

# Radiation Report

## LMP7704-SP Total Ionizing Dose (TID)



### ABSTRACT

This report covers the radiation characterization results of the LMP7704-SP. The study helps determine the Total Ionizing Dose (TID) effects under high dose rate (HDR) up to 100 krad (Si). The results show that all samples passed within the specified limits up to 100 krad(Si).

This appendix provides the LMP7704-SP TID HDR report.

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### Trademarks

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## 1 Device Information

### 1.1 Product Description

The LMP7704-SP is a precision amplifier with low input bias, low offset voltage, 2.5-MHz gain bandwidth product, and a wide supply voltage. The device is radiation hardened and operates in the military temperature range of  $-55^{\circ}\text{C}$  to  $+125^{\circ}\text{C}$ .

The high dc precision of this amplifier, specifically the low offset voltage of  $\pm 60\ \mu\text{V}$  and ultra-low input bias of  $\pm 500\ \text{fA}$ , make this device an excellent choice for interfacing with precision sensors with high output impedances. This amplifier can be configured for transducer, bridge, strain gauge, and transimpedance amplification.

### 1.2 Device Details

Table 1-1 lists the device information used in the initial TID characterization and qualification of HDR tests.

**Table 1-1. Device and Exposure Details**

TID HDR Details: 100 krad(Si)	
TI Device Number	LMP7704-SP
Package	14-Pin / HBH
Technology	VIP050
Die Lot Number	9002663
A/T Lot Number / Date Code	1009413/2125A
Quantity Tested	25units
Lot Accept/Reject	Devices passed 100 krad(Si)
HDR Radiation Facility	Texas Instruments SVA Group, Santa Clara, CA
HDR Dose Level	100 krad(Si)
HDR Dose Rate	294.890121 rad(Si)/s
HDR Radiation Source	Gammacell 220 Excel (GC-220E) Co-60
Irradiation Temperature	Ambient, room temperature

## 2 Total Dose Test Setup

### 2.1 Test Overview

The LMP7704-SP is irradiated up to 100 krad(Si) and then put through full electrical parametric testing on the production Automated Test Equipment (ATE). The device is functional and passes all electrical parametric tests with the readings within guard bands of the data sheet electrical specification limits.

The LMP7704-SP VIP050 process technology contains CMOS components. HDR were performed.

### 2.2 Test Description and Facilities

The LMP7704-SP HDR exposure was performed on biased and unbiased devices in a Co-60 gamma cell at TI SVA facility in Santa Clara, California. The un-attenuated dose rate of this cell is 294.890121 rad(Si)/s. After exposure, the devices were packed in dry ice (per MIL-STD-883 Method 1019.9 section 3.10) and returned to TI Dallas for a full post radiation electrical evaluation using Texas Instruments ATE. ATE guard band test limits are set within SMD electrical limits to ensure a minimum Cpk and test error margin based on initial qualification and characterization data. Post radiation measurements were taken within 30 minutes of removal of the devices from the dry ice container. The devices were allowed to reach room temperature prior to electrical post radiation measurements.

The LMP7704-SP LDR exposure was performed on biased and unbiased devices in a Co60 gamma cell under a 10-mrad(Si)/s exposure rate. The dose rate of the irradiator used in the exposure ranges from < 10 mrad(Si)/s to a maximum of approximately 84 rad(Si)/s, determined by the distance from the source. For the LDR (10 mrad(Si)/s) exposure, the test box was positioned approximately 2 m from the source. The exposure boards are housed in a lead-aluminum box (as specified in MIL-STD-883 TM 1019.9) to harden the gamma spectrum and minimize dose enhancement effects. The irradiator calibration is maintained by Logmire Laboratories using Thermoluminescence Dosimeters (TLDs) traceable to the National Institute of Standards and Technology (NIST) and the dosimetry was verified using TLDs prior to the radiation exposures. ATE guard band test limits are set within SMD electrical limits to ensure a minimum Cpk and test error margin based on initial qualification and characterization data.

### 2.3 Test Setup Details

Biased HDR up to 100 krad(Si) exposure are tested as well and device is functional and passes electrical test within datasheet limit. The devices under LDR exposure are tested in unbiased and biased condition. Unbiased exposure means with all pins grounded.

### 2.4 Test Configuration and Condition

HDR devices were stressed at 20 krad(Si), 30 krad(Si), 50 krad(Si), 100 krad(Si) for biased conditions. LDR devices were stressed at 50 krad(Si), 75 krad(Si), and 100 krad(Si) for biased and unbiased conditions.

### Figure 2-1. Bias Diagram Used in TID Exposure

**Table 2-1. HDR  $\leq$  50–100 rad(Si)/s Biased Device Information (HDR)**

Total sample size : 24
Exposure Levels:
100 krad(Si)
649,650, 651, 652, 653, 654, 655, 656, 657, 658, 659, 660, 661, 662, 663, 664, 666, 667,668, 669, 576, 676, 678, 679

### 3 Tested Parameters

HDR devices were stressed at 20 krad(Si), 30 krad(Si), 50 krad(Si), 100 krad(Si) for biased conditions. LDR devices were stressed at 50 krad(Si), 75 krad(Si), and 100 krad(Si) for biased and unbiased conditions.

**Table 3-1. LMP7704-SP Specification Compliance Matrix**

Parameter	Test Condition	LMP7704-SP Data Sheet (SNOSDB6)				Test #
		MIN	TYP	MAX	Unit	
Input offset voltage			±60	±260	µV	104.x
	TA = -55°C to +125°C			±520	µV	104.x
Power-supply rejection ratio	2.7 V < VS < 12 V	86	100		dB	104.x
	TA = -55°C to +125°C	82			dB	104.x
Input bias current	VS=5V		±0.5	±10	pA	120.x
	VS=5V, TA = -55°C to +125°C			±400	pA	120.x
	VS=10V		±1	±10	pA	120.x
	VS=10V, TA = -55°C to +125°C			±400	pA	120.x
Input offset current			±40		fA	120.x
Common-mode rejection ratio	VS=5V, (V-) < VCM < (V+)	76	130		dB	105.x
	VS=5V, (V-) < VCM < (V+), TA = -55°C to +125°C	71			dB	105.x
	VS=10V, (V-) < VCM < (V+)	83	130		dB	105.x
	VS=10V, (V-) < VCM < (V+), TA = -55°C to +125°C	78			dB	105.x

**Table 3-1. LMP7704-SP Specification Compliance Matrix (continued)**

Open-loop voltage gain	VS=5V, (V-) + 0.3 V < VOUT < (V+) - 0.3 V, RL = 2 kΩ	84	119		dB	106.x
	VS=5V, (V-) + 0.3 V < VOUT < (V+) - 0.3 V, RL = 2 kΩ, TA = -55°C to +125°C	79			dB	106.x
	VS=5V, (V-) + 0.3 V < VOUT < (V+) - 0.3 V, RL = 10 kΩ	84	130		dB	106.x
	VS=5V, (V-) + 0.3 V < VOUT < (V+) - 0.3 V, RL = 10 kΩ, TA = -55°C to +125°C	79			dB	106.x
	VS=10V, (V-) + 0.3 V < VOUT < (V+) - 0.3 V, RL = 2 kΩ	100	121		dB	106.x
	VS=10V, (V-) + 0.3 V < VOUT < (V+) - 0.3 V, RL = 2 kΩ, TA = -55°C to +125°C	94			dB	106.x
	VS=10V, (V-) + 0.3 V < VOUT < (V+) - 0.3 V, RL = 10 kΩ	100	134		dB	106.x
	VS=10V, (V-) + 0.3 V < VOUT < (V+) - 0.3 V, RL = 10 kΩ, TA = -55°C to +125°C	97			dB	106.x
Gain bandwidth			2.5		MHz	116.x
Slew rate	VS=10V, G = 1, 9-V step, 10% to 90% rising		0.8		V/μs	109.x

**Table 3-1. LMP7704-SP Specification Compliance Matrix (continued)**

Voltage output swing from rail	Positive rail, $R_L = 2\text{ k}\Omega$ to $V_S / 2$		60	120	mV	110.x
	Positive rail, $R_L = 2\text{ k}\Omega$ to $V_S / 2$ , $T_A = -55^\circ\text{C}$ to $+125^\circ\text{C}$			200	mV	110.x
	Positive rail, $R_L = 10\text{ k}\Omega$ to $V_S / 2$		40	60		110.x
	Positive rail, $R_L = 10\text{ k}\Omega$ to $V_S / 2$ , $T_A = -55^\circ\text{C}$ to $+125^\circ\text{C}$			120	mV	110.x
	Negative rail, $R_L = 2\text{ k}\Omega$ to $V_S / 2$		50	120	mV	110.x
	Negative rail, $R_L = 2\text{ k}\Omega$ to $V_S / 2$ , $T_A = -55^\circ\text{C}$ to $+125^\circ\text{C}$			190	mV	110.x
	Negative rail, $R_L = 10\text{ k}\Omega$ to $V_S / 2$		30	50		110.x
	Negative rail, $R_L = 10\text{ k}\Omega$ to $V_S / 2$ , $T_A = -55^\circ\text{C}$ to $+125^\circ\text{C}$			100	mV	110.x
Short-circuit current	$V_S = 5\text{V}$ , $V_{OUT} = V_S / 2$ , $V_{IN} = \pm 100\text{ mV}$		+66 / -76		mA	111.x
Total quiescent current	$V_S = 5\text{V}$ , $I_O = 0\text{ A}$		2.9	3.7	mA	112.x
	$V_S = 5\text{V}$ , $I_O = 0\text{ A}$ , $T_A = -55^\circ\text{C}$ to $+125^\circ\text{C}$			5.1	mA	112.x
	$V_S = 10\text{V}$ , $I_O = 0\text{ A}$		3.2	4.2	mA	112.x
	$V_S = 10\text{V}$ , $I_O = 0\text{ A}$ , $T_A = -55^\circ\text{C}$ to $+125^\circ\text{C}$			5.7	mA	112.x

## 4 Total Ionizing Dose Characterization Test Results

### 4.1 Total Ionizing Dose Characterization Summary Results

The following list summarizes the TID characterization results.

- The parametric data for the LMP7704-SP passes up to 100-krad(Si) HDR.
- The LMP7704-SP passes post electrical test over all conditions below at 100-krad(Si).
- Overall radiation performance is solid. There were no functional or parametric failures at any read point. All data sheet parameters pass at all exposure levels with margin. However, radiation end-point limits for the noted parameters are ensured only for the conditions as specified in MIL-STD-883, method 1019, condition A.



## 5 References

1. Texas Instruments, [Radiation Hardness Assured \(RHA\), Precision, CMOS Input, RRIO, Wide Supply Amplifiers Data Sheet](#)