in accordance with method 5004 of MIL-STD-883. The verified failures of group A, subgroup 1, after burn-in divided by the total number of devices submitted for burn-in in that lot shall be used to determine the percent for the lot.

Linear Technology Corporation reserves the right to test to tighter limits than those given.

TOTAL DOSE BIAS CIRCUIT

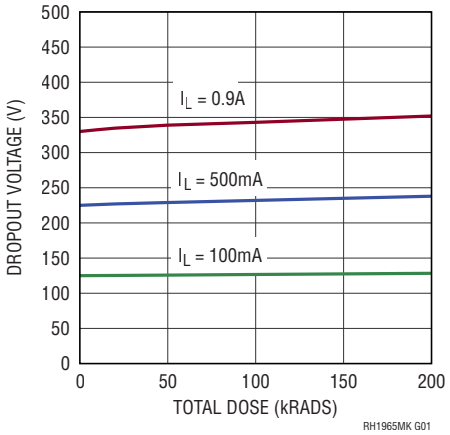


BURN-IN CIRCUIT

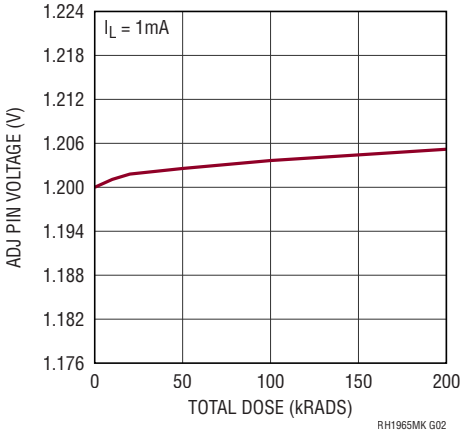


TYPICAL PERFORMANCE CHARACTERISTICS T_A = 25°C

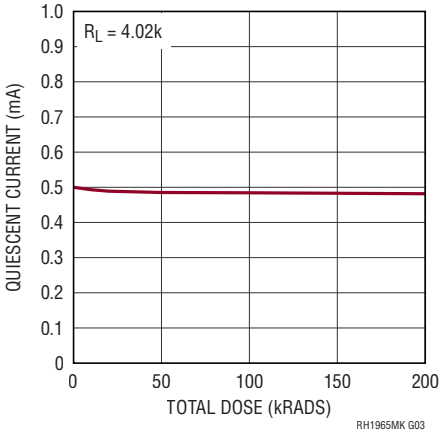
Dropout Voltage



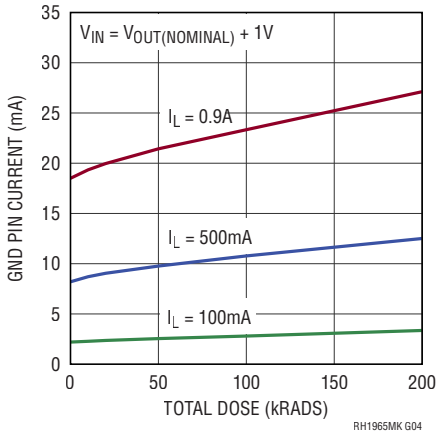
ADJ Pin Voltage



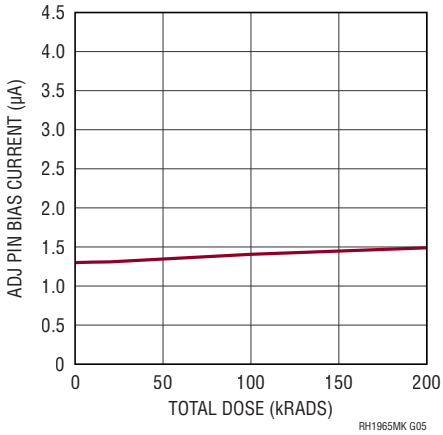
Quiescent Current



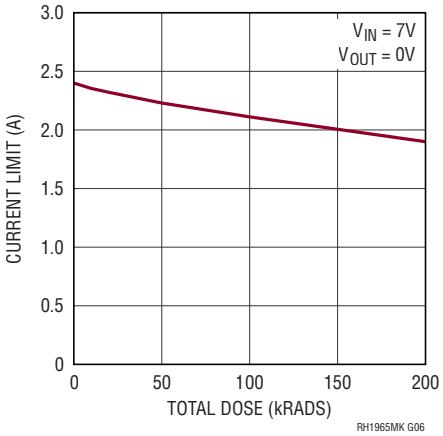
GND Pin Current



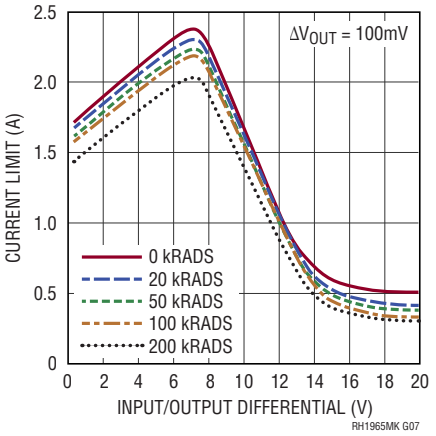
ADJ Pin Bias Current



Current Limit

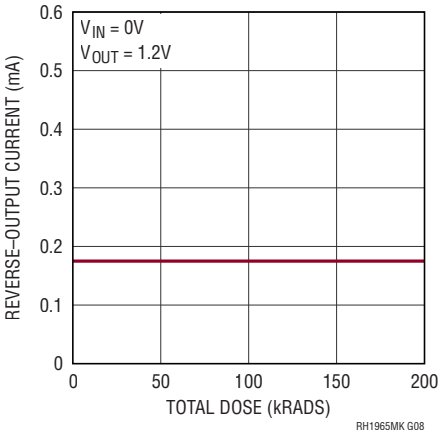


Current Limit vs $V_{IN} - V_{OUT}$

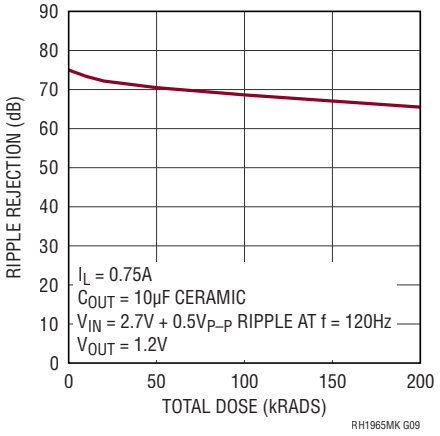


TYPICAL PERFORMANCE CHARACTERISTICS T_A = 25°C

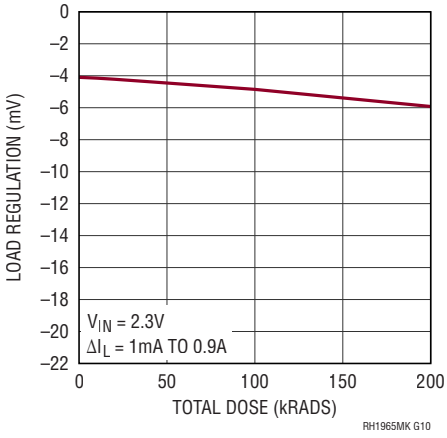
Reverse-Output Current



Ripple Rejection



Load Regulation



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