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LM4040/LM4041

Precision Micropower Shunt Voltage Reference

Features

- Small SOT-23 Package
- No Output Capacitor Required
- Tolerates Capacitive Loads
- Fixed Reverse-Breakdown Voltages of 1.225V, 2.500V, 4.096V, and 5.000V
- Adjustable Reverse-Breakdown Version

Applications

- Battery-Powered Equipment
- Data Acquisition Systems
- Instrumentation
- Process Control
- Energy Management
- Product Testing
- Automotive Electronics
- Precision Audio Components

General Description

Ideal for space critical applications, the LM4040 and LM4041 precision voltage references are available in the subminiature SOT-23 surface-mount package.

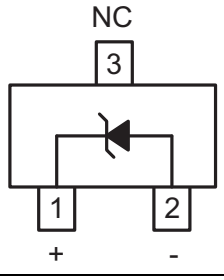
The LM4040 is available in fixed reverse-breakdown voltages of 2.500V, 4.096V, and 5.000V. The LM4041 is available with a fixed 1.225V or an adjustable reverse-breakdown voltage.

The minimum operating current ranges from 60 µA for the LM4041-1.2 to 74 µA for the LM4040-5.0. LM4040 versions have a maximum operating current of 15 mA. LM4041 versions have a maximum operating current of 12 mA.

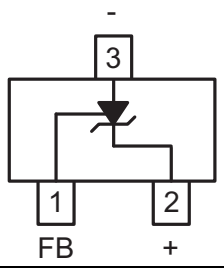
The LM4040 and LM4041 have bandgap reference temperature drift curvature correction and low dynamic impedance, ensuring stable reverse-breakdown voltage accuracy over a wide range of operating temperatures and currents.

Package Types

LM4040/LM4041 (FIXED VERSION)
3-Pin SOT-23



LM4041 (ADJUSTABLE VERSION)
3-Pin SOT-23



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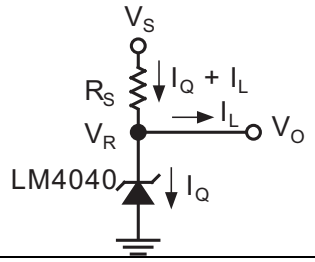
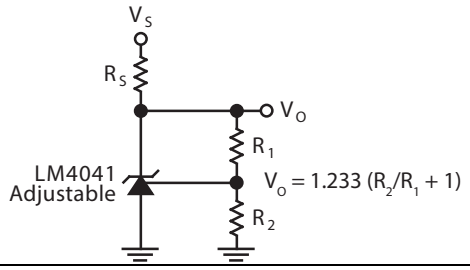
Typical Application Diagrams

LM4040/LM4041 Fixed Shunt Regulator Application

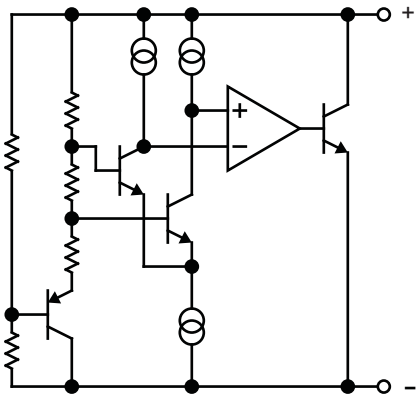


LM4041 Adjustable Shunt Regulator Application

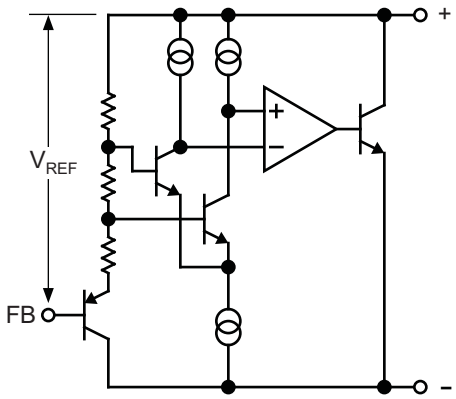


Functional Block Diagrams

LM4040/LM4041 Fixed



LM4041 Adjustable



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1.0 ELECTRICAL CHARACTERISTICS

Absolute Maximum Ratings †

Reverse Current ..... 20 mA
Forward Current ..... 10 mA
Maximum Output Voltage (LM4041-ADJ) 15V
Power Dissipation (T_A = +25°C; Note 1) ..... 306 mW
ESD Susceptibility (HBM; Note 2) ..... 2 kV
ESD Susceptibility (MM; Note 2) 200V

Operating Ratings ‡

Reverse Current (LM4040-2.5) ..... 60 µA to 15 mA
Reverse Current (LM4040-4.1) ..... 68 µA to 15 mA
Reverse Current (LM4040-5.0) ..... 74 µA to 15 mA
Reverse Current (LM4041-1.2) ..... 60 µA to 12 mA
Reverse Current (LM4040-ADJ) ..... 60 µA to 12 mA
Output Voltage Range (LM4041-ADJ) ..... 1.24V to 10V

† Notice: Stresses above those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. This is a stress rating only and functional operation of the device at those or any other conditions above those indicated in the operational sections of this specification is not intended. Exposure to maximum rating conditions for extended periods may affect device reliability.

‡ Notice: The device is not guaranteed to function outside its operating ratings.

Note 1: The maximum power dissipation must be derated at elevated temperatures and is dictated by T_{JMAX} (maximum junction temperature), Θ_{JA} (junction-to-ambient thermal resistance), and T_A (ambient temperature). The maximum allowable power dissipation at any temperature is $P_{DMAX} = (T_{JMAX} – T_A)/ \Theta_{JA}$ or the number given in the Absolute Maximum Ratings, whichever is lower. For the LM4040 and LM4041, T_{JMAX} = +125°C and the typical thermal resistance, when board-mounted, is +326°C/W for the SOT-23 package.

2: Devices are ESD sensitive. Handling precautions are recommended. Human body model, 1.5 kΩ in series with 100 pF. The machine model is a 200 pF capacitor discharged directly into each pin.

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LM4040-2.5 ELECTRICAL CHARACTERISTICS (Note 1)

T_A = Operating Temperature Range, $T_A = T_J$ = –40°C to +85°C, unless noted.

Parameters	Sym.	Min.	Typ.	Max.	Units	Conditions
LM4040C						
Reverse-Breakdown Voltage	V_R	—	2.500	—	V	I_R = 100 µA, T_A = +25°C
Reverse-Breakdown Voltage Tolerance (Note 2)		—	—	±12	mV	I_R = 100 µA, T_A = +25°C
		—	—	±29	mV	I_R = 100 µA
Minimum Operating Current	I_{RMIN}	—	45	60	µA	T_A = +25°C
		—	—	65		—
Average Reverse-Breakdown Voltage Temperature Coefficient	$\Delta V_R/\Delta_T$	—	±20	—	ppm/°C	I_R = 10 mA, T_A = +25°C
		—	±15	±100		I_R = 1 mA
		—	±15	—		I_R = 100 µA, T_A = +25°C
Reverse-Breakdown Voltage Change with Operating Current Change	$\Delta V_R/\Delta I_R$	—	0.3	0.8	mV	$I_{RMIN} \le I_R \le$ 1 mA, T_A = +25°C
		—	—	1.0		$I_{RMIN} \le I_R \le$ 1 mA
		—	2.5	6.0		1 mA ≤ I_R ≤ 15 mA, T_A = +25°C
		—	—	8.0		1 mA ≤ I_R ≤ 15 mA
Reverse Dynamic Impedance	Z_R	—	0.3	0.9	Ω	I_R = 1 mA, f = 120 Hz, $I_{AC} = 0.1\ I_R$, T_A = +25°C
Wideband Noise	e_N	—	35	—	μV_{RMS}	I_R = 100 µA, T_A = +25°C, 10 Hz ≤ f ≤ 10 kHz
Reverse-Breakdown Voltage Long-Term Stability	ΔV_R	—	120	—	ppm	t = 1000 hrs., T_A = +25°C ±0.1°C, I_R = 100 µA
LM4040D						
Reverse-Breakdown Voltage	V_R	—	2.500	—	V	I_R = 100 µA, T_A = +25°C
Reverse-Breakdown Voltage Tolerance (Note 2)		—	—	±25	mV	I_R = 100 µA, T_A = +25°C
		—	—	±49	mV	I_R = 100 µA
Minimum Operating Current	I_{RMIN}	—	45	65	µA	T_A = +25°C
		—	—	70		—
Average Reverse-Breakdown Voltage Temperature Coefficient	$\Delta V_R/\Delta_T$	—	±20	—	ppm/°C	I_R = 10 mA, T_A = +25°C
		—	±15	±150		I_R = 1 mA
		—	±15	—		I_R = 100 µA, T_A = +25°C

Note 1: Specification for packaged product only.

2: The boldface (overtemperature) limit for Reverse-Breakdown Voltage Tolerance is defined as the room temperature Reverse-Breakdown Voltage Tolerance ±[($\Delta V_R/\Delta T$)(65°C)(V_R)]. $\Delta V_R/\Delta T$ is the V_R temperature coefficient, 65°C is the temperature range from –40°C to the reference point of 25°C, and V_R is the reverse-breakdown voltage. The total overtemperature tolerance for the different grades follows:

a. C-grade: ±1.15% = ±0.5% ±100 ppm/°C × 65°C

b. D-grade: ±1.98% = ±1.0% ±150 ppm/°C × 65°C

Example: The C-grade LM4040-2.5 has an overtemperature Reverse-Breakdown Voltage tolerance of ±2.5 × 1.15% = ±29 mV.

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LM4040-2.5 ELECTRICAL CHARACTERISTICS (Note 1) (CONTINUED)

T_A = Operating Temperature Range, $T_A = T_J$ = –40°C to +85°C, unless noted.

Parameters	Sym.	Min.	Typ.	Max.	Units	Conditions
Reverse-Breakdown Voltage Change with Operating Current Change	$\Delta V_R/\Delta I_R$	—	0.3	1.0	mV	$I_{RMIN} \le I_R \le 1$ mA, T_A = +25°C
		—	—	1.2		$I_{RMIN} \le I_R \le 1$ mA
		—	2.5	8.0		1 mA ≤ I_R ≤ 15 mA, T_A = +25°C
		—	—	10.0		1 mA ≤ I_R ≤ 15 mA
Reverse Dynamic Impedance	Z_R	—	0.3	1.1	Ω	I_R = 1 mA, f = 120 Hz, $I_{AC} = 0.1\ I_R$, T_A = +25°C
Wideband Noise	e_N	—	35	—	μV_{RMS}	I_R = 100 µA, 10 Hz ≤ f ≤ 10 kHz
Reverse-Breakdown Voltage Long-Term Stability	ΔV_R	—	120	—	ppm	t = 1000 hrs., T_A = +25°C ±0.1°C, I_R = 100 µA

Note 1: Specification for packaged product only.

2: The boldface (overtemperature) limit for Reverse-Breakdown Voltage Tolerance is defined as the room temperature Reverse-Breakdown Voltage Tolerance ±[($\Delta V_R/\Delta T$)(65°C)(V_R)]. $\Delta V_R/\Delta T$ is the V_R temperature coefficient, 65°C is the temperature range from –40°C to the reference point of 25°C, and V_R is the reverse-breakdown voltage. The total overtemperature tolerance for the different grades follows:

a. C-grade: ±1.15% = ±0.5% ±100 ppm/°C × 65°C

b. D-grade: ±1.98% = ±1.0% ±150 ppm/°C × 65°C

Example: The C-grade LM4040-2.5 has an overtemperature Reverse-Breakdown Voltage tolerance of ±2.5 × 1.15% = ±29 mV.

LM4040-4.1 ELECTRICAL CHARACTERISTICS (Note 1)

T_A = Operating Temperature Range, $T_A = T_J$ = –40°C to +85°C, unless noted.

Parameters	Sym.	Min.	Typ.	Max.	Units	Conditions
LM4040C						
Reverse-Breakdown Voltage	V_R	—	4.096	—	V	I_R = 100 µA, T_A = +25°C
Reverse-Breakdown Voltage Tolerance (Note 2)		—	—	±20	mV	I_R = 100 µA, T_A = +25°C
		—	—	±47	mV	I_R = 100 µA
Minimum Operating Current	I_{RMIN}	—	50	68	µA	T_A = +25°C
		—	—	73		—
Average Reverse-Breakdown Voltage Temperature Coefficient	$\Delta V_R/\Delta_T$	—	±30	—	ppm/°C	I_R = 10 mA, T_A = +25°C
		—	±20	±100		I_R = 1 mA
		—	±20	—		I_R = 100 µA, T_A = +25°C
Reverse-Breakdown Voltage Change with Operating Current Change	$\Delta V_R/\Delta I_R$	—	0.5	0.9	mV	$I_{RMIN} \le I_R \le$ 1 mA, T_A = +25°C
		—	—	1.2		$I_{RMIN} \le I_R \le$ 1 mA
		—	3.0	7.0		1 mA ≤ I_R ≤ 15 mA, T_A = +25°C
		—	—	10.0		1 mA ≤ I_R ≤ 15 mA
Reverse Dynamic Impedance	Z_R	—	0.5	1.0	Ω	I_R = 1 mA, f = 120 Hz, $I_{AC} = 0.1\ I_R$, T_A = +25°C
Wideband Noise	e_N	—	80	—	μV_{RMS}	I_R = 100 µA, T_A = +25°C, 10 Hz ≤ f ≤ 10 kHz
Reverse-Breakdown Voltage Long-Term Stability	ΔV_R	—	120	—	ppm	t = 1000 hrs., T_A = +25°C ±0.1°C, I_R = 100 µA
LM4040D						
Reverse-Breakdown Voltage	V_R	—	4.096	—	V	I_R = 100 µA, T_A = +25°C
Reverse-Breakdown Voltage Tolerance (Note 2)		—	—	±41	mV	I_R = 100 µA, T_A = +25°C
		—	—	±81	mV	I_R = 100 µA
Minimum Operating Current	I_{RMIN}	—	50	73	µA	T_A = +25°C
		—	—	78		—
Average Reverse-Breakdown Voltage Temperature Coefficient	$\Delta V_R/\Delta_T$	—	±30	—	ppm/°C	I_R = 10 mA, T_A = +25°C
		—	±20	±150		I_R = 1 mA
		—	±20	—		I_R = 100 µA, T_A = +25°C

Note 1: Specification for packaged product only.

2: The boldface (overtemperature) limit for Reverse-Breakdown Voltage Tolerance is defined as the room temperature Reverse-Breakdown Voltage Tolerance ±[($\Delta V_R/\Delta T$)(65°C)(V_R)]. $\Delta V_R/\Delta T$ is the V_R temperature coefficient, 65°C is the temperature range from –40°C to the reference point of 25°C, and V_R is the reverse-breakdown voltage. The total overtemperature tolerance for the different grades follows:

a. C-grade: ±1.15% = ±0.5% ±100 ppm/°C × 65°C

b. D-grade: ±1.98% = ±1.0% ±150 ppm/°C × 65°C

Example: The C-grade LM4040-2.5 has an overtemperature Reverse-Breakdown Voltage tolerance of ±2.5 × 1.15% = ±29 mV.

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LM4040-4.1 ELECTRICAL CHARACTERISTICS (Note 1) (CONTINUED)

T_A = Operating Temperature Range, $T_A = T_J$ = –40°C to +85°C, unless noted.

Parameters	Sym.	Min.	Typ.	Max.	Units	Conditions
Reverse-Breakdown Voltage Change with Operating Current Change	$\Delta V_R/\Delta I_R$	—	0.5	1.2	mV	$I_{RMIN} \le I_R \le 1$ mA, T_A = +25°C
		—	—	1.5		$I_{RMIN} \le I_R \le 1$ mA
		—	3.0	9.0		1 mA ≤ I_R ≤ 15 mA, T_A = +25°C
		—	—	13.0		1 mA ≤ I_R ≤ 15 mA
Reverse Dynamic Impedance	Z_R	—	0.5	1.3	Ω	I_R = 1 mA, f = 120 Hz, $I_{AC} = 0.1\ I_R$, T_A = +25°C
Wideband Noise	e_N	—	80	—	μV_{RMS}	I_R = 100 µA, T_A = +25°C 10 Hz ≤ f ≤ 10 kHz
Reverse-Breakdown Voltage Long-Term Stability	ΔV_R	—	120	—	ppm	t = 1000 hrs., T_A = +25°C ±0.1°C, I_R = 100 µA

Note 1: Specification for packaged product only.

2: The boldface (overtemperature) limit for Reverse-Breakdown Voltage Tolerance is defined as the room temperature Reverse-Breakdown Voltage Tolerance ±[($\Delta V_R/\Delta T$)(65°C)(V_R)]. $\Delta V_R/\Delta T$ is the V_R temperature coefficient, 65°C is the temperature range from –40°C to the reference point of 25°C, and V_R is the reverse-breakdown voltage. The total overtemperature tolerance for the different grades follows:

a. C-grade: ±1.15% = ±0.5% ±100 ppm/°C × 65°C

b. D-grade: ±1.98% = ±1.0% ±150 ppm/°C × 65°C

Example: The C-grade LM4040-2.5 has an overtemperature Reverse-Breakdown Voltage tolerance of ±2.5 × 1.15% = ±29 mV.

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LM4040-5.0 ELECTRICAL CHARACTERISTICS (Note 1)

T_A = Operating Temperature Range, $T_A = T_J$ = –40°C to +85°C, unless noted.

Parameters	Sym.	Min.	Typ.	Max.	Units	Conditions
LM4040C						
Reverse-Breakdown Voltage	V_R	—	5.000	—	V	I_R = 100 µA, T_A = +25°C
Reverse-Breakdown Voltage Tolerance (Note 2)		—	—	±25	mV	I_R = 100 µA, T_A = +25°C
		—	—	±58	mV	I_R = 100 µA
Minimum Operating Current	I_{RMIN}	—	54	74	µA	T_A = +25°C
		—	—	80		—
Average Reverse-Breakdown Voltage Temperature Coefficient	$\Delta V_R/\Delta_T$	—	±30	—	ppm/°C	I_R = 10 mA, T_A = +25°C
		—	±20	±100		I_R = 1 mA
		—	±20	—		I_R = 100 µA, T_A = +25°C
Reverse-Breakdown Voltage Change with Operating Current Change	$\Delta V_R/\Delta I_R$	—	0.5	1.0	mV	$I_{RMIN} \le I_R \le$ 1 mA, T_A = +25°C
		—	—	1.4		$I_{RMIN} \le I_R \le$ 1 mA
		—	3.5	8.0		1 mA ≤ I_R ≤ 15 mA, T_A = +25°C
		—	—	12.0		1 mA ≤ I_R ≤ 15 mA
Reverse Dynamic Impedance	Z_R	—	0.5	1.1	Ω	I_R = 1 mA, f = 120 Hz, $I_{AC} = 0.1\ I_R$, T_A = +25°C
Wideband Noise	e_N	—	80	—	μV_{RMS}	I_R = 100 µA, T_A = +25°C, 10 Hz ≤ f ≤ 10 kHz
Reverse-Breakdown Voltage Long-Term Stability	ΔV_R	—	120	—	ppm	t = 1000 hrs., T_A = +25°C ±0.1°C, I_R = 100 µA
LM4040D						
Reverse-Breakdown Voltage	V_R	—	5.000	—	V	I_R = 100 µA, T_A = +25°C
Reverse-Breakdown Voltage Tolerance (Note 2)		—	—	±50	mV	I_R = 100 µA, T_A = +25°C
		—	—	±99	mV	I_R = 100 µA
Minimum Operating Current	I_{RMIN}	—	54	79	µA	T_A = +25°C
		—	—	85		—
Average Reverse-Breakdown Voltage Temperature Coefficient	$\Delta V_R/\Delta_T$	—	±30	—	ppm/°C	I_R = 10 mA, T_A = +25°C
		—	±20	±150		I_R = 1 mA
		—	±20	—		I_R = 100 µA, T_A = +25°C

Note 1: Specification for packaged product only.

2: The boldface (overtemperature) limit for Reverse-Breakdown Voltage Tolerance is defined as the room temperature Reverse-Breakdown Voltage Tolerance ±[($\Delta V_R/\Delta T$)(65°C)(V_R)]. $\Delta V_R/\Delta T$ is the V_R temperature coefficient, 65°C is the temperature range from –40°C to the reference point of 25°C, and V_R is the reverse-breakdown voltage. The total overtemperature tolerance for the different grades follows:

a. C-grade: ±1.15% = ±0.5% ±100 ppm/°C × 65°C

b. D-grade: ±1.98% = ±1.0% ±150 ppm/°C × 65°C

Example: The C-grade LM4040-2.5 has an overtemperature Reverse-Breakdown Voltage tolerance of ±2.5 × 1.15% = ±29 mV.

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LM4040-5.0 ELECTRICAL CHARACTERISTICS (Note 1) (CONTINUED)

T_A = Operating Temperature Range, $T_A = T_J$ = –40°C to +85°C, unless noted.

Parameters	Sym.	Min.	Typ.	Max.	Units	Conditions
Reverse-Breakdown Voltage Change with Operating Current Change	$\Delta V_R/\Delta I_R$	—	0.5	1.3	mV	$I_{RMIN} \le I_R \le 1$ mA, T_A = +25°C
		—	—	1.8		$I_{RMIN} \le I_R \le 1$ mA
		—	3.5	10.0		1 mA ≤ I_R ≤ 15 mA, T_A = +25°C
		—	—	15.0		1 mA ≤ I_R ≤ 15 mA
Reverse Dynamic Impedance	Z_R	—	0.5	1.5	Ω	I_R = 1 mA, f = 120 Hz, $I_{AC} = 0.1\ I_R$, T_A = +25°C
Wideband Noise	e_N	—	80	—	μV_{RMS}	I_R = 100 µA, T_A = +25°C, 10 Hz ≤ f ≤ 10 kHz
Reverse-Breakdown Voltage Long-Term Stability	ΔV_R	—	120	—	ppm	t = 1000 hrs., T_A = +25°C ±0.1°C, I_R = 100 µA

Note 1: Specification for packaged product only.

2: The boldface (overtemperature) limit for Reverse-Breakdown Voltage Tolerance is defined as the room temperature Reverse-Breakdown Voltage Tolerance ±[($\Delta V_R/\Delta T$)(65°C)(V_R)]. $\Delta V_R/\Delta T$ is the V_R temperature coefficient, 65°C is the temperature range from –40°C to the reference point of 25°C, and V_R is the reverse-breakdown voltage. The total overtemperature tolerance for the different grades follows:

a. C-grade: ±1.15% = ±0.5% ±100 ppm/°C × 65°C

b. D-grade: ±1.98% = ±1.0% ±150 ppm/°C × 65°C

Example: The C-grade LM4040-2.5 has an overtemperature Reverse-Breakdown Voltage tolerance of ±2.5 × 1.15% = ±29 mV.

LM4041-1.2 ELECTRICAL CHARACTERISTICS (Note 1)

T_A = Operating Temperature Range, $T_A = T_J$ = –40°C to +85°C, unless noted.

Parameters	Sym.	Min.	Typ.	Max.	Units	Conditions
LM4041C						
Reverse-Breakdown Voltage	V_R	—	1.225	—	V	I_R = 100 µA, T_A = +25°C
Reverse-Breakdown Voltage Tolerance (Note 2)		—	—	±6	mV	I_R = 100 µA, T_A = +25°C
		—	—	±14	mV	I_R = 100 µA
Minimum Operating Current	I_{RMIN}	—	45	60	µA	T_A = +25°C
		—	—	65		—
Average Reverse-Breakdown Voltage Temperature Coefficient	$\Delta V_R/\Delta_T$	—	±20	—	ppm/°C	I_R = 10 mA, T_A = +25°C
		—	±15	±100		I_R = 1 mA
		—	±15	—		I_R = 100 µA, T_A = +25°C
Reverse-Breakdown Voltage Change with Operating Current Change	$\Delta V_R/\Delta I_R$	—	0.7	1.5	mV	$I_{RMIN} \le I_R \le$ 1 mA, T_A = +25°C
		—	—	2.0		$I_{RMIN} \le I_R \le$ 1 mA
		—	4.0	6.0		1 mA ≤ I_R ≤ 15 mA, T_A = +25°C
		—	—	8.0		1 mA ≤ I_R ≤ 15 mA
Reverse Dynamic Impedance	Z_R	—	0.5	1.5	Ω	I_R = 1 mA, f = 120 Hz, $I_{AC} = 0.1\ I_R$, T_A = +25°C
Wideband Noise	e_N	—	20	—	μV_{RMS}	I_R = 100 µA, T_A = +25°C, 10 Hz ≤ f ≤ 10 kHz
Reverse-Breakdown Voltage Long-Term Stability	ΔV_R	—	120	—	ppm	t = 1000 hrs., T_A = +25°C ±0.1°C, I_R = 100 µA
LM4041D						
Reverse-Breakdown Voltage	V_R	—	1.225	—	V	I_R = 100 µA, T_A = +25°C
Reverse-Breakdown Voltage Tolerance (Note 2)		—	—	±12	mV	I_R = 100 µA, T_A = +25°C
		—	—	±24		I_R = 100 µA
Minimum Operating Current	I_{RMIN}	—	45	65	µA	T_A = +25°C
		—	—	70		—
Average Reverse-Breakdown Voltage Temperature Coefficient	$\Delta V_R/\Delta_T$	—	±20	—	ppm/°C	I_R = 10 mA, T_A = +25°C
		—	±15	±150		I_R = 1 mA
		—	±15	—		I_R = 100 µA, T_A = +25°C

Note 1: Specification for packaged product only.

2: The boldface (overtemperature) limit for Reverse-Breakdown Voltage Tolerance is defined as the room temperature Reverse-Breakdown Voltage Tolerance ±[($\Delta V_R/\Delta T$)(65°C)(V_R)]. $\Delta V_R/\Delta T$ is the V_R temperature coefficient, 65°C is the temperature range from –40°C to the reference point of 25°C, and V_R is the reverse-breakdown voltage. The total overtemperature tolerance for the different grades follows:

a. C-grade: ±1.15% = ±0.5% ±100 ppm/°C × 65°C

b. D-grade: ±1.98% = ±1.0% ±150 ppm/°C × 65°C

Example: The C-grade LM4040-2.5 has an overtemperature Reverse-Breakdown Voltage tolerance of ±2.5 × 1.15% = ±29 mV.

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LM4041-1.2 ELECTRICAL CHARACTERISTICS (Note 1) (CONTINUED)

T_A = Operating Temperature Range, $T_A = T_J$ = –40°C to +85°C, unless noted.

Parameters	Sym.	Min.	Typ.	Max.	Units	Conditions
Reverse-Breakdown Voltage Change with Operating Current Change	$\Delta V_R/\Delta I_R$	—	0.7	2.0	mV	$I_{RMIN} \le I_R \le 1$ mA, T_A = +25°C
		—	—	2.5		$I_{RMIN} \le I_R \le 1$ mA
		—	2.5	8.0		1 mA ≤ I_R ≤ 15 mA, T_A = +25°C
		—	—	10.0		1 mA ≤ I_R ≤ 15 mA
Reverse Dynamic Impedance	Z_R	—	0.5	2.0	Ω	I_R = 1 mA, f = 120 Hz, $I_{AC} = 0.1\ I_R$, T_A = +25°C
Wideband Noise	e_N	—	20	—	μV_{RMS}	I_R = 100 µA, T_A = +25°C, 10 Hz ≤ f ≤ 10 kHz
Reverse-Breakdown Voltage Long-Term Stability	ΔV_R	—	120	—	ppm	t = 1000 hrs., T_A = +25°C ±0.1°C, I_R = 100 µA

Note 1: Specification for packaged product only.

2: The boldface (overtemperature) limit for Reverse-Breakdown Voltage Tolerance is defined as the room temperature Reverse-Breakdown Voltage Tolerance ±[($\Delta V_R/\Delta T$)(65°C)(V_R)]. $\Delta V_R/\Delta T$ is the V_R temperature coefficient, 65°C is the temperature range from –40°C to the reference point of 25°C, and V_R is the reverse-breakdown voltage. The total overtemperature tolerance for the different grades follows:

a. C-grade: ±1.15% = ±0.5% ±100 ppm/°C × 65°C

b. D-grade: ±1.98% = ±1.0% ±150 ppm/°C × 65°C

Example: The C-grade LM4040-2.5 has an overtemperature Reverse-Breakdown Voltage tolerance of ±2.5 × 1.15% = ±29 mV.

LM4041-ADJ ELECTRICAL CHARACTERISTICS (Note 1)

T_A = Operating Temperature Range, $T_A = T_J$ = –40°C to +85°C, unless noted.

Parameters	Sym.	Min.	Typ.	Max.	Units	Conditions
LM4041C						
Reverse-Breakdown Voltage	V_R	—	1.233	—	V	I_R = 100 µA, V_{OUT} = 5V
Reverse-Breakdown Voltage Tolerance (Note 2)		—	—	±6.2	mV	I_R = 100 µA, T_A = +25°C
		—	—	±14	mV	I_R = 100 µA
Minimum Operating Current	I_{RMIN}	—	45	60	µA	T_A = +25°C
		—	—	65		—
Reference Voltage Change with Operating Current	$\Delta V_{REF}/\Delta I_R$	—	0.7	1.5	mV	$I_{RMIN} \le I_R \le 1$ mA, $V_{OUT} \ge 1.6V$ (Note 3), T_A = +25°C
		—	—	2.0		$I_{RMIN} \le I_R \le 1$ mA, $V_{OUT} \ge 1.6V$ (Note 3)
		—	2.0	4.0		1 mA ≤ I_R ≤ 15 mA, $V_{OUT} \ge 1.6V$ (Note 3), T_A = +25°C
		—	—	6.0		1 mA ≤ I_R ≤ 15 mA, $V_{OUT} \ge 1.6V$ (Note 3)
Reference Voltage Change with Output Voltage Change	$\Delta V_{REF}/\Delta V_O$	—	–1.55	–2.0	mV/V	I_R = 1 mA, T_A = +25°C
		—	—	–2.5		I_R = 1 mA
Feedback Current	I_{FB}	—	60	100	nA	T_A = +25°C
		—	—	120		—
Average Reference Voltage Temperature Coefficient	$\Delta V_{REF}/\Delta T$	—	±20	—	ppm/°C	V_{OUT} = 5V, I_R = 10 mA, T_A = +25°C
		—	±15	±100		V_{OUT} = 5V, I_R = 1 mA
		—	±15	—		V_{OUT} = 5V, I_R = 100 µA, T_A = +25°C
Dynamic Output Impedance	Z_{OUT}	—	0.3	—	Ω	I_R = 1 mA, f = 120 Hz, T_A = +25°C, $I_{AC} = 0.1\ I_R$, $V_{OUT} = V_{REF}$
		—	—	2.0		V_{OUT} = 10V, T_A = +25°C
Wideband Noise	e_N	—	20	—	μV_{RMS}	I_R = 100 µA, T_A = +25°C, 10 Hz ≤ f ≤ 10 kHz

Note 1: Specification for packaged product only.

2: The boldface (overtemperature) limit for Reverse-Breakdown Voltage Tolerance is defined as the room temperature Reverse-Breakdown Voltage Tolerance ±[($\Delta V_R/\Delta T$)(65°C)(V_R)]. $\Delta V_R/\Delta T$ is the V_R temperature coefficient, 65°C is the temperature range from –40°C to the reference point of 25°C, and V_R is the reverse-breakdown voltage. The total overtemperature tolerance for the different grades follows:

a. C-grade: ±1.15% = ±0.5% ±100 ppm/°C × 65°C

b. D-grade: ±1.98% = ±1.0% ±150 ppm/°C × 65°C

Example: The C-grade LM4040-2.5 has an overtemperature Reverse-Breakdown Voltage tolerance of ±2.5 × 1.15% = ±29 mV.

3: When $V_{OUT} \le 1.6V$, the LM4041-ADJ must operate at reduced I_R. This is caused by the series resistance of the die attach between the die (-) output and the package (-) output pin. See the Output Saturation curve in the Typical Performance Curves section.

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LM4041-ADJ ELECTRICAL CHARACTERISTICS (Note 1) (CONTINUED)

T_A = Operating Temperature Range, $T_A = T_J$ = –40°C to +85°C, unless noted.

Parameters	Sym.	Min.	Typ.	Max.	Units	Conditions
Reverse-Breakdown Voltage Long-Term Stability	ΔV_R	—	120	—	ppm	t = 1000 hrs., T_A = +25°C ±0.1°C, I_R = 100 µA
LM4041D						
Reverse-Breakdown Voltage	V_R	—	1.233	—	V	I_R = 100 µA, V_{OUT} = 5V
Reverse-Breakdown Voltage Tolerance (Note 2)		—	—	±12	mV	I_R = 100 µA, T_A = +25°C
		—	—	±24	mV	I_R = 100 µA
Minimum Operating Current	I_{RMIN}	—	45	65	µA	T_A = +25°C
		—	—	70		—
Reference Voltage Change with Operating Current	$\Delta V_{REF}/\Delta I_R$	—	0.7	2.0	mV	$I_{RMIN} \le I_R \le$ 1 mA, $V_{OUT} \ge$ 1.6V (Note 3), T_A = +25°C
		—	—	2.5		$I_{RMIN} \le I_R \le$ 1 mA, $V_{OUT} \ge$ 1.6V (Note 3)
		—	2.0	6.0		1 mA $\le I_R \le$ 15 mA, $V_{OUT} \ge$ 1.6V (Note 3), T_A = +25°C
		—	—	8.0		1 mA $\le I_R \le$ 15 mA, $V_{OUT} \ge$ 1.6V (Note 3)
Reference Voltage Change with Output Voltage Change	$\Delta V_{REF}/\Delta V_O$	—	–1.55	–2.5	mV/V	I_R = 1 mA, T_A = +25°C
		—	—	–3.0		I_R = 1 mA
Feedback Current	I_{FB}	—	60	150	nA	T_A = +25°C
		—	—	200		—
Average Reference Voltage Temperature Coefficient	$\Delta V_{REF}/\Delta T$	—	±20	—	ppm/°C	V_{OUT} = 5V, I_R = 10 mA, T_A = +25°C
		—	±15	±150		V_{OUT} = 5V, I_R = 1 mA
		—	±15	—		V_{OUT} = 5V, I_R = 100 µA, T_A = +25°C
Dynamic Output Impedance	Z_{OUT}	—	0.3	—	Ω	I_R = 1 mA, f = 120 Hz, T_A = +25°C, $I_{AC} = 0.1\ I_R$, $V_{OUT} = V_{REF}$
		—	—	2.0		V_{OUT} = 10V, T_A = +25°C

Note 1: Specification for packaged product only.

2: The boldface (overtemperature) limit for Reverse-Breakdown Voltage Tolerance is defined as the room temperature Reverse-Breakdown Voltage Tolerance ±[($\Delta V_R/\Delta T$)(65°C)(V_R)]. $\Delta V_R/\Delta T$ is the V_R temperature coefficient, 65°C is the temperature range from –40°C to the reference point of 25°C, and V_R is the reverse-breakdown voltage. The total overtemperature tolerance for the different grades follows:

a. C-grade: ±1.15% = ±0.5% ±100 ppm/°C × 65°C

b. D-grade: ±1.98% = ±1.0% ±150 ppm/°C × 65°C

Example: The C-grade LM4040-2.5 has an overtemperature Reverse-Breakdown Voltage tolerance of ±2.5 × 1.15% = ±29 mV.

3: When $V_{OUT} \le$ 1.6V, the LM4041-ADJ must operate at reduced I_R. This is caused by the series resistance of the die attach between the die (-) output and the package (-) output pin. See the Output Saturation curve in the Typical Performance Curves section.

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LM4041-ADJ ELECTRICAL CHARACTERISTICS (Note 1) (CONTINUED)

T_A = Operating Temperature Range, $T_A = T_J$ = –40°C to +85°C, unless noted.

Parameters	Sym.	Min.	Typ.	Max.	Units	Conditions
Wideband Noise	e_N	—	20	—	μV_{RMS}	I_R = 100 µA, T_A = +25°C, 10 Hz ≤ f ≤ 10 kHz
Reverse-Breakdown Voltage Long-Term Stability	ΔV_R	—	120	—	ppm	t = 1000 hrs., T_A = +25°C ±0.1°C, I_R = 100 µA

Note 1: Specification for packaged product only.

2: The boldface (overtemperature) limit for Reverse-Breakdown Voltage Tolerance is defined as the room temperature Reverse-Breakdown Voltage Tolerance ±[($\Delta V_R/\Delta T$)(65°C)(V_R)]. $\Delta V_R/\Delta T$ is the V_R temperature coefficient, 65°C is the temperature range from –40°C to the reference point of 25°C, and V_R is the reverse-breakdown voltage. The total overtemperature tolerance for the different grades follows:

a. C-grade: ±1.15% = ±0.5% ±100 ppm/°C × 65°C

b. D-grade: ±1.98% = ±1.0% ±150 ppm/°C × 65°C

Example: The C-grade LM4040-2.5 has an overtemperature Reverse-Breakdown Voltage tolerance of ±2.5 × 1.15% = ±29 mV.

3: When $V_{OUT} \leq 1.6V$, the LM4041-ADJ must operate at reduced I_R. This is caused by the series resistance of the die attach between the die (-) output and the package (-) output pin. See the Output Saturation curve in the Typical Performance Curves section.

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TEMPERATURE SPECIFICATIONS (Note 1)

Parameters	Sym.	Min.	Typ.	Max.	Units	Conditions
Temperature Ranges						
Operating Temperature Range	T_A	–40	—	+85	°C	—
Storage Temperature	T_S	–65	—	+150	°C	—
Lead Temperature	—	—	+215	—	°C	Vapor phase, 60s
Lead Temperature	—	—	+220	—	°C	Infrared, 15s
Package Thermal Resistance						
3-Pin SOT-23	Θ_{JA}	—	+326	—	°C/W	—

Note 1: The maximum allowable power dissipation is a function of ambient temperature, the maximum allowable junction temperature and the thermal resistance from junction to air (i.e., T_A, T_J, θ_{JA}). Exceeding the maximum allowable power dissipation will cause the device operating junction temperature to exceed the maximum +125°C rating. Sustained junction temperatures above +125°C can impact the device reliability.

Test Circuits

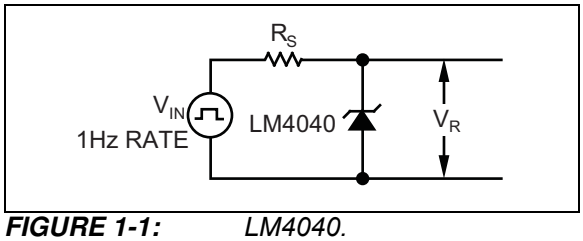

FIGURE 1-1: *LM4040.*

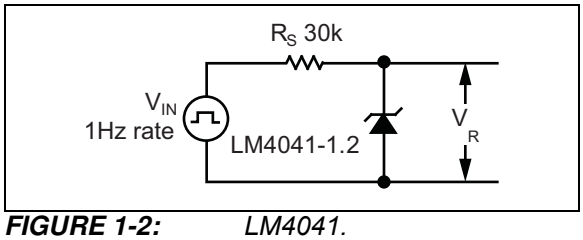

FIGURE 1-2: *LM4041.*

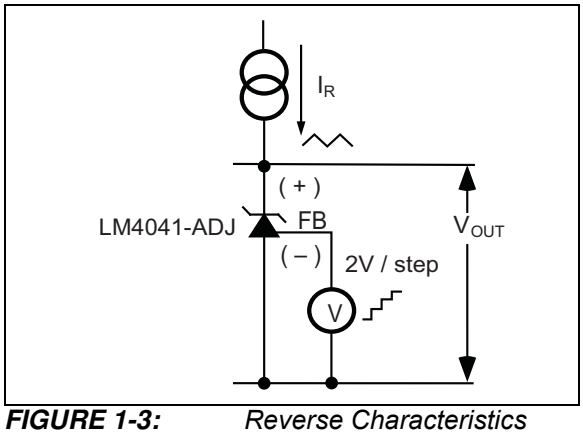

FIGURE 1-3: *Reverse Characteristics Test Circuit.*

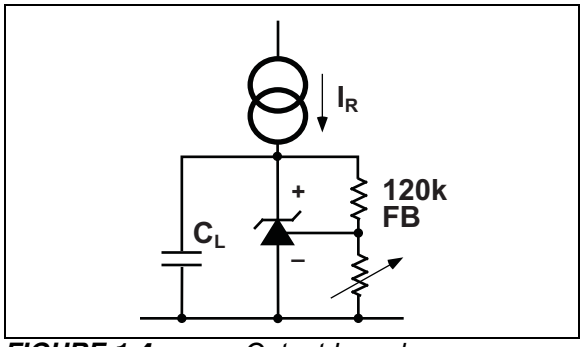

FIGURE 1-4: *Output Impedance vs. Frequency Test Circuit.*

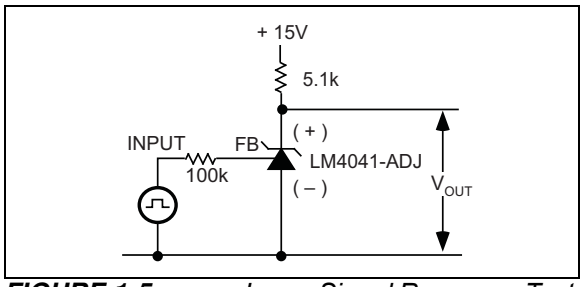

FIGURE 1-5: *Large Signal Response Test Circuit.*

2.0 TYPICAL PERFORMANCE CURVES

Note: The graphs and tables provided following this note are a statistical summary based on a limited number of samples and are provided for informational purposes only. The performance characteristics listed herein are not tested or guaranteed. In some graphs or tables, the data presented may be outside the specified operating range (e.g., outside specified power supply range) and therefore outside the warranted range.

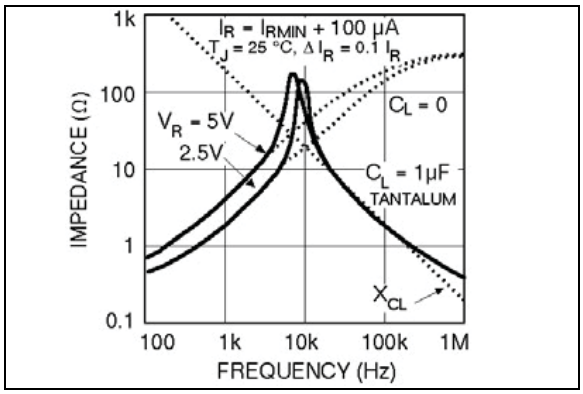

FIGURE 2-1: *LM4040 Output Impedance vs. Frequency.*

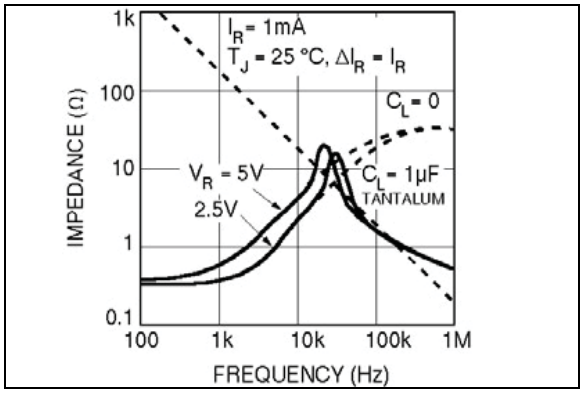

FIGURE 2-2: *LM4040 Output Impedance vs. Frequency.*

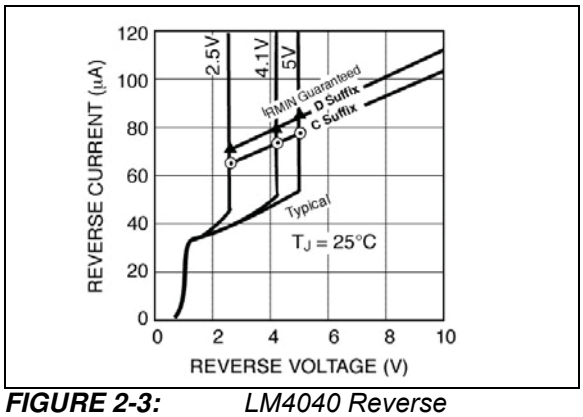

FIGURE 2-3: *LM4040 Reverse Characteristics and Minimum Operating Current.*

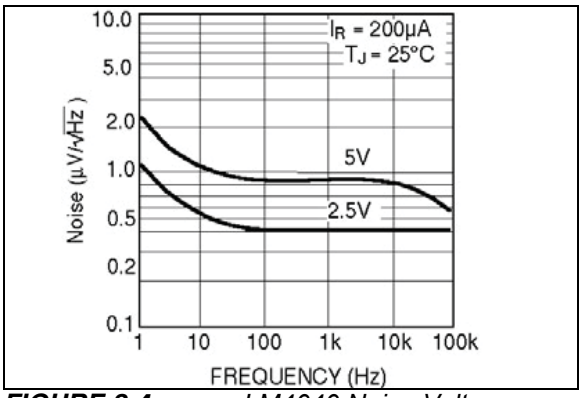

FIGURE 2-4: *LM4040 Noise Voltage vs. Frequency.*

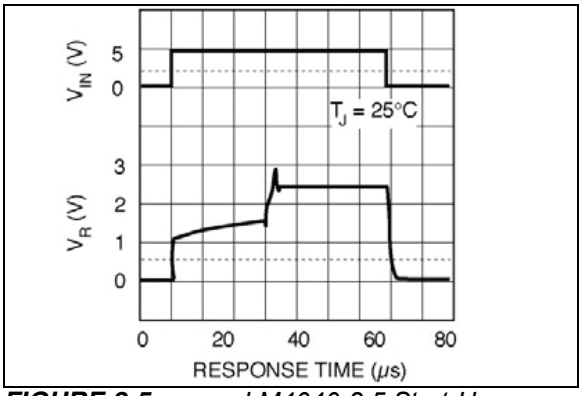

FIGURE 2-5: *LM4040-2.5 Start-Up Characteristics (R_S = 30 kΩ).*

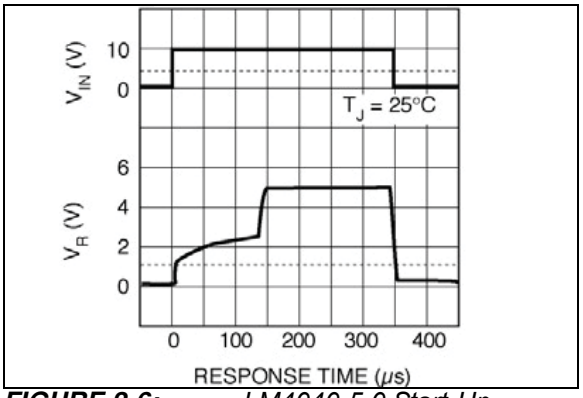

FIGURE 2-6: *LM4040-5.0 Start-Up Characteristics (R_S = 30 kΩ).*

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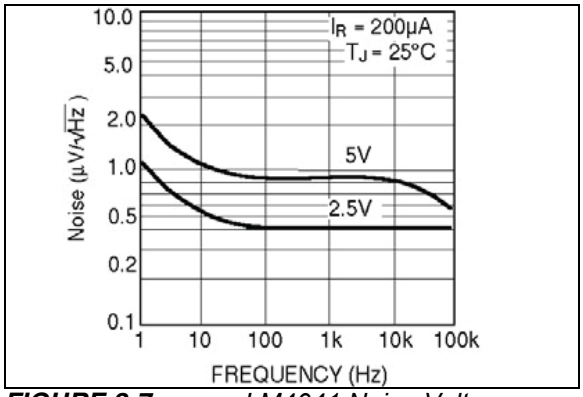

FIGURE 2-7: *LM4041 Noise Voltage vs. Frequency.*

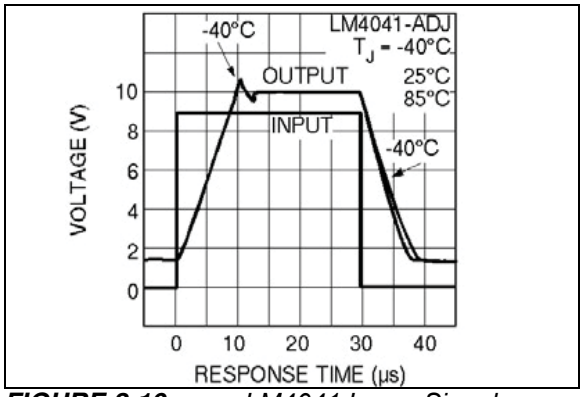

FIGURE 2-10: *LM4041 Large Signal Response.*

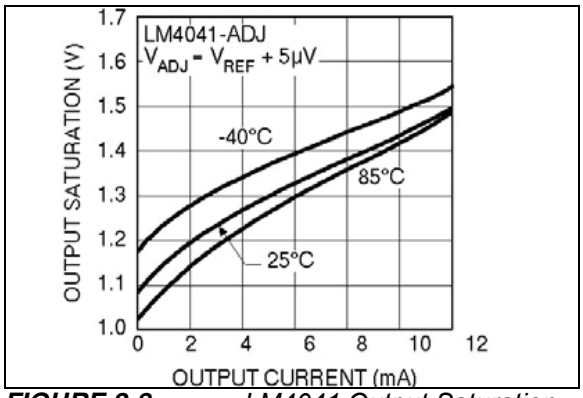

FIGURE 2-8: *LM4041 Output Saturation.*

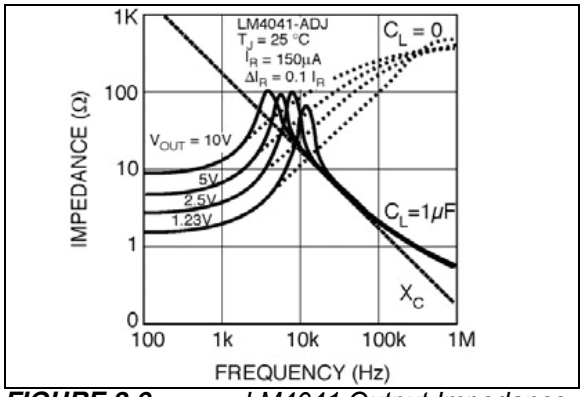

FIGURE 2-9: *LM4041 Output Impedance vs. Frequency.*

3.0 PIN DESCRIPTIONS

The descriptions of the pins are listed in Table 3-1.

TABLE 3-1: PIN FUNCTION TABLE

Pin Number Fixed	Pin Number Adjustable	Pin Name	Description
1	2	+	Cathode. Connect to positive voltage.
—	1	FB	Feedback. Connect to a resistive divider network to set the output voltage.
2	3	–	Anode. Connect to negative voltage.
3	—	NC	Not internally connected. This pin must be left floating or connected to –.

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4.0 APPLICATION INFORMATION

The stable operation of the LM4040 and LM4041 references require an external capacitor greater than 10 nF connected between the (+) and (–) pins. Bypass capacitors with values between 100 pF and 10 nF have been found to cause the devices to exhibit instabilities.

4.1 Schottky Diode

LM4040-x.x and LM4041-1.2 in the SOT-23 package have a parasitic Schottky diode between Pin 2 (–) and Pin 3 (die attach interface connect). Pin 3 of the SOT-23 package must float or be connected to Pin 2. The LM4041-ADJ use Pin 3 as the (–) output.

4.2 Conventional Shunt Regulator

In a conventional shunt regulator application (see Figure 5-1), an external series resistor (R_S) is connected between the supply voltage and the LM4040-x.x or LM4041-1.2 reference. R_S determines the current that flows through the load (I_L) and the reference (I_Q). Because load current and supply voltage may vary, R_S should be small enough to supply at least the minimum acceptable I_Q to the reference even when the supply voltage is at its minimum and the load current is at its maximum value. When the supply voltage is at its maximum and I_L is at its minimum, R_S should be large enough so that the current flowing through the LM4040-x.x is less than 15 mA, and the current flowing through the LM4041-1.2 or LM4041-ADJ is less than 12 mA.

R_S is determined by the supply voltage (V_S), the load and operating current, (I_L and I_Q), and the reference's reverse breakdown voltage (V_R):

EQUATION 4-1:

$$R_S = \frac{(V_S - V_R)}{(I_L + I_Q)}$$

4.3 Adjustable Regulator

The LM4041-ADJ's output voltage can be adjusted to any value between 1.24V and 10V. It is a function of the internal reference voltage (V_{REF}) and the ratio of the external feedback resistors as shown in Figure 5-2. The output is found using the following equation:

EQUATION 4-2:

$$V_O = V_{REF}[(R2/R1) + 1]$$

Where:

V_O Desired Output Voltage

The actual value of the internal V_{REF} is a function of V_O. The corrected V_{REF} is determined by:

EQUATION 4-3:

$$V_{REF} = V_O \times \left(\frac{\Delta V_{REF}}{\Delta V_O}\right) + V_Y$$

Where:

V_O Desired Output Voltage

$\Delta V_{REF}/\Delta V_O$ is found in the Electrical Characteristics section and is typically –1.3 mV/V and V_Y is equal to 1.233V. Replace the value of V_{REF} in Equation 4-2 with the value V_{REF} found using Equation 4-3.

Note that actual output voltage can deviate from that predicted using the typical $\Delta V_{REF}/\Delta V_O$ in Equation 4-3; for C-grade parts, the worst case $\Delta V_{REF}/\Delta V_O$ is –2.5 mV/V and V_Y = 1.248V.

The following example shows the difference in output voltage resulting from the typical and worst case values of $\Delta V_{REF}/\Delta V_O$.

Let V_O = +9V. Using the typical values of $\Delta V_{REF}/\Delta V_O$, V_{REF} is 1.223V. Choosing a value of R1 = 10 kΩ, R2 = 63.272 kΩ. Using the worst case $\Delta V_{REF}/\Delta V_O$ for the C-grade and D-grade parts, the output voltage is actually 8.965V and 8.946V respectively. This results in possible errors as large as 0.39% for the C-grade parts and 0.59% for the D-grade parts. Once again, resistor values found using the typical value of $\Delta V_{REF}/\Delta V_O$ will work in most cases, requiring no further adjustment.

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5.0 TYPICAL APPLICATION CIRCUITS

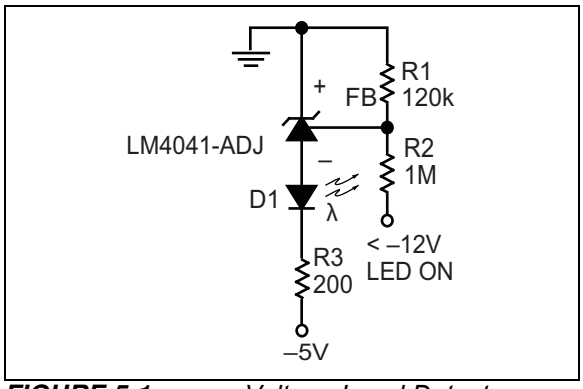

FIGURE 5-1: *Voltage Level Detector.*

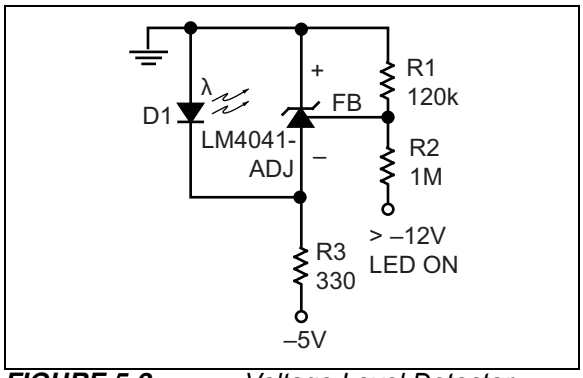

FIGURE 5-2: *Voltage Level Detector.*

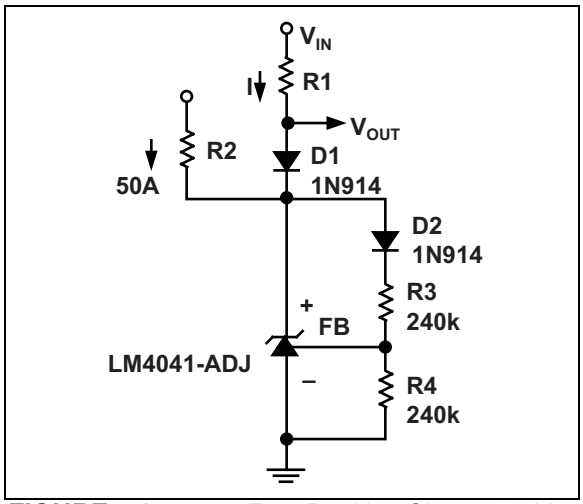

FIGURE 5-3: *Fast Positive Clamp, 2.4V + ΔV_{D1}.*

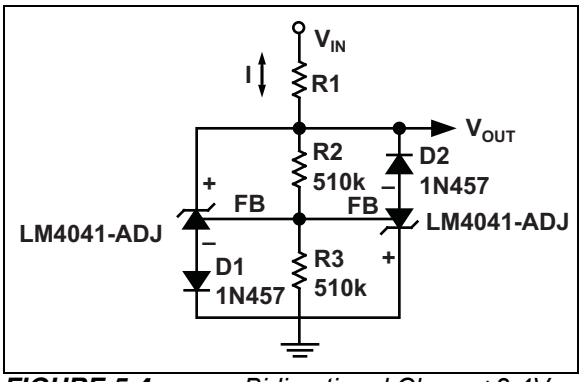

FIGURE 5-4: *Bidirectional Clamp ±2.4V.*

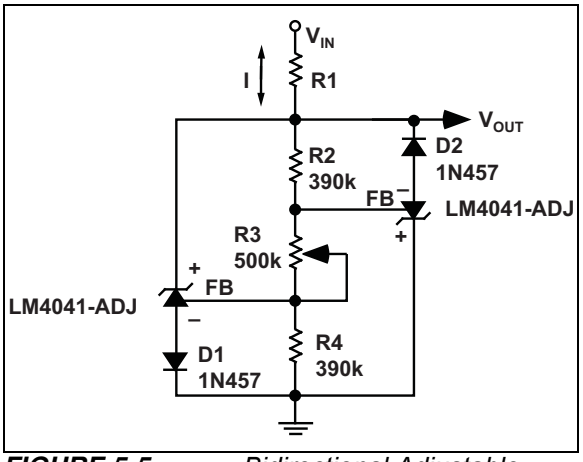

FIGURE 5-5: *Bidirectional Adjustable Clamp ±1.8V to ±2.4V.*

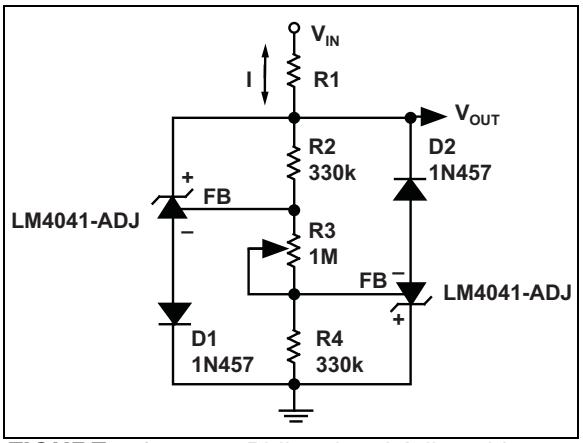

FIGURE 5-6: *Bidirectional Adjustable Clamp ±2.4V to ±6V.*

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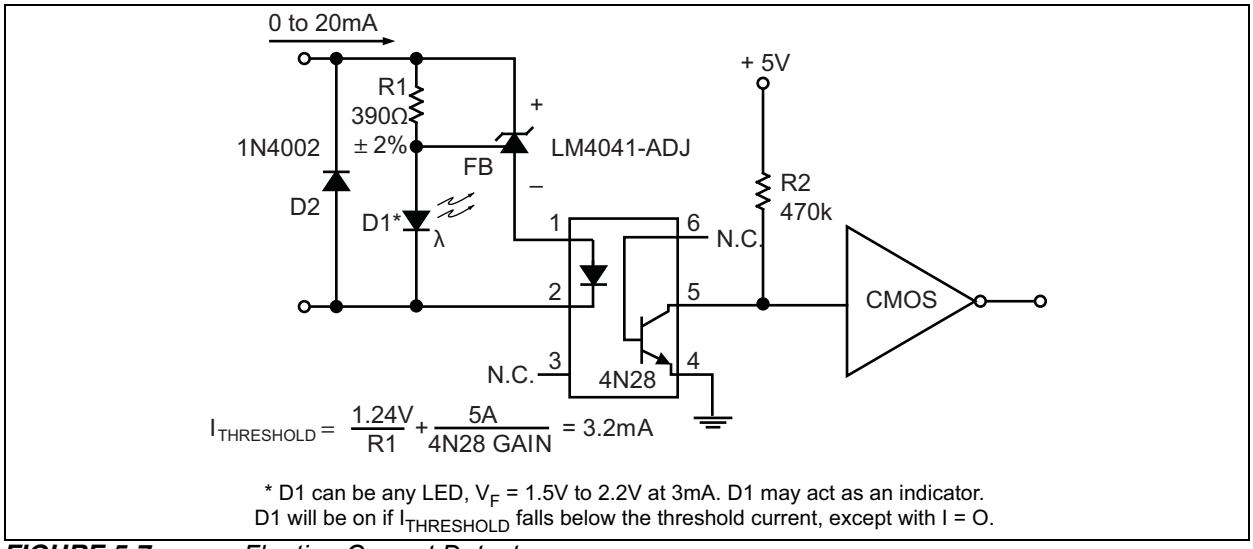


FIGURE 5-7: *Floating Current Detector.*

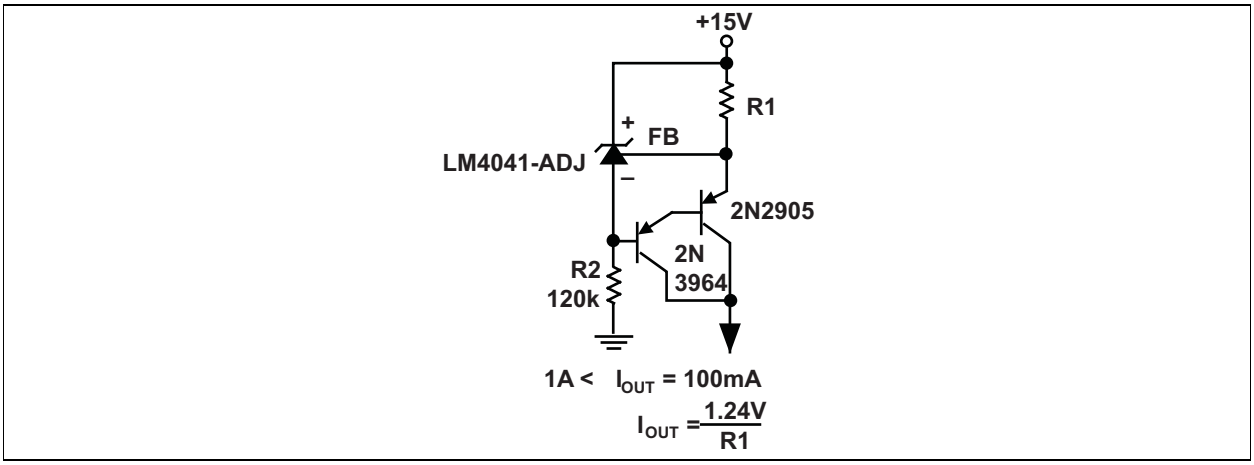


FIGURE 5-8: *Current Source.*

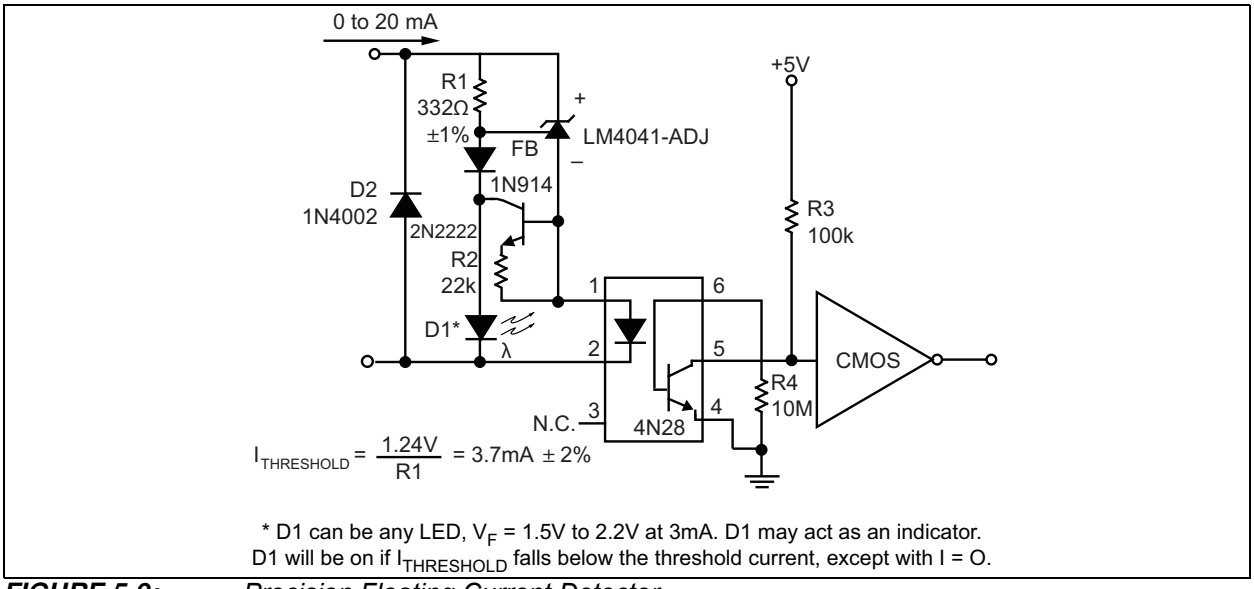
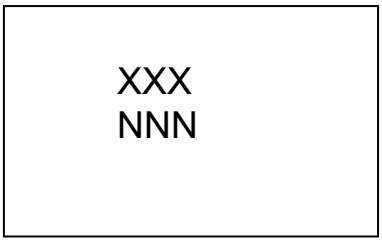


FIGURE 5-9: *Precision Floating Current Detector.*

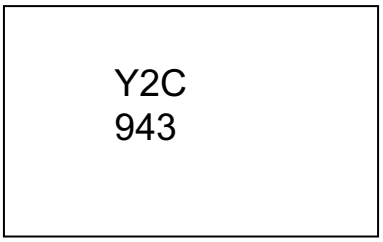
6.0 PACKAGING INFORMATION

6.1 Package Marking Information

3-Pin SOT-23*



Example



Legend:	XX...X	Product code or customer-specific information
	Y	Year code (last digit of calendar year)
	YY	Year code (last 2 digits of calendar year)
	WW	Week code (week of January 1 is week '01')
	NNN	Alphanumeric traceability code
	(e3)	Pb-free JEDEC® designator for Matte Tin (Sn)
	*	This package is Pb-free. The Pb-free JEDEC designator ((e3)) can be found on the outer packaging for this package.
	●, ▲, ▼	Pin one index is identified by a dot, delta up, or delta down (triangle mark).
Note:	In the event the full Microchip part number cannot be marked on one line, it will be carried over to the next line, thus limiting the number of available characters for customer-specific information. Package may or may not include the corporate logo.	
	Underbar (_) and/or Overbar (¯) symbol may not be to scale.	

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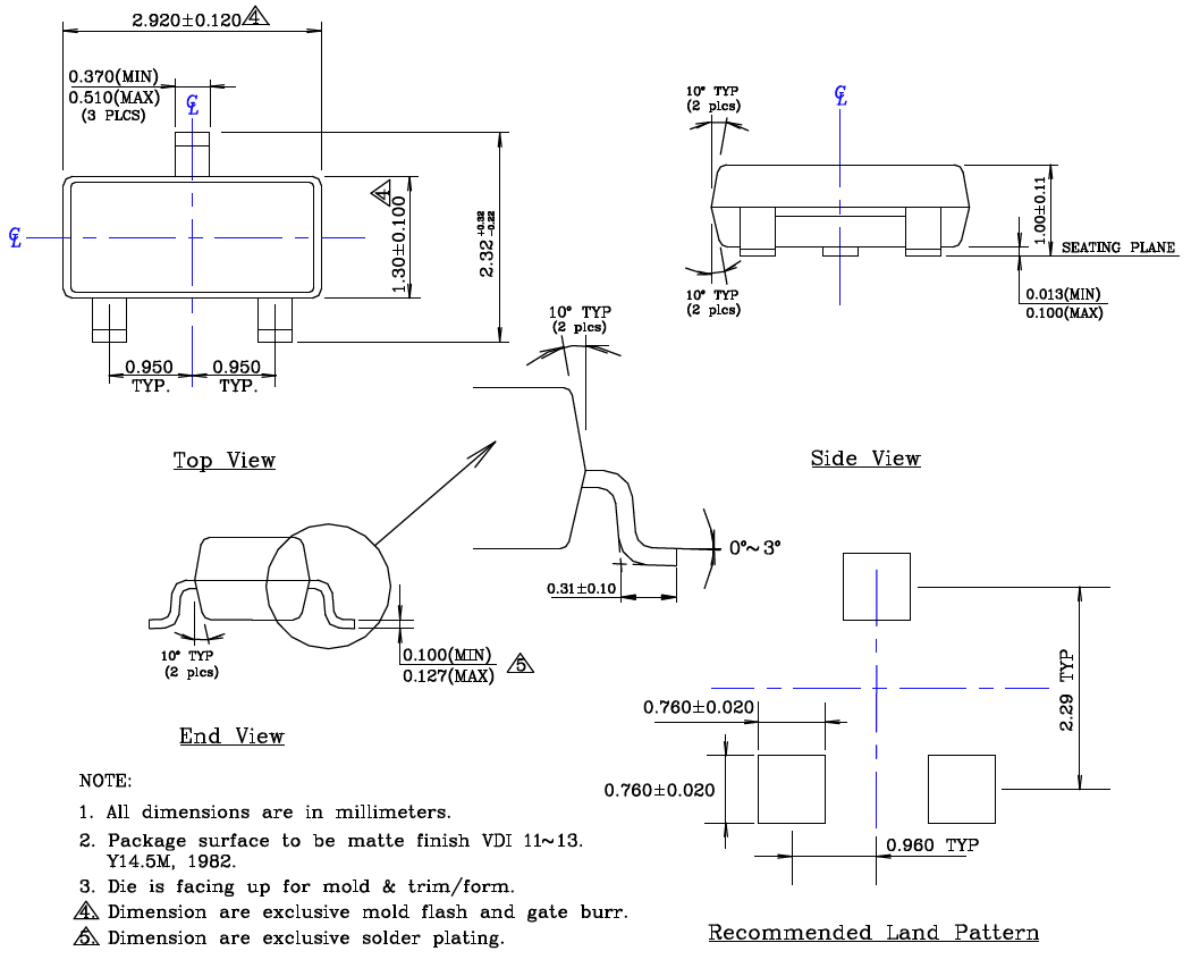
3-Lead SOT-23 Package Outline and Recommended Land Pattern

TITLE
3 LEAD SOT23 PACKAGE OUTLINE & RECOMMENDED LAND PATTERN

DRAWING #	SOT23-3LD-PL-1	UNIT	MM



NOTE:

1. All dimensions are in millimeters.
2. Package surface to be matte finish VDI 11~13. Y14.5M, 1982.
3. Die is facing up for mold & trim/form.

4 Dimension are exclusive mold flash and gate burr.

5 Dimension are exclusive solder plating.

Note: For the most current package drawings, please see the Microchip Packaging Specification located at http://www.microchip.com/packaging.

NOTES:

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APPENDIX A: REVISION HISTORY

Revision A (April 2017)

- Converted Micrel data sheet LM4040/LM4041 to Microchip DS20005757A.
- Minor text changes throughout.
- Updated temperature information in all Electrical Characteristics tables to better reflect which values are valid for T_A = +25°C.