TD 1

Exercice 1

1. Quelle est la différence entre capteur normale et capteur intelligent
2. Citer les différents fonctionnalités d'un capteur intelligent
3. Citer les différentes unités (ensembles) des capteurs intelligents

Exercice 2

Répondrez par « oui » ou « non » si la réponse est non corrigez la phrase.

1. Le rôle de l'unité de traitement est la transmission du signal de mesure et des informations de diagnostic
2. L'autodiagnostic dans un capteur intelligent c-à -d la configuration du système
3. Le capteur intelligent est un système autonome et il n'a pas besoin d'une source d'alimentation

Exercice 3 :

Les mesures des accélérations suivant les axes x, y et z sont obtenues sur les entrées analogique d'un accéléromètre ADXL335.

1. D'après la fiche technique Déterminer la sensibilité du capteur donnée en V/g.
2. Déterminer la tension d'offset V_0
3. Ecrire le programme qui permet de visualiser les 3 accélérations sur le moniteur série.
4. Donner l'inclinaison (angle) de l'accéléromètre en utilisant uniquement l'axe X.
5. Donner l'inclinaison en ° de l'accéléromètre en utilisant les axes X et y.
6. Calculer la valeur des condensateurs c_x, c_y et c_z entre l'entrée analogique et la masse la sachant que résistance de sortie de l'accéléromètre a pour valeur 32 kΩ. permettant d'obtenir la fréquence de coupure de coupure donné dans le datasheet

Exercice 4 :

Soit un MEMS MPU-6050, capteur IMU (Inertial Measurement Unit) composé d'un accéléromètre à 3 axes (x,y,z) et d'un gyroscope à 3 axes (x,y,z). Ce module numérique utilise une interface série I2C – 400kHz, pour la communication avec la carte de traitement. L'accéléromètre mesure l'accélération linéaire du robot sur 3 axes ; mais il est possible de s'en

servir pour mesurer l'inclinaison du robot, puisque la force de gravitation (g) n'est autre qu'une accélération. Cette mesure est généralement tachée des bruits de haute fréquence.
Nous allons choisir la plage de mesure de ±16g.

1. Donner la valeur de la sensibilité
2. Compléter le tableau ci-dessous, représentant les valeurs stockées dans l'accéléromètre en fonction de sa position pour la plage ±16g.

Valeurs d'accélération sur axe X	ACCEL_XOUT[15..8]	ACCEL_XOUT[7..0]
0,35g		
1g		
0.707g		

3. Donner la valeur stockée dans le registre de configuration de l'accéléromètre permettant de configurer la plage de mesure ±16g.
4. Ecrire un programme qui permet d'indiquer à la carte que l'on communique en I2C, de visualiser les 3 accélérations et de faire le réglage de la gamme de mesure (et de la sensibilité)

Annexe

Extrait du Datasheet d'un ADXL335

ANALOG DEVICES

Small, Low Power, 3-Axis ±3 *g* *i*MEMS® Accelerometer

ADXL330

FEATURES

3-axis sensing
Small, low-profile package
  4 mm × 4 mm × 1.45 mm LFCSP
Low power
  200 µA at V_S = 2.0 V (typical)
Single-supply operation
  2.0 V to 3.6 V
10,000 *g* shock survival
Excellent temperature stability
BW adjustment with a single capacitor per axis
RoHS/WEEE lead-free compliant

APPLICATIONS

Cost-sensitive, low power, motion- and tilt-sensing applications
  Mobile devices
  Gaming systems
  Disk drive protection
  Image stabilization
  Sports and health devices

GENERAL DESCRIPTION

The ADXL330 is a small, thin, low power, complete three axis accelerometer with signal conditioned voltage outputs, all on a single monolithic IC. The product measures acceleration with a minimum full-scale range of ±3 *g*. It can measure the static acceleration of gravity in tilt-sensing applications, as well as dynamic acceleration resulting from motion, shock, or vibration.

The user selects the bandwidth of the accelerometer using the C_X, C_Y, and C_Z capacitors at the X_{OUT}, Y_{OUT}, and Z_{OUT} pins. Bandwidths can be selected to suit the application, with a range of 0.5 Hz to 1,600 Hz for X and Y axes, and a range of 0.5 Hz to 550 Hz for the Z axis.

The ADXL330 is available in a small, low-profile, 4 mm × 4 mm × 1.45 mm, 16-lead, plastic lead frame chip scale package (LFCSP_LQ).

FUNCTIONAL BLOCK DIAGRAM

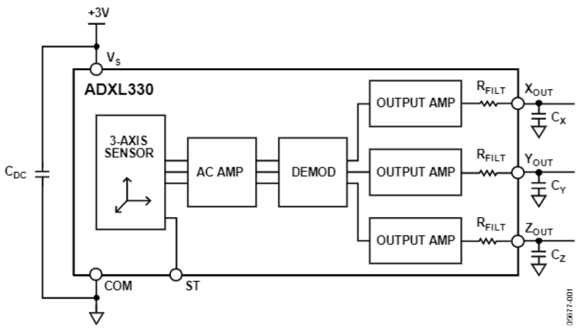

Figure 1.

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Fax: 781.461.3113

SPECIFICATIONS

T_A = 25°C, V_S = 3 V, C_X = C_Y = C_Z = 0.1 µF, acceleration = 0 *g*, unless otherwise noted. All minimum and maximum specifications are guaranteed. Typical specifications are not guaranteed.

Table 1.

Parameter	Conditions	Min	Typ	Max	Unit
SENSOR INPUT	Each axis				
Measurement Range		±3	±3.6		*g*
Nonlinearity	% of full scale		±0.3		%
Package Alignment Error			±1		Degrees
Inter-Axis Alignment Error			±0.1		Degrees
Cross Axis Sensitivity[1]			±1		%
SENSITIVITY (RATIOMETRIC)[2]	Each axis				
Sensitivity at X_{OUT}, Y_{OUT}, Z_{OUT}	V_S = 3 V	270	300	330	mV/*g*
Sensitivity Change Due to Temperature[3]	V_S = 3 V		±0.015		%/°C
ZERO *g* BIAS LEVEL (RATIOMETRIC)	Each axis				
0 *g* Voltage at X_{OUT}, Y_{OUT}, Z_{OUT}	V_S = 3 V	1.2	1.5	1.8	V
0 *g* Offset vs. Temperature			±1		m*g*/°C
NOISE PERFORMANCE					
Noise Density X_{OUT}, Y_{OUT}			280		µ*g*/√Hz rms
Noise Density Z_{OUT}			350		µ*g*/√Hz rms
FREQUENCY RESPONSE[4]					
Bandwidth X_{OUT}, Y_{OUT}[5]	No external filter		1600		Hz
Bandwidth Z_{OUT}[5]	No external filter		550		Hz
R_{FILT} Tolerance			32 ± 15%		kΩ
Sensor Resonant Frequency			5.5		kHz
SELF-TEST[6]					
Logic Input Low			+0.6		V
Logic Input High			+2.4		V
ST Actuation Current			+60		µA
Output Change at X_{OUT}	Self-test 0 to 1		−150		mV
Output Change at Y_{OUT}	Self-test 0 to 1		+150		mV
Output Change at Z_{OUT}	Self-test 0 to 1		−60		mV
OUTPUT AMPLIFIER					
Output Swing Low	No load		0.1		V
Output Swing High	No load		2.8		V
POWER SUPPLY					
Operating Voltage Range		2.0		3.6	V
Supply Current	V_S = 3 V		320		µA
Turn-On Time[7]	No external filter		1		ms
TEMPERATURE					
Operating Temperature Range		−25		+70	°C

Extrait du Datasheet d'un MPU-6050

4.32 Register 117 – Who Am I
WHO_AM_I

Type: Read Only

Register (Hex)	Register (Decimal)	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
75	117	-	WHO_AM_I[6:1]						-

Description:

This register is used to verify the identity of the device. The contents of *WHO_AM_I* are the upper 6 bits of the MPU-60X0's 7-bit I^2C address. The least significant bit of the MPU-60X0's I^2C address is determined by the value of the AD0 pin. The value of the AD0 pin is not reflected in this register.

The default value of the register is 0x68.

Bits 0 and 7 are reserved. (Hard coded to 0)

Parameters:

WHO_AM_I Contains the 6-bit I^2C address of the MPU-60X0.

The Power-On-Reset value of Bit6:Bit1 is 110 100.

4.17 Registers 59 to 64 – Accelerometer Measurements
ACCEL_XOUT_H, ACCEL_XOUT_L, ACCEL_YOUT_H, ACCEL_YOUT_L, ACCEL_ZOUT_H, and ACCEL_ZOUT_L

Type: Read Only

Register (Hex)	Register (Decimal)	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
3B	59	ACCEL_XOUT[15:8]							
3C	60	ACCEL_XOUT[7:0]							
3D	61	ACCEL_YOUT[15:8]							
3E	62	ACCEL_YOUT[7:0]							
3F	63	ACCEL_ZOUT[15:8]							
40	64	ACCEL_ZOUT[7:0]							

Description:

These registers store the most recent accelerometer measurements.

Accelerometer measurements are written to these registers at the Sample Rate as defined in Register 25.

The accelerometer measurement registers, along with the temperature measurement registers, gyroscope measurement registers, and external sensor data registers, are composed of two sets of registers: an internal register set and a user-facing read register set.

The data within the accelerometer sensors' internal register set is always updated at the Sample Rate. Meanwhile, the user-facing read register set duplicates the internal register set's data values whenever the serial interface is idle. This guarantees that a burst read of sensor registers will read measurements from the same sampling instant. Note that if burst reads are not used, the user is responsible for ensuring a set of single byte reads correspond to a single sampling instant by checking the Data Ready interrupt.

Each 16-bit accelerometer measurement has a full scale defined in *ACCEL_FS* (Register 28). For each full scale setting, the accelerometers' sensitivity per LSB in *ACCEL_xOUT* is shown in the table below.

AFS_SEL	Full Scale Range	LSB Sensitivity
0	$\pm 2g$	16384 LSB/g
1	$\pm 4g$	8192 LSB/g
2	$\pm 8g$	4096 LSB/g
3	$\pm 16g$	2048 LSB/g

Parameters:

ACCEL_XOUT 16-bit 2's complement value.

Stores the most recent X axis accelerometer measurement.

ACCEL_YOUT 16-bit 2's complement value.

Stores the most recent Y axis accelerometer measurement.

ACCEL_ZOUT 16-bit 2's complement value.

Stores the most recent Z axis accelerometer measurement.

4.5 Register 28 – Accelerometer Configuration
ACCEL_CONFIG

Type: Read/Write

Register (Hex)	Register (Decimal)	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
1C	28	XA_ST	YA_ST	ZA_ST	AFS_SEL[1:0]		-		

Description:

This register is used to trigger accelerometer self test and configure the accelerometer full scale range. This register also configures the Digital High Pass Filter (DHPF).

Accelerometer self-test permits users to test the mechanical and electrical portions of the accelerometer. The self-test for each accelerometer axis can be activated by controlling the *XA_ST*, *YA_ST*, and *ZA_ST* bits of this register. Self-test for each axis may be performed independently or all at the same time.

When self-test is activated, the on-board electronics will actuate the appropriate sensor. This actuation simulates an external force. The actuated sensor, in turn, will produce a corresponding output signal. The output signal is used to observe the self-test response.

The self-test response is defined as follows:

Self-test response = Sensor output with self-test enabled – Sensor output without self-test enabled

The self-test limits for each accelerometer axis is provided in the electrical characteristics tables of the MPU-6000/MPU-6050 Product Specification document. When the value of the self-test response is within the min/max limits of the product specification, the part has passed self test. When the self-test response exceeds the min/max values specified in the document, the part is deemed to have failed self-test.

AFS_SEL selects the full scale range of the accelerometer outputs according to the following table.

AFS_SEL	Full Scale Range
0	± 2*g*
1	± 4*g*
2	± 8*g*
3	± 16*g*