



Chipsmall Limited consists of a professional team with an average of over 10 year of expertise in the distribution of electronic components. Based in Hongkong, we have already established firm and mutual-benefit business relationships with customers from,Europe,America and south Asia,supplying obsolete and hard-to-find components to meet their specific needs.

With the principle of “Quality Parts,Customers Priority,Honest Operation,and Considerate Service”,our business mainly focus on the distribution of electronic components. Line cards we deal with include Microchip,ALPS,ROHM,Xilinx,Pulse,ON,Everlight and Freescale. Main products comprise IC,Modules,Potentiometer,IC Socket,Relay,Connector.Our parts cover such applications as commercial,industrial, and automotives areas.

We are looking forward to setting up business relationship with you and hope to provide you with the best service and solution. Let us make a better world for our industry!



Contact us

Tel: +86-755-8981 8866 Fax: +86-755-8427 6832

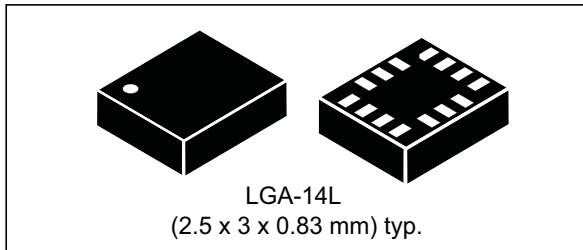
Email & Skype: info@chipsmall.com Web: www.chipsmall.com

Address: A1208, Overseas Decoration Building, #122 Zhenhua RD., Futian, Shenzhen, China



iNEMO inertial module: always-on 3D accelerometer and 3D gyroscope

Datasheet - production data



Features

- Power consumption: 0.4 mA in combo normal mode and 0.65 mA in combo high-performance mode
- “Always-on” experience with low power consumption for both accelerometer and gyroscope
- Smart FIFO up to 4 kbyte based on features set
- Android M compliant
- Hard, soft ironing for external magnetic sensor corrections
- $\pm 2/\pm 4/\pm 8/\pm 16$ g full scale
- $\pm 125/\pm 245/\pm 500/\pm 1000/\pm 2000$ dps full scale
- Analog supply voltage: 1.71 V to 3.6 V
- Independent IOs supply (1.62 V)
- Compact footprint, 2.5 mm x 3 mm x 0.83 mm
- SPI & I²C serial interface with main processor data synchronization feature
- Pedometer, step detector and step counter
- Significant motion and tilt function
- Standard interrupts: free-fall, wakeup, 6D/4D orientation, click and double-click
- Embedded temperature sensor
- ECOPACK[®], RoHS and “Green” compliant

Applications

- Motion tracking and gesture detection
- Collecting sensor data
- Indoor navigation
- IoT and connected devices
- Intelligent power saving for handheld devices
- Vibration monitoring and compensation

Description

The LSM6DSL is a system-in-package featuring a 3D digital accelerometer and a 3D digital gyroscope performing at 0.65 mA in high-performance mode and enabling always-on low-power features for an optimal motion experience for the consumer.

The LSM6DSL supports main OS requirements, offering real, virtual and batch sensors with 4 kbyte for dynamic data batching.

ST’s family of MEMS sensor modules leverages the robust and mature manufacturing processes already used for the production of micromachined accelerometers and gyroscopes.

The various sensing elements are manufactured using specialized micromachining processes, while the IC interfaces are developed using CMOS technology that allows the design of a dedicated circuit which is trimmed to better match the characteristics of the sensing element.

The LSM6DSL has a full-scale acceleration range of $\pm 2/\pm 4/\pm 8/\pm 16$ g and an angular rate range of $\pm 125/\pm 245/\pm 500/\pm 1000/\pm 2000$ dps.

High robustness to mechanical shock makes the LSM6DSL the preferred choice of system designers for the creation and manufacturing of reliable products.

The LSM6DSL is available in a plastic land grid array (LGA) package.

Table 1. Device summary

Part number	Temp. range [°C]	Package	Packing
LSM6DSL	-40 to +85	LGA-14L (2.5x3x0.83mm)	Tray
LSM6DSLTR	-40 to +85		Tape & Reel

Contents

1	Overview	15
2	Embedded low-power features	16
2.1	Tilt detection	16
2.2	Absolute wrist tilt	17
3	Pin description	18
3.1	Pin connections	19
4	Module specifications	21
4.1	Mechanical characteristics	21
4.2	Electrical characteristics	24
4.3	Temperature sensor characteristics	25
4.4	Communication interface characteristics	26
4.4.1	SPI - serial peripheral interface	26
4.4.2	I ² C - inter-IC control interface	27
4.5	Absolute maximum ratings	28
4.6	Terminology	29
4.6.1	Sensitivity	29
4.6.2	Zero-g and zero-rate level	29
5	Functionality	30
5.1	Operating modes	30
5.2	Gyroscope power modes	30
5.3	Accelerometer power modes	30
5.4	Block diagram of filters	31
5.4.1	Block diagrams of the gyroscope filters	31
5.4.2	Block diagrams of the accelerometer filters	32
5.5	FIFO	33
5.5.1	Bypass mode	33
5.5.2	FIFO mode	34
5.5.3	Continuous mode	34
5.5.4	Continuous-to-FIFO mode	34

5.5.5	Bypass-to-Continuous mode	34
5.5.6	FIFO reading procedure	35
6	Digital interfaces	36
6.1	I ² C/SPI interface	36
6.2	Master I ² C	36
6.3	I ² C serial interface	37
6.3.1	I ² C operation	37
6.4	SPI bus interface	39
6.4.1	SPI read	40
6.4.2	SPI write	41
6.4.3	SPI read in 3-wire mode	42
7	Application hints	43
7.1	LSM6DSL electrical connections in Mode 1	43
7.2	LSM6DSL electrical connections in Mode 2	44
8	Register mapping	47
9	Register description	51
9.1	FUNC_CFG_ACCESS (01h)	51
9.2	SENSOR_SYNC_TIME_FRAME (04h)	51
9.3	SENSOR_SYNC_RES_RATIO (05h)	52
9.4	FIFO_CTRL1 (06h)	52
9.5	FIFO_CTRL2 (07h)	53
9.6	FIFO_CTRL3 (08h)	54
9.7	FIFO_CTRL4 (09h)	55
9.8	FIFO_CTRL5 (0Ah)	56
9.9	DRDY_PULSE_CFG_G (0Bh)	57
9.10	INT1_CTRL (0Dh)	57
9.11	INT2_CTRL (0Eh)	58
9.12	WHO_AM_I (0Fh)	58
9.13	CTRL1_XL (10h)	59
9.14	CTRL2_G (11h)	60
9.15	CTRL3_C (12h)	61

9.16	CTRL4_C (13h)	62
9.17	CTRL5_C (14h)	62
9.18	CTRL6_C (15h)	64
9.19	CTRL7_G (16h)	65
9.20	CTRL8_XL (17h)	65
9.21	CTRL9_XL (18h)	66
9.22	CTRL10_C (19h)	67
9.23	MASTER_CONFIG (1Ah)	67
9.24	WAKE_UP_SRC (1Bh)	68
9.25	TAP_SRC (1Ch)	69
9.26	D6D_SRC (1Dh)	70
9.27	STATUS_REG (1Eh)	70
9.28	OUT_TEMP_L (20h), OUT_TEMP_H (21h)	71
9.29	OUTX_L_G (22h)	71
9.30	OUTX_H_G (23h)	71
9.31	OUTY_L_G (24h)	72
9.32	OUTY_H_G (25h)	72
9.33	OUTZ_L_G (26h)	72
9.34	OUTZ_H_G (27h)	73
9.35	OUTX_L_XL (28h)	73
9.36	OUTX_H_XL (29h)	73
9.37	OUTY_L_XL (2Ah)	73
9.38	OUTY_H_XL (2Bh)	74
9.39	OUTZ_L_XL (2Ch)	74
9.40	OUTZ_H_XL (2Dh)	74
9.41	SENSORHUB1_REG (2Eh)	74
9.42	SENSORHUB2_REG (2Fh)	75
9.43	SENSORHUB3_REG (30h)	75
9.44	SENSORHUB4_REG (31h)	75
9.45	SENSORHUB5_REG (32h)	75
9.46	SENSORHUB6_REG (33h)	76
9.47	SENSORHUB7_REG (34h)	76
9.48	SENSORHUB8_REG(35h)	76

9.49	SENSORHUB9_REG (36h)	76
9.50	SENSORHUB10_REG (37h)	77
9.51	SENSORHUB11_REG (38h)	77
9.52	SENSORHUB12_REG (39h)	77
9.53	FIFO_STATUS1 (3Ah)	77
9.54	FIFO_STATUS2 (3Bh)	78
9.55	FIFO_STATUS3 (3Ch)	78
9.56	FIFO_STATUS4 (3Dh)	79
9.57	FIFO_DATA_OUT_L (3Eh)	79
9.58	FIFO_DATA_OUT_H (3Fh)	79
9.59	TIMESTAMP0_REG (40h)	80
9.60	TIMESTAMP1_REG (41h)	80
9.61	TIMESTAMP2_REG (42h)	80
9.62	STEP_TIMESTAMP_L (49h)	81
9.63	STEP_TIMESTAMP_H (4Ah)	81
9.64	STEP_COUNTER_L (4Bh)	81
9.65	STEP_COUNTER_H (4Ch)	82
9.66	SENSORHUB13_REG (4Dh)	82
9.67	SENSORHUB14_REG (4Eh)	82
9.68	SENSORHUB15_REG (4Fh)	82
9.69	SENSORHUB16_REG (50h)	83
9.70	SENSORHUB17_REG (51h)	83
9.71	SENSORHUB18_REG (52h)	83
9.72	FUNC_SRC1 (53h)	84
9.73	FUNC_SRC2 (54h)	84
9.74	WRIST_TILT_IA (55h)	85
9.75	TAP_CFG (58h)	86
9.76	TAP_THS_6D (59h)	87
9.77	INT_DUR2 (5Ah)	87
9.78	WAKE_UP_THS (5Bh)	88
9.79	WAKE_UP_DUR (5Ch)	88
9.80	FREE_FALL (5Dh)	89
9.81	MD1_CFG (5Eh)	90

9.82	MD2_CFG (5Fh)	91
9.83	MASTER_CMD_CODE (60h)	92
9.84	SENS_SYNC_SPI_ERROR_CODE (61h)	92
9.85	OUT_MAG_RAW_X_L (66h)	92
9.86	OUT_MAG_RAW_X_H (67h)	92
9.87	OUT_MAG_RAW_Y_L (68h)	93
9.88	OUT_MAG_RAW_Y_H (69h)	93
9.89	OUT_MAG_RAW_Z_L (6Ah)	93
9.90	OUT_MAG_RAW_Z_H (6Bh)	93
9.91	X_OFS_USR (73h)	94
9.92	Y_OFS_USR (74h)	94
9.93	Z_OFS_USR (75h)	94
10	Embedded functions register mapping	95
11	Embedded functions registers description - Bank A	97
11.1	SLV0_ADD (02h)	97
11.2	SLV0_SUBADD (03h)	97
11.3	SLAVE0_CONFIG (04h)	97
11.4	SLV1_ADD (05h)	98
11.5	SLV1_SUBADD (06h)	98
11.6	SLAVE1_CONFIG (07h)	99
11.7	SLV2_ADD (08h)	99
11.8	SLV2_SUBADD (09h)	99
11.9	SLAVE2_CONFIG (0Ah)	100
11.10	SLV3_ADD (0Bh)	100
11.11	SLV3_SUBADD (0Ch)	100
11.12	SLAVE3_CONFIG (0Dh)	101
11.13	DATAWRITE_SRC_MODE_SUB_SLV0 (0Eh)	101
11.14	CONFIG_PEDO_THS_MIN (0Fh)	101
11.15	SM_THS (13h)	102
11.16	PEDO_DEB_REG (14h)	102
11.17	STEP_COUNT_DELTA (15h)	102
11.18	MAG_SI_XX (24h)	103

11.19	MAG_SI_XY (25h)	103
11.20	MAG_SI_XZ (26h)	103
11.21	MAG_SI_YX (27h)	103
11.22	MAG_SI_YY (28h)	104
11.23	MAG_SI_YZ (29h)	104
11.24	MAG_SI_ZX (2Ah)	104
11.25	MAG_SI_ZY (2Bh)	104
11.26	MAG_SI_ZZ (2Ch)	105
11.27	MAG_OFFX_L (2Dh)	105
11.28	MAG_OFFX_H (2Eh)	105
11.29	MAG_OFFY_L (2Fh)	105
11.30	MAG_OFFY_H (30h)	106
11.31	MAG_OFFZ_L (31h)	106
11.32	MAG_OFFZ_H (32h)	106
12	Embedded functions registers description - Bank B	107
12.1	A_WRIST_TILT_LAT (50h)	107
12.2	A_WRIST_TILT_THS (54h)	107
12.3	A_WRIST_TILT_Mask (59h)	107
13	Soldering information	108
14	Package information	109
14.1	LGA-14 package information	109
14.2	LGA-14 packing information	110
15	Revision history	112

List of tables

Table 1.	Device summary	1
Table 2.	Pin description	20
Table 3.	Mechanical characteristics	21
Table 4.	Electrical characteristics	24
Table 5.	Temperature sensor characteristics	25
Table 6.	SPI slave timing values	26
Table 7.	I ² C slave timing values	27
Table 8.	Absolute maximum ratings	28
Table 9.	Serial interface pin description	36
Table 10.	Master I ² C pin details	36
Table 11.	I ² C terminology	37
Table 12.	SAD+Read/Write patterns	38
Table 13.	Transfer when master is writing one byte to slave	38
Table 14.	Transfer when master is writing multiple bytes to slave	38
Table 15.	Transfer when master is receiving (reading) one byte of data from slave	38
Table 16.	Transfer when master is receiving (reading) multiple bytes of data from slave	38
Table 17.	Internal pin status	45
Table 18.	Registers address map	47
Table 19.	FUNC_CFG_ACCESS register	51
Table 20.	FUNC_CFG_ACCESS register description	51
Table 21.	Configuration of embedded functions register banks	51
Table 22.	SENSOR_SYNC_TIME_FRAME register	51
Table 23.	SENSOR_SYNC_TIME_FRAME register description	51
Table 24.	SENSOR_SYNC_RES_RATIO register	52
Table 25.	SENSOR_SYNC_RES_RATIO register description	52
Table 26.	FIFO_CTRL1 register	52
Table 27.	FIFO_CTRL1 register description	52
Table 28.	FIFO_CTRL2 register	53
Table 29.	FIFO_CTRL2 register description	53
Table 30.	FIFO_CTRL3 register	54
Table 31.	FIFO_CTRL3 register description	54
Table 32.	Gyro FIFO decimation setting	54
Table 33.	Accelerometer FIFO decimation setting	54
Table 34.	FIFO_CTRL4 register	55
Table 35.	FIFO_CTRL4 register description	55
Table 36.	Fourth FIFO data set decimation setting	55
Table 37.	Third FIFO data set decimation setting	55
Table 38.	FIFO_CTRL5 register	56
Table 39.	FIFO_CTRL5 register description	56
Table 40.	FIFO ODR selection	56
Table 41.	FIFO mode selection	56
Table 42.	DRDY_PULSE_CFG_G register	57
Table 43.	DRDY_PULSE_CFG_G register description	57
Table 44.	INT1_CTRL register	57
Table 45.	INT1_CTRL register description	57
Table 46.	INT2_CTRL register	58
Table 47.	INT2_CTRL register description	58
Table 48.	WHO_AM_I register	58

Table 49.	CTRL1_XL register	59
Table 50.	CTRL1_XL register description	59
Table 51.	Accelerometer ODR register setting	59
Table 52.	CTRL2_G register	60
Table 53.	CTRL2_G register description	60
Table 54.	Gyroscope ODR configuration setting	60
Table 55.	CTRL3_C register	61
Table 56.	CTRL3_C register description	61
Table 57.	CTRL4_C register	62
Table 58.	CTRL4_C register description	62
Table 59.	CTRL5_C register	62
Table 60.	CTRL5_C register description	62
Table 61.	Output registers rounding pattern	63
Table 62.	Angular rate sensor self-test mode selection	63
Table 63.	Linear acceleration sensor self-test mode selection	63
Table 64.	CTRL6_C register	64
Table 65.	CTRL6_C register description	64
Table 66.	Trigger mode selection	64
Table 67.	Gyroscope LPF1 bandwidth selection	64
Table 68.	CTRL7_G register	65
Table 69.	CTRL7_G register description	65
Table 70.	CTRL8_XL register	65
Table 71.	CTRL8_XL register description	65
Table 72.	Accelerometer bandwidth selection	66
Table 73.	CTRL9_XL register	66
Table 74.	CTRL9_XL register description	66
Table 75.	CTRL10_C register	67
Table 76.	CTRL10_C register description	67
Table 77.	MASTER_CONFIG register	67
Table 78.	MASTER_CONFIG register description	68
Table 79.	WAKE_UP_SRC register	68
Table 80.	WAKE_UP_SRC register description	68
Table 81.	TAP_SRC register	69
Table 82.	TAP_SRC register description	69
Table 83.	D6D_SRC register	70
Table 84.	D6D_SRC register description	70
Table 85.	STATUS_REG register	70
Table 86.	STATUS_REG register description	70
Table 87.	OUT_TEMP_L register	71
Table 88.	OUT_TEMP_H register	71
Table 89.	OUT_TEMP register description	71
Table 90.	OUTX_L_G register	71
Table 91.	OUTX_L_G register description	71
Table 92.	OUTX_H_G register	71
Table 93.	OUTX_H_G register description	71
Table 94.	OUTY_L_G register	72
Table 95.	OUTY_L_G register description	72
Table 96.	OUTY_H_G register	72
Table 97.	OUTY_H_G register description	72
Table 98.	OUTZ_L_G register	72
Table 99.	OUTZ_L_G register description	72
Table 100.	OUTZ_H_G register	73

Table 101.	OUTZ_H_G register description	73
Table 102.	OUTX_L_XL register	73
Table 103.	OUTX_L_XL register description	73
Table 104.	OUTX_H_XL register	73
Table 105.	OUTX_H_XL register description	73
Table 106.	OUTY_L_XL register	73
Table 107.	OUTY_L_XL register description	73
Table 108.	OUTY_H_G register	74
Table 109.	OUTY_H_G register description	74
Table 110.	OUTZ_L_XL register	74
Table 111.	OUTZ_L_XL register description	74
Table 112.	OUTZ_H_XL register	74
Table 113.	OUTZ_H_XL register description	74
Table 114.	SENSORHUB1_REG register	74
Table 115.	SENSORHUB1_REG register description	74
Table 116.	SENSORHUB2_REG register	75
Table 117.	SENSORHUB2_REG register description	75
Table 118.	SENSORHUB3_REG register	75
Table 119.	SENSORHUB3_REG register description	75
Table 120.	SENSORHUB4_REG register	75
Table 121.	SENSORHUB4_REG register description	75
Table 122.	SENSORHUB5_REG register	75
Table 123.	SENSORHUB5_REG register description	75
Table 124.	SENSORHUB6_REG register	76
Table 125.	SENSORHUB6_REG register description	76
Table 126.	SENSORHUB7_REG register	76
Table 127.	SENSORHUB7_REG register description	76
Table 128.	SENSORHUB8_REG register	76
Table 129.	SENSORHUB8_REG register description	76
Table 130.	SENSORHUB9_REG register	76
Table 131.	SENSORHUB9_REG register description	76
Table 132.	SENSORHUB10_REG register	77
Table 133.	SENSORHUB10_REG register description	77
Table 134.	SENSORHUB11_REG register	77
Table 135.	SENSORHUB11_REG register description	77
Table 136.	SENSORHUB12_REG register	77
Table 137.	SENSORHUB12_REG register description	77
Table 138.	FIFO_STATUS1 register	77
Table 139.	FIFO_STATUS1 register description	77
Table 140.	FIFO_STATUS2 register	78
Table 141.	FIFO_STATUS2 register description	78
Table 142.	FIFO_STATUS3 register	78
Table 143.	FIFO_STATUS3 register description	78
Table 144.	FIFO_STATUS4 register	79
Table 145.	FIFO_STATUS4 register description	79
Table 146.	FIFO_DATA_OUT_L register	79
Table 147.	FIFO_DATA_OUT_L register description	79
Table 148.	FIFO_DATA_OUT_H register	79
Table 149.	FIFO_DATA_OUT_H register description	79
Table 150.	TIMESTAMP0_REG register	80
Table 151.	TIMESTAMP0_REG register description	80
Table 152.	TIMESTAMP1_REG register	80

Table 153.	TIMESTAMP1_REG register description	80
Table 154.	TIMESTAMP2_REG register	80
Table 155.	TIMESTAMP2_REG register description	80
Table 156.	STEP_TIMESTAMP_L register	81
Table 157.	STEP_TIMESTAMP_L register description	81
Table 158.	STEP_TIMESTAMP_H register	81
Table 159.	STEP_TIMESTAMP_H register description	81
Table 160.	STEP_COUNTER_L register	81
Table 161.	STEP_COUNTER_L register description	81
Table 162.	STEP_COUNTER_H register	82
Table 163.	STEP_COUNTER_H register description	82
Table 164.	SENSORHUB13_REG register	82
Table 165.	SENSORHUB13_REG register description	82
Table 166.	SENSORHUB14_REG register	82
Table 167.	SENSORHUB14_REG register description	82
Table 168.	SENSORHUB15_REG register	82
Table 169.	SENSORHUB15_REG register description	82
Table 170.	SENSORHUB16_REG register	83
Table 171.	SENSORHUB16_REG register description	83
Table 172.	SENSORHUB17_REG register	83
Table 173.	SENSORHUB17_REG register description	83
Table 174.	SENSORHUB18_REG register	83
Table 175.	SENSORHUB18_REG register description	83
Table 176.	FUNC_SRC1 register	84
Table 177.	FUNC_SRC1 register description	84
Table 178.	FUNC_SRC2 register	84
Table 179.	FUNC_SRC2 register description	84
Table 180.	WRIST_TILT_IA register	85
Table 181.	WRIST_TILT_IA register description	85
Table 182.	TAP_CFG register	86
Table 183.	TAP_CFG register description	86
Table 184.	TAP_THS_6D register	87
Table 185.	TAP_THS_6D register description	87
Table 186.	Threshold for D4D/D6D function	87
Table 187.	INT_DUR2 register	87
Table 188.	INT_DUR2 register description	87
Table 189.	WAKE_UP_THS register	88
Table 190.	WAKE_UP_THS register description	88
Table 191.	WAKE_UP_DUR register	88
Table 192.	WAKE_UP_DUR register description	88
Table 193.	FREE_FALL register	89
Table 194.	FREE_FALL register description	89
Table 195.	Threshold for free-fall function	89
Table 196.	MD1_CFG register	90
Table 197.	MD1_CFG register description	90
Table 198.	MD2_CFG register	91
Table 199.	MD2_CFG register description	91
Table 200.	MASTER_CMD_CODE register	92
Table 201.	MASTER_CMD_CODE register description	92
Table 202.	SENS_SYNC_SPI_ERROR_CODE register	92
Table 203.	SENS_SYNC_SPI_ERROR_CODE register description	92
Table 204.	OUT_MAG_RAW_X_L register	92

Table 205.	OUT_MAG_RAW_X_L register description	92
Table 206.	OUT_MAG_RAW_X_H register	92
Table 207.	OUT_MAG_RAW_X_H register description	92
Table 208.	OUT_MAG_RAW_Y_L register	93
Table 209.	OUT_MAG_RAW_Y_L register description	93
Table 210.	OUT_MAG_RAW_Y_H register	93
Table 211.	OUT_MAG_RAW_Y_H register description	93
Table 212.	OUT_MAG_RAW_Z_L register	93
Table 213.	OUT_MAG_RAW_Z_L register description	93
Table 214.	OUT_MAG_RAW_Z_H register	93
Table 215.	OUT_MAG_RAW_Z_H register description	93
Table 216.	X_OFS_USR register	94
Table 217.	X_OFS_USR register description	94
Table 218.	Y_OFS_USR register	94
Table 219.	Y_OFS_USR register description	94
Table 220.	Z_OFS_USR register	94
Table 221.	Z_OFS_USR register description	94
Table 222.	Register address map - Bank A - embedded functions	95
Table 223.	Register address map - Bank B - embedded functions	96
Table 224.	SLV0_ADD register	97
Table 225.	SLV0_ADD register description	97
Table 226.	SLV0_SUBADD register	97
Table 227.	SLV0_SUBADD register description	97
Table 228.	SLAVE0_CONFIG register	97
Table 229.	SLAVE0_CONFIG register description	98
Table 230.	SLV1_ADD register	98
Table 231.	SLV1_ADD register description	98
Table 232.	SLV1_SUBADD register	98
Table 233.	SLV1_SUBADD register description	98
Table 234.	SLAVE1_CONFIG register	99
Table 235.	SLAVE1_CONFIG register description	99
Table 236.	SLV2_ADD register	99
Table 237.	SLV2_ADD register description	99
Table 238.	SLV2_SUBADD register	99
Table 239.	SLV2_SUBADD register description	99
Table 240.	SLAVE2_CONFIG register	100
Table 241.	SLAVE2_CONFIG register description	100
Table 242.	SLV3_ADD register	100
Table 243.	SLV3_ADD register description	100
Table 244.	SLV3_SUBADD register	100
Table 245.	SLV3_SUBADD register description	100
Table 246.	SLAVE3_CONFIG register	101
Table 247.	SLAVE3_CONFIG register description	101
Table 248.	DATAWRITE_SRC_MODE_SUB_SLV0 register	101
Table 249.	DATAWRITE_SRC_MODE_SUB_SLV0 register description	101
Table 250.	CONFIG_PEDO_THS_MIN register	101
Table 251.	CONFIG_PEDO_THS_MIN register description	101
Table 252.	SM_THS register	102
Table 253.	SM_THS register description	102
Table 254.	PEDO_DEB_REG register default values	102
Table 255.	PEDO_DEB_REG register description	102
Table 256.	STEP_COUNT_DELTA register	102

Table 257.	STEP_COUNT_DELTA register description	102
Table 258.	MAG_SI_XX register	103
Table 259.	MAG_SI_XX register description	103
Table 260.	MAG_SI_XY register	103
Table 261.	MAG_SI_XY register description	103
Table 262.	MAG_SI_XZ register	103
Table 263.	MAG_SI_XZ register description	103
Table 264.	MAG_SI_YX register	103
Table 265.	MAG_SI_YX register description	103
Table 266.	MAG_SI_YY register	104
Table 267.	MAG_SI_YY register description	104
Table 268.	MAG_SI_YZ register	104
Table 269.	MAG_SI_YZ register description	104
Table 270.	MAG_SI_ZX register	104
Table 271.	MAG_SI_ZX register description	104
Table 272.	MAG_SI_ZY register	104
Table 273.	MAG_SI_ZY register description	104
Table 274.	MAG_SI_ZZ register	105
Table 275.	MAG_SI_ZZ register description	105
Table 276.	MAG_OFFX_L register	105
Table 277.	MAG_OFFX_L register description	105
Table 278.	MAG_OFFX_H register	105
Table 279.	MAG_OFFX_H register description	105
Table 280.	MAG_OFFY_L register	105
Table 281.	MAG_OFFY_L register description	105
Table 282.	MAG_OFFY_H register	106
Table 283.	MAG_OFFY_H register description	106
Table 284.	MAG_OFFZ_L register	106
Table 285.	MAG_OFFZ_L register description	106
Table 286.	MAG_OFFZ_H register	106
Table 287.	MAG_OFFZ_H register description	106
Table 288.	A_WRIST_TILT_LAT register	107
Table 289.	A_WRIST_TILT_LAT register description	107
Table 290.	A_WRIST_TILT_THS register	107
Table 291.	A_WRIST_TILT_THS register description	107
Table 292.	A_WRIST_TILT_Mask register	107
Table 293.	A_WRIST_TILT_Mask register description	107
Table 294.	Reel dimensions for carrier tape of LGA-14 package	111
Table 295.	Document revision history	112

List of figures

Figure 1.	Pin connections	18
Figure 2.	LSM6DSL connection modes	19
Figure 3.	SPI slave timing diagram	26
Figure 4.	I ² C slave timing diagram	27
Figure 5.	Block diagram of filters	31
Figure 6.	Gyroscope digital chain - Mode 1 (UI/EIS) and Mode 2	31
Figure 7.	Accelerometer chain	32
Figure 8.	Accelerometer composite filter	32
Figure 9.	Read and write protocol	39
Figure 10.	SPI read protocol	40
Figure 11.	Multiple byte SPI read protocol (2-byte example).	40
Figure 12.	SPI write protocol	41
Figure 13.	Multiple byte SPI write protocol (2-byte example).	41
Figure 14.	SPI read protocol in 3-wire mode	42
Figure 15.	LSM6DSL electrical connections in Mode 1	43
Figure 16.	LSM6DSL electrical connections in Mode 2	44
Figure 17.	LGA-14 2.5x3x0.86 mm package outline and mechanical data	109
Figure 18.	Carrier tape information for LGA-14 package.	110
Figure 19.	LGA-14 package orientation in carrier tape	110
Figure 20.	Reel information for carrier tape of LGA-14 package	111

1 Overview

The LSM6DSL is a system-in-package featuring a high-performance 3-axis digital accelerometer and 3-axis digital gyroscope.

The integrated power-efficient modes are able to reduce the power consumption down to 0.65 mA in high-performance mode, combining always-on low-power features with superior sensing precision for an optimal motion experience for the consumer thanks to ultra-low noise performance for both the gyroscope and accelerometer.

The LSM6DSL delivers best-in-class motion sensing that can detect orientation and gestures in order to empower application developers and consumers with features and capabilities that are more sophisticated than simply orienting their devices to portrait and landscape mode.

The event-detection interrupts enable efficient and reliable motion tracking and contextual awareness, implementing hardware recognition of free-fall events, 6D orientation, click and double-click sensing, activity or inactivity, and wakeup events.

The LSM6DSL supports main OS requirements, offering real, virtual and batch mode sensors. In addition, the LSM6DSL can efficiently run the sensor-related features specified in Android, saving power and enabling faster reaction time. In particular, the LSM6DSL has been designed to implement hardware features such as significant motion detection, tilt, pedometer functions, timestamping and to support the data acquisition of an external magnetometer with ironing correction (hard, soft).

The LSM6DSL offers hardware flexibility to connect the pins with different mode connections to external sensors to expand functionalities such as adding a sensor hub, etc.

Up to 4 kbyte of FIFO with dynamic allocation of significant data (i.e. external sensors, timestamp, etc.) allows overall power saving of the system.

Like the entire portfolio of MEMS sensor modules, the LSM6DSL leverages the robust and mature in-house manufacturing processes already used for the production of micromachined accelerometers and gyroscopes. The various sensing elements are manufactured using specialized micromachining processes, while the IC interfaces are developed using CMOS technology that allows the design of a dedicated circuit which is trimmed to better match the characteristics of the sensing element.

The LSM6DSL is available in a small plastic land grid array (LGA) package of 2.5 x 3.0 x 0.83 mm to address ultra-compact solutions.

2 Embedded low-power features

The LSM6DSL has been designed to be fully compliant with Android, featuring the following on-chip functions:

- 4 kbyte data buffering
 - 100% efficiency with flexible configurations and partitioning
 - Possibility to store timestamp
- Event-detection interrupts (fully configurable):
 - Free-fall
 - Wakeup
 - 6D orientation
 - Click and double-click sensing
 - Activity / inactivity recognition
- Specific IP blocks with negligible power consumption and high-performance:
 - Pedometer functions: step detector and step counters
 - Tilt (refer to [Section 2.1: Tilt detection](#) for additional information)
 - Absolute Wrist Tilt (refer to [Section 2.2: Absolute wrist tilt](#) for additional information)
 - Significant Motion Detection
- Sensor hub
 - Up to 6 total sensors: 2 internal (accelerometer and gyroscope) and 4 external sensors
- Data rate synchronization with external trigger for reduced sensor access and enhanced fusion

2.1 Tilt detection

The tilt function helps to detect activity change and has been implemented in hardware using only the accelerometer to achieve both the targets of ultra-low power consumption and robustness during the short duration of dynamic accelerations.

It is based on a trigger of an event each time the device's tilt changes. For a more customized user experience, in the LSM6DSL the tilt function is configurable through:

- a programmable average window
- a programmable average threshold

The tilt function can be used with different scenarios, for example:

- a) Triggers when phone is in a front pants pocket and the user goes from sitting to standing or standing to sitting;
- b) Doesn't trigger when phone is in a front pants pocket and the user is walking, running or going upstairs.

2.2 Absolute wrist tilt

The LSM6DSL implements in hardware the Absolute Wrist Tilt (AWT) function which allows detecting when the angle between a selectable accelerometer semi-axis and the horizontal plane becomes higher than a specific user-selectable value.

Configurable threshold and latency parameters are associated with the AWT function: the threshold parameter defines the amplitude of the tilt angle; the latency parameter defines the minimum duration of the AWT event to be recognized. The AWT interrupt signal is generated if the tilt angle is higher than the threshold angle for a period of time equal to or greater than the latency period.

The AWT function is based on the accelerometer sensor only and works at 26 Hz, so the accelerometer ODR must be set at a value of 26 Hz or higher.

By default, the AWT algorithm is applied to the positive X-axis.

In order to enable the AWT function it is necessary to set to 1 both the FUNC_EN bit and the WRIST_TILT_EN bit of *CTRL10_C (19h)*.

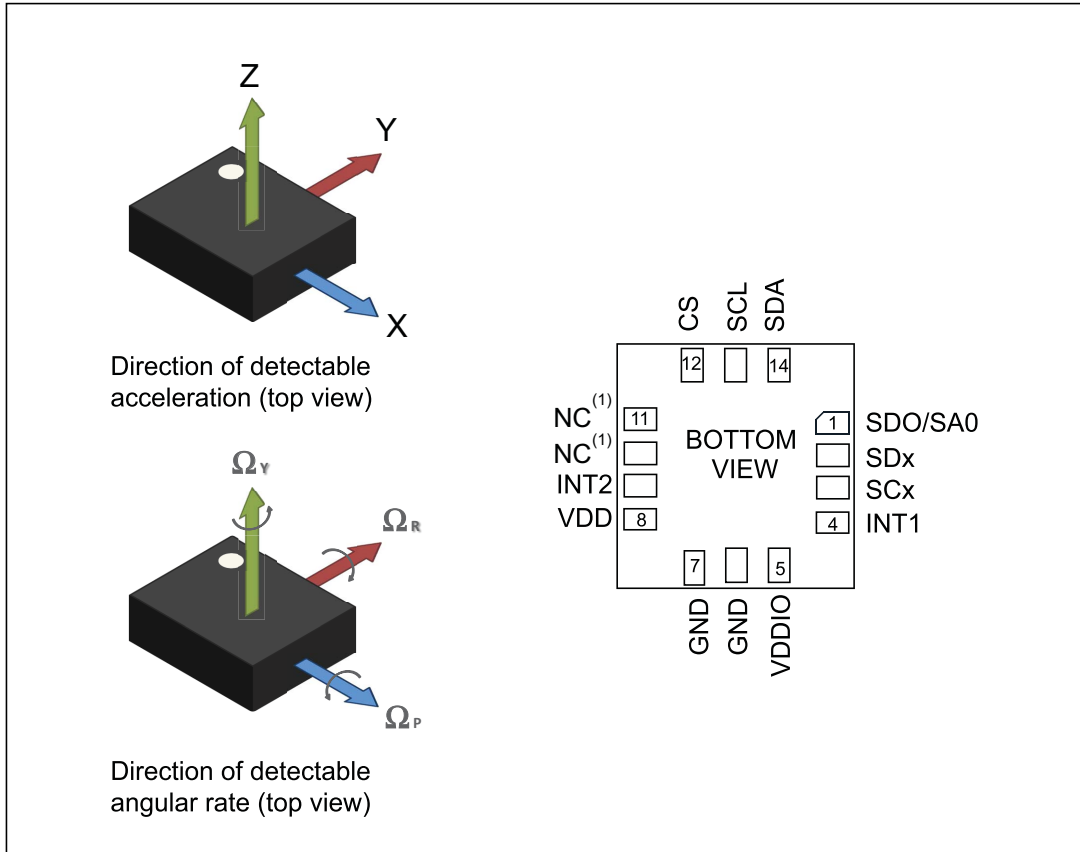
The AWT interrupt signal can be driven to the INT2 interrupt pin by setting to 1 the INT2_WRIST_TILT bit of the *DRDY_PULSE_CFG_G (0Bh)* register; it can also be checked by reading the WRIST_TILT_IA bit of the *FUNC_SRC2 (54h)* register (it will also clear the interrupt signal if latched).

WRIST_TILT_IA (55h) is the status register to be used to detect which axis has triggered the AWT event (not applicable when using one axis side only).

The full description and an example is given in the dedicated application note.

3 Pin description

Figure 1. Pin connections



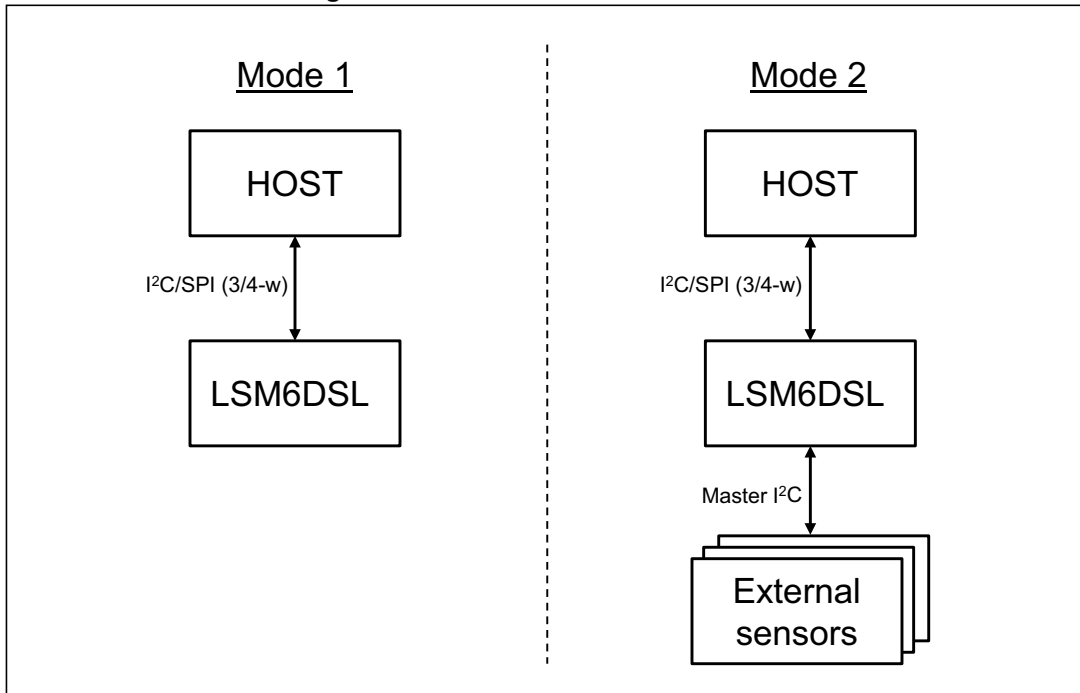
1. Leave pin electrically unconnected and soldered to PCB.

3.1 Pin connections

The LSM6DSL offers flexibility to connect the pins in order to have two different mode connections and functionalities. In detail:

- **Mode 1:** I²C slave interface or SPI (3- and 4-wire) serial interface is available;
- **Mode 2:** I²C slave interface or SPI (3- and 4-wire) serial interface and I²C interface master for external sensor connections are available;

Figure 2. LSM6DSL connection modes



In the following table each mode is described for the pin connection and function.

Table 2. Pin description

Pin#	Name	Mode 1 function	Mode 2 function
1	SDO/SA0	SPI 4-wire interface serial data output (SDO) I ² C least significant bit of the device address (SA0)	SPI 4-wire interface serial data output (SDO) I ² C least significant bit of the device address (SA0)
2	SDx	Connect to VDDIO or GND	I ² C serial data master (MSDA)
3	SCx	Connect to VDDIO or GND	I ² C serial clock master (MSCL)
4	INT1	Programmable interrupt 1	
5	VDDIO ⁽¹⁾	Power supply for I/O pins	
6	GND	0 V supply	
7	GND	0 V supply	
8	VDD ⁽¹⁾	Power supply	
9	INT2	Programmable interrupt 2 (INT2) / Data enable (DEN)	Programmable interrupt 2 (INT2)/ Data enable (DEN)/ I ² C master external synchronization signal (MDRDY)
10	NC ⁽²⁾	Leave unconnected	
11	NC ⁽²⁾	Leave unconnected	
12	CS	I ² C/SPI mode selection (1: SPI idle mode / I ² C communication enabled; 0: SPI communication mode / I ² C disabled)	I ² C/SPI mode selection (1: SPI idle mode / I ² C communication enabled; 0: SPI communication mode / I ² C disabled)
13	SCL	I ² C serial clock (SCL) SPI serial port clock (SPC)	I ² C serial clock (SCL) SPI serial port clock (SPC)
14	SDA	I ² C serial data (SDA) SPI serial data input (SDI) 3-wire interface serial data output (SDO)	I ² C serial data (SDA) SPI serial data input (SDI) 3-wire interface serial data output (SDO)

1. Recommended 100 nF filter capacitor.
2. Leave pin electrically unconnected and soldered to PCB.

4 Module specifications

4.1 Mechanical characteristics

@ Vdd = 1.8 V, T = 25 °C unless otherwise noted.

Table 3. Mechanical characteristics

Symbol	Parameter	Test conditions	Min.	Typ. ⁽¹⁾	Max.	Unit
LA_FS	Linear acceleration measurement range			±2		g
				±4		
				±8		
				±16		
G_FS	Angular rate measurement range			±125		dps
				±245		
				±500		
				±1000		
LA_So	Linear acceleration sensitivity ⁽²⁾	FS = ±2		0.061		mg/LSB
		FS = ±4		0.122		
		FS = ±8		0.244		
		FS = ±16		0.488		
G_So	Angular rate sensitivity ⁽²⁾	FS = ±125		4.375		mdps/LSB
		FS = ±245		8.75		
		FS = ±500		17.50		
		FS = ±1000		35		
		FS = ±2000		70		
G_So%	Sensitivity tolerance ⁽³⁾	at component level		±1		%
LA_SoDr	Linear acceleration sensitivity change vs. temperature ⁽⁴⁾	from -40° to +85°		±0.01		%/°C
G_SoDr	Angular rate sensitivity change vs. temperature ⁽⁴⁾	from -40° to +85°		±0.007		%/°C
LA_TyOff	Linear acceleration zero-g level offset accuracy ⁽⁵⁾			±40		mg
G_TyOff	Angular rate zero-rate level ⁽⁴⁾			±3		dps
LA_OffDr	Linear acceleration zero-g level change vs. temperature ⁽⁴⁾			±0.1		mg/°C
G_OffDr	Angular rate typical zero-rate level change vs. temperature ⁽⁴⁾			±0.015		dps/°C
Rn	Rate noise density in high-performance mode ⁽⁶⁾			4		mdps/√Hz

Table 3. Mechanical characteristics (continued)

Symbol	Parameter	Test conditions	Min.	Typ. ⁽¹⁾	Max.	Unit
RnRMS	Gyroscope RMS noise in normal/low-power mode ⁽⁷⁾			75		mdps
An	Acceleration noise density in high-performance mode ⁽⁸⁾	FS = ±2 g		90		μg/√Hz
		FS = ±4 g		90		
		FS = ±8 g		90		
		FS = ±16 g		130		
RMS	Acceleration RMS noise in normal/low-power mode ⁽⁹⁾⁽¹⁰⁾	FS = ±2 g		1.8		mg(RMS)
		FS = ±4 g		2.0		
		FS = ±8 g		2.4		
		FS = ±16 g		3.0		
LA_ODR	Linear acceleration output data rate			1.6 ⁽¹¹⁾		Hz
				12.5		
				26		
				52		
				104		
				208		
				416		
				833		
				1666		
				3332		
		6664				
G_ODR	Angular rate output data rate			12.5		Hz
				26		
				52		
				104		
				208		
				416		
				833		
				1666		
				3332		
				6664		
Vst	Linear acceleration self-test output change ⁽¹²⁾⁽¹³⁾⁽¹⁴⁾		90		1700	mg
	Angular rate self-test output change ⁽¹⁵⁾⁽¹⁶⁾	FS = 245 dps	20		80	dps
		FS = 2000 dps	150		700	dps
Top	Operating temperature range		-40		+85	°C

1. Typical specifications are not guaranteed.
2. Sensitivity values after factory calibration test and trimming
3. Subject to change.
4. Measurements are performed in a uniform temperature setup and they are based on characterization data in a limited number of samples. Not measured during final test for production.
5. Values after factory calibration test and trimming.



6. Gyroscope rate noise density in high-performance mode is independent of the ODR and FS setting.
7. Gyroscope RMS noise in normal/low-power mode is independent of the ODR and FS setting.
8. Accelerometer noise density in high-performance mode is independent of the ODR.
9. Accelerometer RMS noise in normal/low-power mode is independent of the ODR.
10. Noise RMS related to $BW = ODR / 2$ (for $ODR / 9$, typ value can be calculated by $Typ * 0.6$).
11. This ODR is available when accelerometer is in low-power mode.
12. The sign of the linear acceleration self-test output change is defined by the STx_XL bits in [CTRL5_C \(14h\)](#), [Table 63](#) for all axes.
13. The linear acceleration self-test output change is defined with the device in stationary condition as the absolute value of: $OUTPUT[LSb] \text{ (self-test enabled)} - OUTPUT[LSb] \text{ (self-test disabled)}$. 1LSb = 0.061 mg at $\pm 2 g$ full scale.
14. Accelerometer self-test limits are full-scale independent.
15. The sign of the angular rate self-test output change is defined by the STx_G bits in [CTRL5_C \(14h\)](#), [Table 62](#) for all axes.
16. The angular rate self-test output change is defined with the device in stationary condition as the absolute value of: $OUTPUT[LSb] \text{ (self-test enabled)} - OUTPUT[LSb] \text{ (self-test disabled)}$. 1LSb = 70 mdps at ± 2000 dps full scale.

4.2 Electrical characteristics

@ Vdd = 1.8 V, T = 25 °C unless otherwise noted.

Table 4. Electrical characteristics

Symbol	Parameter	Test conditions	Min.	Typ. ⁽¹⁾	Max.	Unit
Vdd	Supply voltage		1.71	1.8	3.6	V
Vdd_IO	Power supply for I/O		1.62		3.6	V
IddHP	Gyroscope and accelerometer current consumption in high-performance mode	ODR = 1.6 kHz		0.65		mA
IddNM	Gyroscope and accelerometer current consumption in normal mode	ODR = 208 Hz		0.45		mA
IddLP	Gyroscope and accelerometer current consumption in low-power mode	ODR = 52 Hz		0.29		mA
LA_IddHP	Accelerometer current consumption in high-performance mode	ODR < 1.6 kHz ODR ≥ 1.6 kHz		150 160		μA
LA_IddNM	Accelerometer current consumption in normal mode	ODR = 208 Hz		85		μA
LA_IddLM	Accelerometer current consumption in low-power mode	ODR = 52 Hz ODR = 12.5 Hz ODR = 1.6 Hz		25 9 4.5		μA
IddPD	Gyroscope and accelerometer current consumption during power-down			3		μA
Ton	Turn-on time			35		ms
V _{IH}	Digital high-level input voltage		0.7 *VDD_IO			V
V _{IL}	Digital low-level input voltage				0.3 *VDD_IO	V
V _{OH}	High-level output voltage	I _{OH} = 4 mA ⁽²⁾	VDD_IO - 0.2			V
V _{OL}	Low-level output voltage	I _{OL} = 4 mA ⁽²⁾			0.2	V
Top	Operating temperature range		-40		+85	°C

1. Typical specifications are not guaranteed.
2. 4 mA is the maximum driving capability, i.e. the maximum DC current that can be sourced/sunk by the digital pad in order to guarantee the correct digital output voltage levels V_{OH} and V_{OL}.

4.3 Temperature sensor characteristics

@ V_{dd} = 1.8 V, T = 25 °C unless otherwise noted.

Table 5. Temperature sensor characteristics

Symbol	Parameter	Test condition	Min.	Typ. ⁽¹⁾	Max.	Unit
TODR ⁽²⁾	Temperature refresh rate			52		Hz
Toff	Temperature offset ⁽³⁾		-15		+15	°C
TSen	Temperature sensitivity			256		LSB/°C
TST	Temperature stabilization time ⁽⁴⁾				500	µs
T_ADC_res	Temperature ADC resolution			16		bit
Top	Operating temperature range		-40		+85	°C

1. Typical specifications are not guaranteed.
2. When the accelerometer is in Low-Power mode and the gyroscope part is turned off, the TODR value is equal to the accelerometer ODR.
3. The output of the temperature sensor is 0 LSB (typ.) at 25 °C.
4. Time from power ON bit to valid data based on characterization data.