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MFSTEP
E2-M3A BUOY

DETAILED DESIGN OF THE WATER DETECT & ACCELERATION MONITORING UNIT

distribuzione: ASRO/GA, ROSS/CD, ROSS/FZ, OGS

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rev.	data	descrizione	pagine	preparato	verificato	approvato	autorizzato

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1 SCOPE

Purpose of the present document is to describe both the hardware and the software of the Water Detect and Acceleration Monitoring Unit (hereafter referred to as WAU), one of the new packages that has been specifically developed by Tecnomare to upgrade the existing buoy BOMA to the MFSTEP project standard.

The WAU is dedicated to monitor:

- the vertical acceleration (heave) of the E2-M3A buoy;
- the presence of water inside each one of the three compartments of the buoy.

2 BASIC SPECIFICATIONS

Basic specifications for the WAU are listed in the following table:

BOX LAYOUT	GEWISS GW 44 210 30L x 38H x 13D (cm x cm x cm)
INTERFACE	RS-232 to the existing UCM-C Cable to 12 VDC power supply
POWER SUPPLY	12 VDC
CPU TYPE	TEC-CPU2 (same used in BOMA Data Acquisition and Control System)
ACCELEROMETER	Motorola Semiconductor MMA1220D Low G Accelerometer 25 mW @ 5V
WATER DETECTOR	National Semiconductor LM1830 Fluid Detector 60 mW @ 12V
POWER CONSUMPTION	about 80 mW including the DC/DC board consumption

Table 1: basic specifications for the WAU unit

3 INTERCONNECTION

The WAU has been designed to operate a stand alone unit, connected to the main data acquisition and control system of the buoy as indicated in the following Figure 1:

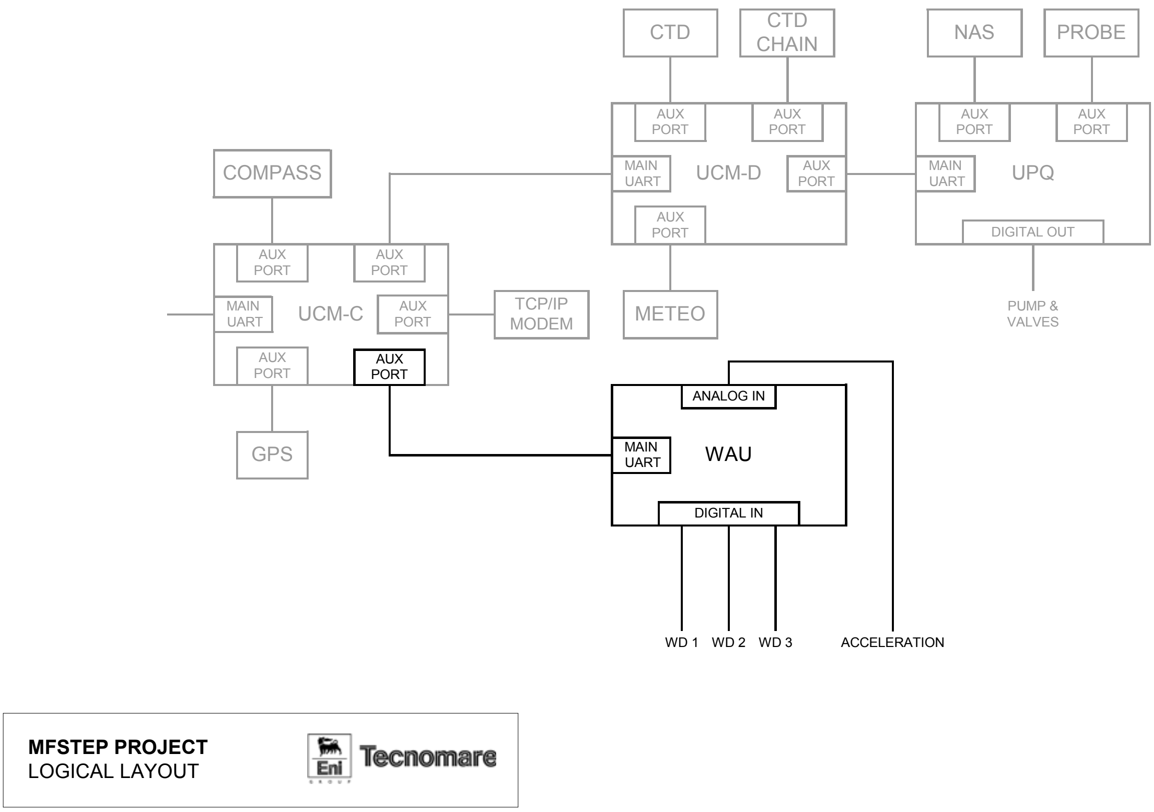
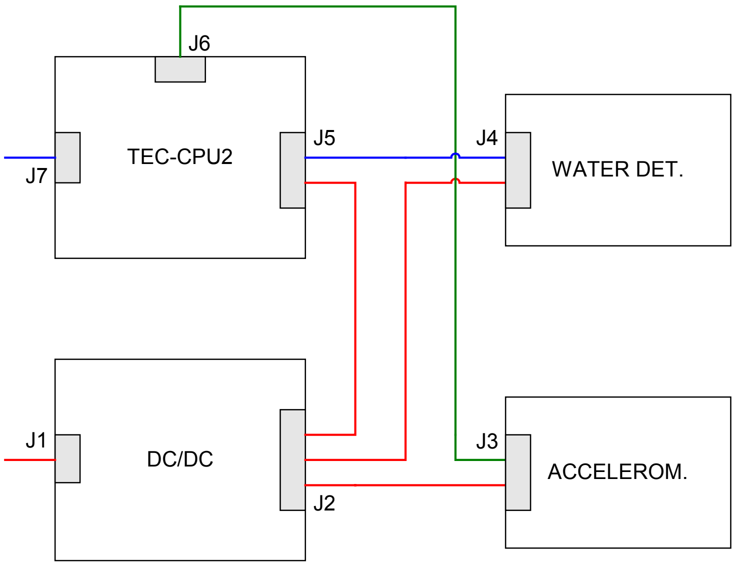


Figure 1: the upgraded layout of BOMA data acquisition and control system

4 HARDWARE DESCRIPTION

The WAU hardware configuration is shown in the following block diagram.



MFSTEP PROJECT
WAU
INTERCONNECTION DIAGRAM

Figure 2: WAU interconnection diagram

As it can be argued from Figure 2 four items must be considered:

- a DC/DC board getting the power voltage from the rest of the system and supplying the right voltage to each board of the WD&ACC;
- a CPU board which is the core of the unit allowing its connection to the rest of the system;
- an accelerometer board, based on the Motorola MMA1220D accelerometer chip;
- a water detect board onto which are mounted three National Semiconductor LM1830 fluid detectors to control the water intrusion inside the three buoy compartments.

4.1 Water Detect Board

In Figure 3 the electrical layout of the water detect board is shown.

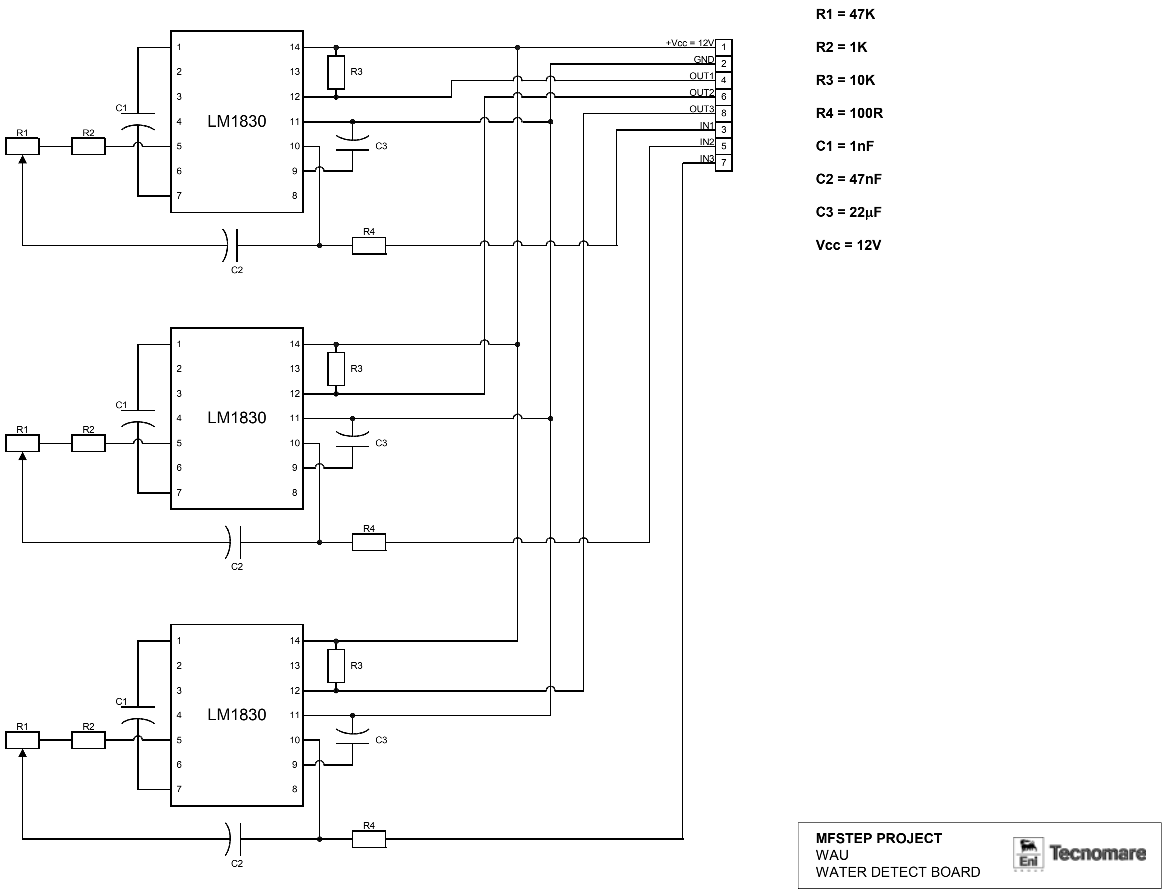


Figure 3: water detect board layout

Pins 3, 5 and 7 are connecetd to three steel bars, the water sensors, each one located on a different compartment of the buoy.

4.2 Accelerometer Board

The accelerometer board layout is shown in the following Figure 4.

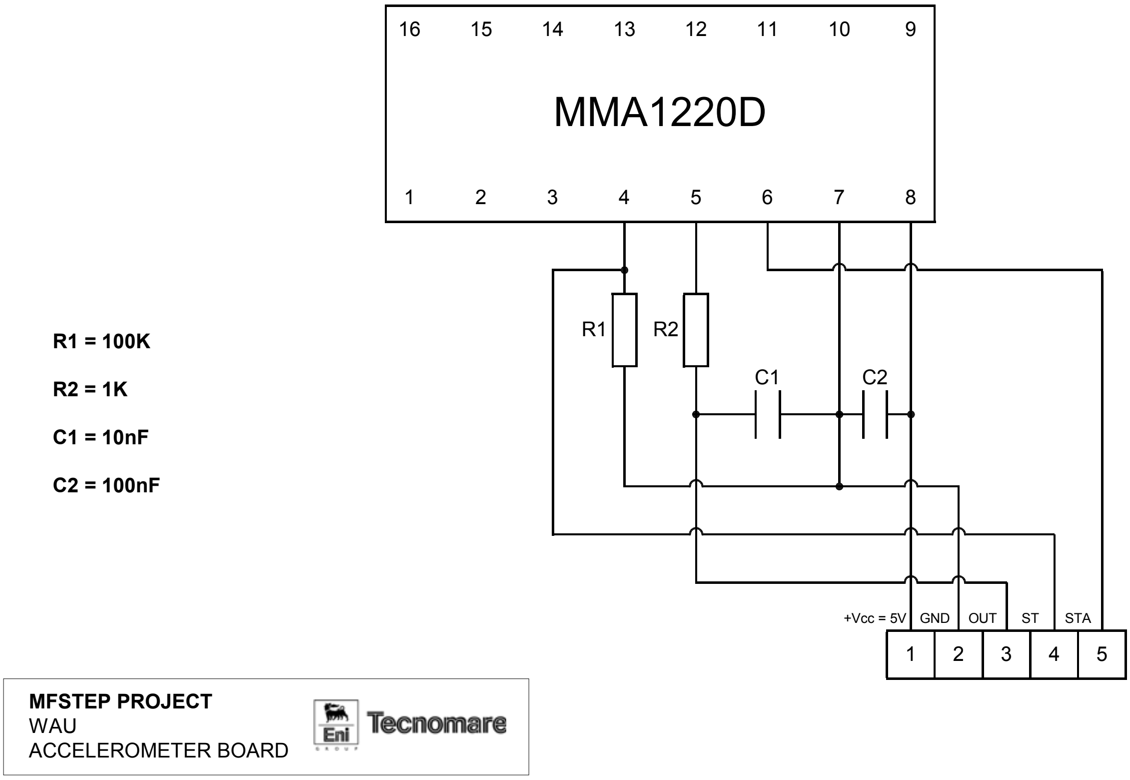


Figure 4: layout of the accelerometer board

Only pins 1 to 3 are used to connect this board to the WAU CPU.

To get a real and valid measurement this board must be kept parallel to the buoy horizontal plane.

4.3 DC/DC Board

Figure 5 shows the layout of the DC/DC board, supplying the proper voltage to all boards of the WAU.

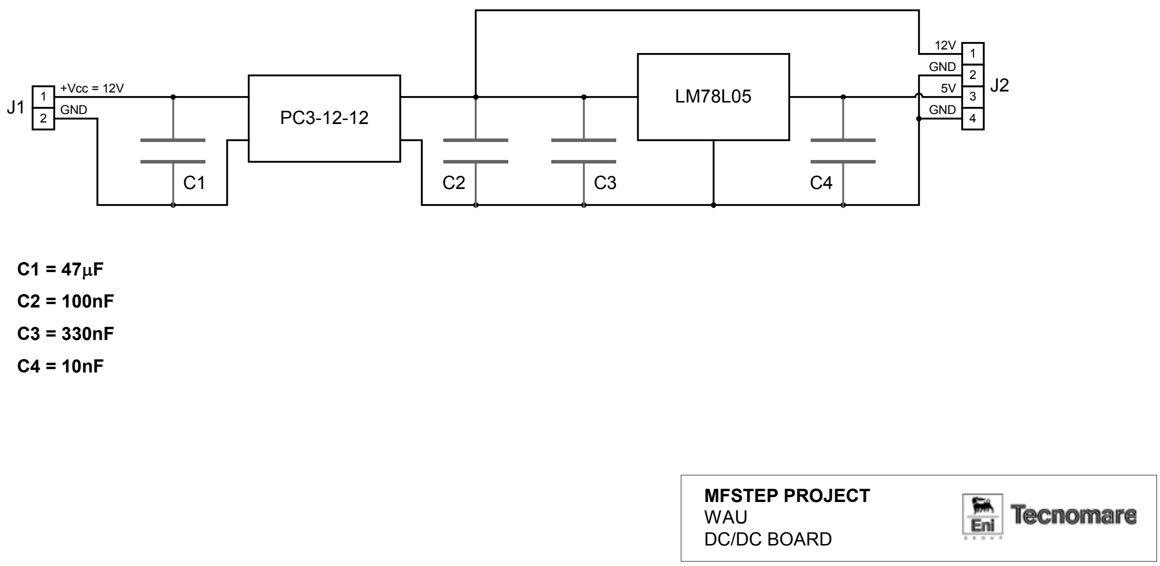


Figure 5: DC/DC board layout

The 5 Volt output voltage is for the accelerometer board while the 12 Volt output voltage is for the water detect board.

4.4 CPU board

The CPU board managing the WAU operation is based on the same board (TEC-CPU2 manufactured by Tecnomare) supervising the BOMA data acquisition and control system.
For a detailed description of this board refer to E2-M3A data book.

4.5 Internal wiring

The internal wiring of the WAU is shown in Figure 6.

Connectors are numbered according to Figure 2.

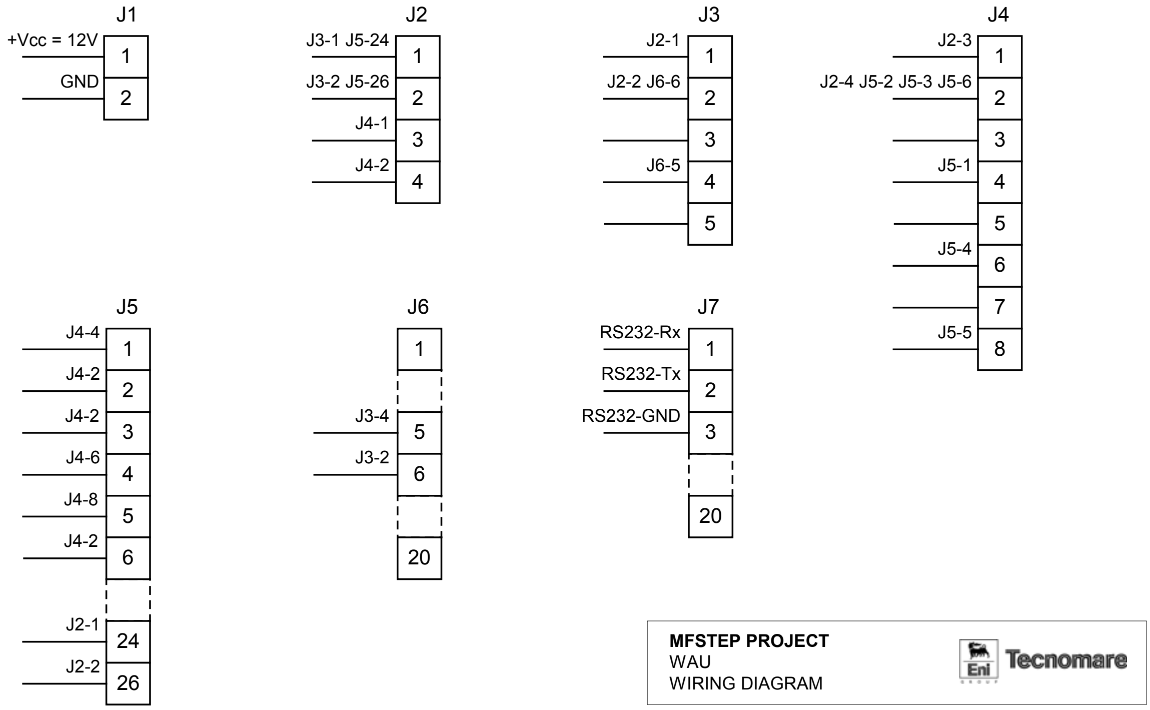


Figure 6: WAU internal wiring

5 SOFTWARE DESCRIPTION

The WAU is a stand alone unit which can be controlled either remotely by another computer or locally using a terminal application.
In the E2-M3A buoy it is connected to the master controlling unit (the UCM-C).
The WAU set of commands includes:

- the *M* command, to get istantaneous values of both the water detect alarms and acceleration;
- the *L* command, to acquire and log acceleration values in a 20 minutes time range;
- the *S* command, to get the last value of the acceleration power calculated upon the last values logged by the *L* command;
- the *T* command, to set the time and date of the unit.

5.1 Commad Syntax and Command Result Syntax

All commands are simple and except for the *M* command they do not need parameters.
Also the answer to a command has a simple syntax:

#<command> <command result values>

where *<command>* is the command and *<command result values>* is a string containing the information requirred which depends on the command itself.
In case of error the result syntax is the following one:

#<command> E '<error message>'

where *<command>* is the command and *E* indicates for an error whose descirption is reported on the following *<error message>* string.
The # is just a leading character to identify a command answer.

5.2 *M* Command

The *M* command allows the user to get istantaneous information about water detect alarms and buoy vertical acceleration.

The answer syntax is the following one:

#M <WD1> <WD2> >WD2> <acceleration value>

where *<WDx>* is the water detect flag for the *x-th* tank, which may be *'Y'* if water inside or *'N'* on the contrary, and *<acceleration value>* is the buoy vertical acceleration value expressed in *g*[1].

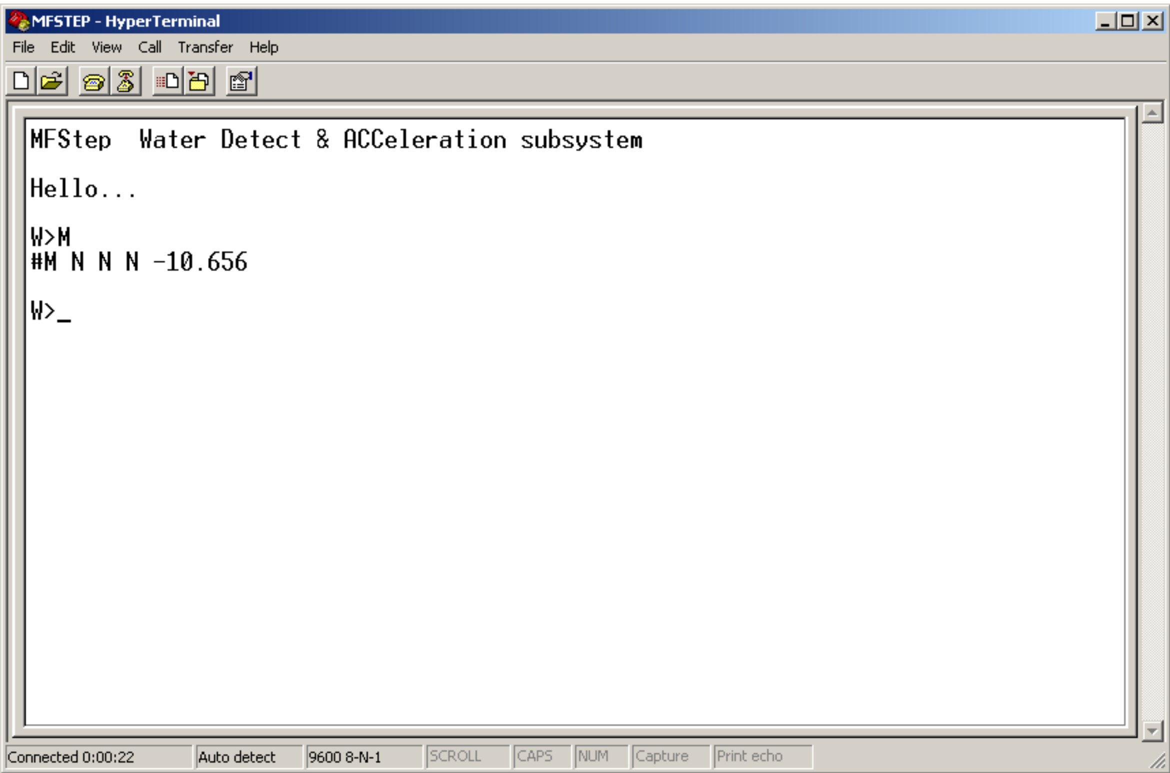


Figure 7: *M* command syntax and answer

In case of failure a proper error message is displayed as reported in 5.1.

[1] $1g \approx 9{,}81\ m/s^2$

5.3 *L* Command

The *L* command allows the user to log on a *gravity file yymmddhh.gra*, a 20 minutes acceleration sampling at 20 Hz frequency. The log file name is significant for the date and time at which the sampling started.

At the end of the sampling the acceleration power is calculated and its value, together with the water detect alarms, is appended to a global status file *wstatus.log*.

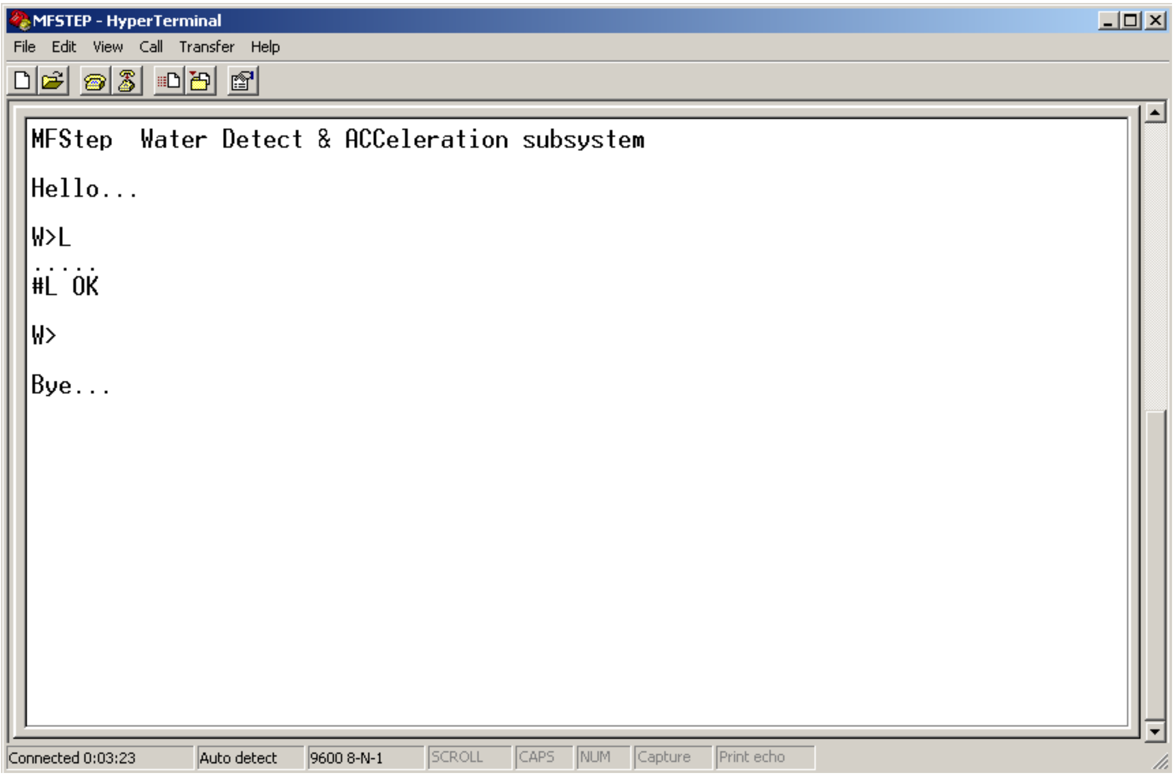


Figure 8: *L* command syntax and answer

If the command succeds a *#L OK* message is reported while in case of failure a proper error message is displayed as reported in 5.1.

5.4 *S* Command

The *S* command can be used to display the values of both the water detect alarms and the acceleration power as a result of the last run *L* command.
The answer syntax is:

#S F <WD1> <WD2> >WD2> <acceleration power value>

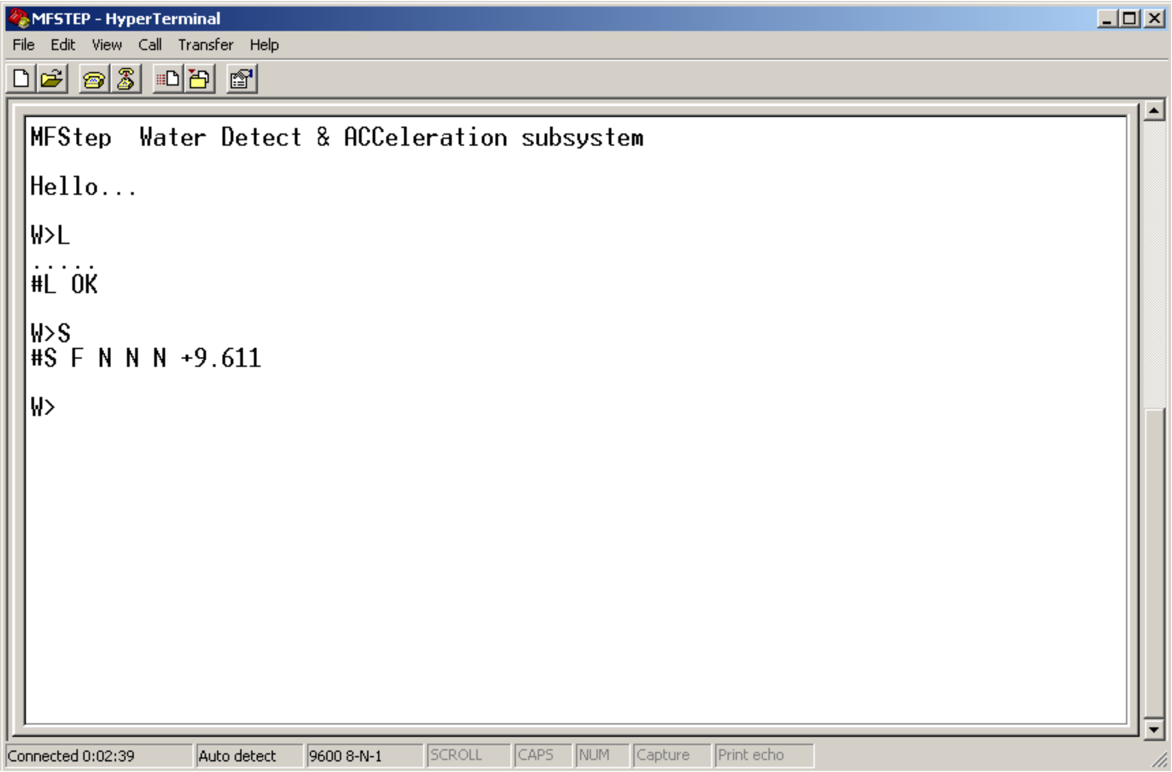


Figure 9: *S* command syntax and answer

In case of failure a proper error message is displayed as reported in 5.1.

5.5 *T* Command

The *T* command must be used to set the time of the WD&ACC.

The command syntax is:

T dd/mm/yy hh:mm:ss

where *dd/mm/yy* is the current date and *hh:mm:ss* is the current time (*yy* = 00 is the year 2000).

The answer syntax is quite similar:

#T dd/mm/yy hh:mm:ss

where *dd/mm/yy* is the new date and *hh:mm:ss* is the new time of the WD&ACC.

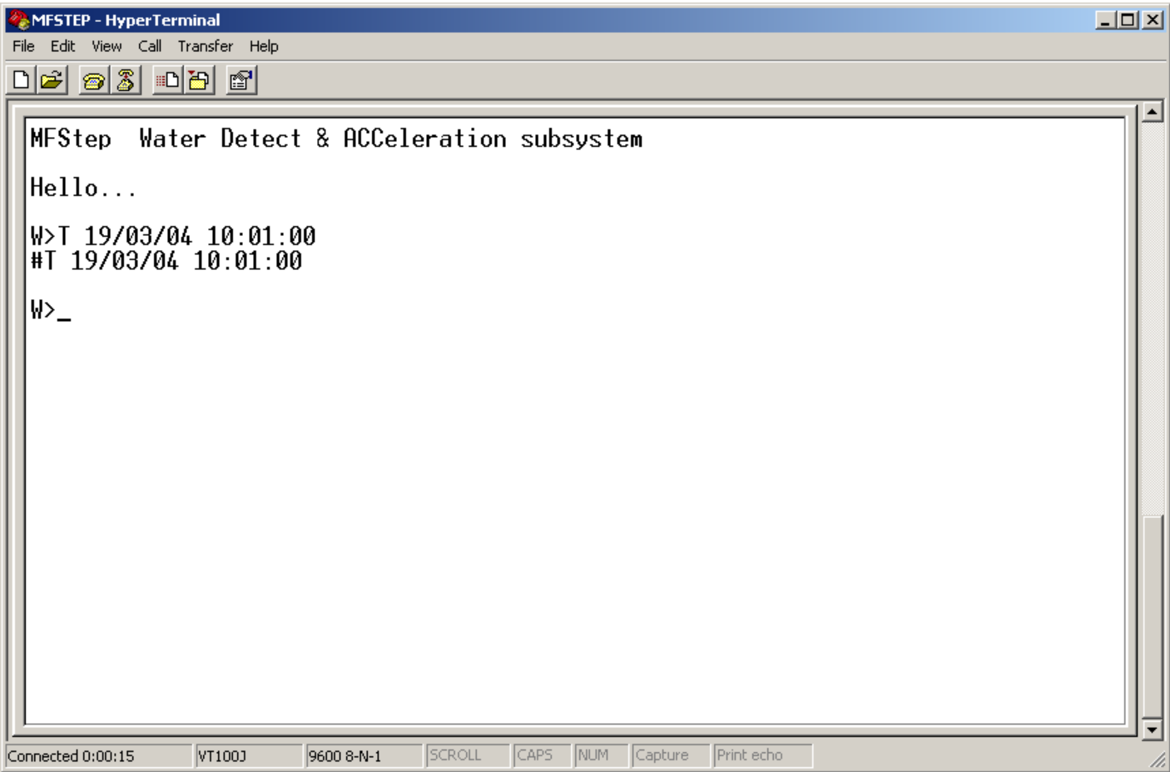


Figure 10: *T* command syntax and answer

In case of failure a proper error message is displayed as reported in 5.1.

6 MANAGEMENT DURING THE MISSION

When the buoy is in Mission Mode, the WAU is managed by the DACS (Data Acquisition and Control System) as follows:

- powered ON at hh:40:00 to run an M command to get the status of the water detectors;
- powered ON every 3 hours to run an L command followed, 20 minutes later, by an S command to log both the acceleration squared mean value and the water detectors status in the daily summary file YYMMDD.SUM;
- the unit is powered OFF.

7 ANNEXES

7.1 Motorola Semiconductor MMA1220D Low G Accelerometer

MOTOROLA
SEMICONDUCTOR TECHNICAL DATA

Order this document by MMA1220D/D

MMA1220D

Low G Micromachined Accelerometer

The MMA series of silicon capacitive, micromachined accelerometers features signal conditioning, a 4–pole low pass filter and temperature compensation. Zero–g offset full scale span and filter cut–off are factory set and require no external devices. A full system self–test capability verifies system functionality.

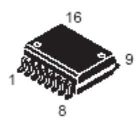
Features

- Integral Signal Conditioning
- Linear Output
- Ratiometric Performance
- 4th Order Bessel Filter Preserves Pulse Shape Integrity
- Calibrated Self–test
- Low Voltage Detect, Clock Monitor, and EPROM Parity Check Status
- Transducer Hermetically Sealed at Wafer Level for Superior Reliability
- Robust Design, High Shock Survivability

Typical Applications

- Vibration Monitoring and Recording
- Appliance Control
- Mechanical Bearing Monitoring
- Computer Hard Drive Protection
- Computer Mouse and Joysticks
- Virtual Reality Input Devices
- Sports Diagnostic Devices and Systems

MMA1220D: Z AXIS SENSITIVITY MICROMACHINED ACCELEROMETER
±8g



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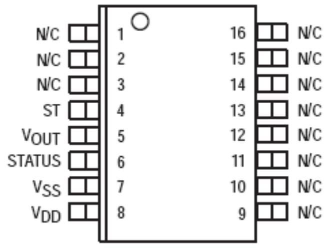
CASE 475–01

Pin Assignment



ORDERING INFORMATION

Device	Temperature Range	Case No.	Package
MMA1220D	–40 to +85°C	Case 475–01	SOIC–16

SIMPLIFIED ACCELEROMETER FUNCTIONAL BLOCK DIAGRAM

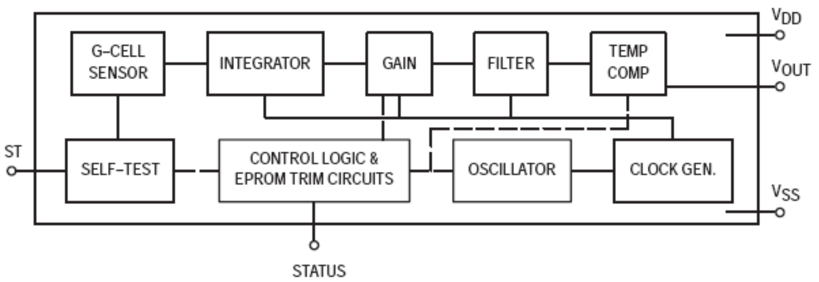


Figure 1. Simplified Accelerometer Functional Block Diagram

REV 0

MOTOROLA

MMA1220D

MAXIMUM RATINGS (Maximum ratings are the limits to which the device can be exposed without causing permanent damage.)

Rating	Symbol	Value	Unit
Powered Acceleration (all axes)	G_{pd}	1500	g
Unpowered Acceleration (all axes)	G_{upd}	2000	g
Supply Voltage	V_{DD}	–0.3 to +7.0	V
Drop Test(1)	D_{drop}	1.2	m
Storage Temperature Range	T_{stg}	–40 to +105	°C

NOTES:
1. Dropped onto concrete surface from any axis.

ELECTRO STATIC DISCHARGE (ESD)

WARNING: This device is sensitive to electrostatic discharge.

Although the Motorola accelerometers contain internal 2kV ESD protection circuitry, extra precaution must be taken by the user to protect the chip from ESD. A charge of over 2000 volts can accumulate on the human body or associated test equipment. A charge of this magnitude can alter the performance or cause failure of the chip. When handling the accelerometer, proper ESD precautions should be followed to avoid exposing the device to discharges which may be detrimental to its performance.

MMA1220D

OPERATING CHARACTERISTICS
(Unless otherwise noted: –40°C ≤ T_A ≤ +85°C, 4.75 ≤ V_{DD} ≤ 5.25, Acceleration = 0g, Loaded output(1))

Characteristic	Symbol	Min	Typ	Max	Unit
Operating Range(2)					
Supply Voltage(3)	V_{DD}	4.75	5.00	5.25	V
Supply Current	I_{DD}	3.0	5.0	6.0	mA
Operating Temperature Range	T_A	−40	—	+85	°C
Acceleration Range	g_{FS}	—	8.0	—	g
Output Signal					
Zero g (V_{DD} = 5.0 V)(4)	V_{OFF}	2.25	2.5	2.75	V
Zero g	$V_{OFF,V}$	0.45 V_{DD}	0.50 V_{DD}	0.55 V_{DD}	V
Sensitivity (T_A = 25°C, V_{DD} = 5.0 V)(5)	S	237.5	250	262.5	mV/g
Sensitivity	S_V	46.5	50	53.5	mV/g/V
Bandwidth Response	f_{-3dB}	150	250	350	Hz
Nonlinearity	NL_{OUT}	−1.0	—	+3.0	% FSO
Noise					
RMS (10 Hz – 1 kHz)	n_{RMS}	—	—	6.0	mVrms
Clock Noise (without RC load on output)(6)	n_{CLK}	—	2.0	—	mVpk
Self–Test					
Output Response	ΔV_{ST}	0.2 V_{DD}	—	0.3 V_{DD}	V
Input Low	V_{IL}	V_{SS}	—	0.3 V_{DD}	V
Input High	V_{IH}	0.7 V_{DD}	—	V_{DD}	V
Input Loading(7)	I_{IN}	−50	−100	−200	µA
Response Time(8)	t_{ST}	—	2.0	10	ms
Status(12)(13)					
Output Low (I_{load} = 100 µA)	V_{OL}	—	—	0.4	V
Output High (I_{load} = 100 µA)	V_{OH}	V_{DD} −0.8	—	—	V
Minimum Supply Voltage (LVD Trip)	V_{LVD}	2.7	3.25	4.0	V
Clock Monitor Fail Detection Frequency	f_{min}	50	—	260	kHz
Output Stage Performance					
Electrical Saturation Recovery Time(9)	t_{DELAY}	—	2.0	—	ms
Full Scale Output Range (I_{OUT} = 200 µA)	V_{FSO}	V_{SS}+0.25	—	V_{DD}−0.25	V
Capacitive Load Drive(10)	C_L	—	—	100	pF
Output Impedance	Z_O	—	300	—	Ω
Mechanical Characteristics					
Transverse Sensitivity(11)	$V_{XZ,YZ}$	—	—	5.0	% FSO
Package Resonance	f_{PKG}	—	10	—	kHz

NOTES:
1. For a loaded output the measurements are observed after an RC filter consisting of a 1 kΩ resistor and a 0.01 µF capacitor to ground.
2. These limits define the range of operation for which the part will meet specification.
3. Within the supply range of 4.75 and 5.25 volts, the device operates as a fully calibrated linear accelerometer. Beyond these supply limits the device may operate as a linear device but is not guaranteed to be in calibration.
4. The device can measure both + and − acceleration. With no input acceleration the output is at midsupply. For positive acceleration the output will increase above $V_{DD}/2$ and for negative acceleration the output will decrease below $V_{DD}/2$.
5. The device is calibrated at 20g, 100 Hz. Sensitivity limits apply to 0 Hz acceleration.
6. At clock frequency ≅ 70 kHz.
7. The digital input pin has an internal pull–down current source to prevent inadvertent self test initiation due to external board level leakages.
8. Time for the output to reach 90% of its final value after a self–test is initiated.
9. Time for amplifiers to recover after an acceleration signal causing them to saturate.
10. Preserves phase margin (60°) to guarantee output amplifier stability.
11. A measure of the device's ability to reject an acceleration applied 90° from the true axis of sensitivity.
12. The Status pin output is not valid following power–up until at least one rising edge has been applied to the self–test pin. The Status pin is high whenever the self–test input is high.
13. The Status pin output latches high if a Low Voltage Detection or Clock Frequency failure occurs, or the EPROM parity changes to odd. The Status pin can be reset by a rising edge on self–test, unless a fault condition continues to exist.

MMA1220D

PRINCIPLE OF OPERATION

The Motorola accelerometer is a surface–micromachined integrated–circuit accelerometer.

The device consists of a surface micromachined capacitive sensing cell (g–cell) and a CMOS signal conditioning ASIC contained in a single integrated circuit package. The sensing element is sealed hermetically at the wafer level using a bulk micromachined “cap” wafer.

The g–cell is a mechanical structure formed from semiconductor materials (polysilicon) using semiconductor processes (masking and etching). It can be modeled as two stationary plates with a moveable plate in–between. The center plate can be deflected from its rest position by subjecting the system to an acceleration (Figure 2).

When the center plate deflects, the distance from it to one fixed plate will increase by the same amount that the distance to the other plate decreases. The change in distance is a measure of acceleration.

The g–cell plates form two back–to–back capacitors (Figure 3). As the center plate moves with acceleration, the distance between the plates changes and each capacitor's value will change, ($C = A\varepsilon/D$). Where A is the area of the plate, ε is the dielectric constant, and D is the distance between the plates.

The CMOS ASIC uses switched capacitor techniques to measure the g–cell capacitors and extract the acceleration data from the difference between the two capacitors. The ASIC also signal conditions and filters (switched capacitor) the signal, providing a high level output voltage that is ratiometric and proportional to acceleration.

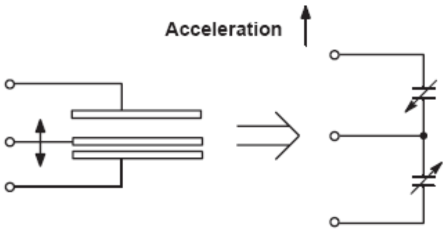


Figure 2. Transducer Physical Model **Figure 3. Equivalent Circuit Model**

SPECIAL FEATURES

Filtering

The Motorola accelerometers contain an onboard 4–pole switched capacitor filter. A Bessel implementation is used because it provides a maximally flat delay response (linear phase) thus preserving pulse shape integrity. Because the filter is realized using switched capacitor techniques, there is no requirement for external passive components (resistors and capacitors) to set the cut–off frequency.

Self–Test

The sensor provides a self–test feature that allows the verification of the mechanical and electrical integrity of the accelerometer at any time before or after installation. This feature is critical in applications such as automotive airbag systems where system integrity must be ensured over the life of the vehicle. A fourth “plate” is used in the g–cell as a self–test plate. When the user applies a logic high input to the self–test pin, a calibrated potential is applied across the self–test plate and the moveable plate. The resulting electrostatic force ($Fe = \frac{1}{2} AV^2/d^2$) causes the center plate to deflect. The resultant deflection is measured by the accelerometer's control ASIC and a proportional output voltage results. This procedure assures that both the mechanical (g–cell) and electronic sections of the accelerometer are functioning.

Ratiometricity

Ratiometricity simply means that the output offset voltage and sensitivity will scale linearly with applied supply voltage. That is, as you increase supply voltage the sensitivity and offset increase linearly; as supply voltage decreases, offset and sensitivity decrease linearly. This is a key feature when interfacing to a microcontroller or an A/D converter because it provides system level cancellation of supply induced errors in the analog to digital conversion process.

Status

Motorola accelerometers include fault detection circuitry and a fault latch. The Status pin is an output from the fault latch, OR'd with self–test, and is set high whenever one (or more) of the following events occur:

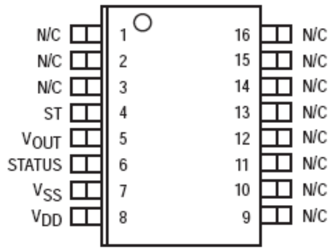
- Supply voltage falls below the Low Voltage Detect (LVD) voltage threshold
- Clock oscillator falls below the clock monitor minimum frequency
- Parity of the EPROM bits becomes odd in number.

The fault latch can be reset by a rising edge on the self–test input pin, unless one (or more) of the fault conditions continues to exist.

MMA1220D

BASIC CONNECTIONS

Pinout Description



Pin No.	Pin Name	Description
1 thru 3	V_{SS}	Redundant connections to the internal V_{SS} and may be left unconnected.
4	ST	Logic input pin used to initiate self–test.
5	V_{OUT}	Output voltage of the accelerometer.
6	STATUS	Logic output pin used to indicate fault.
7	V_{SS}	The power supply ground.
8	V_{DD}	The power supply input.
9 thru 13	Trim pins	Used for factory trim. Leave unconnected.
14 thru 16	—	No internal connection. Leave unconnected.

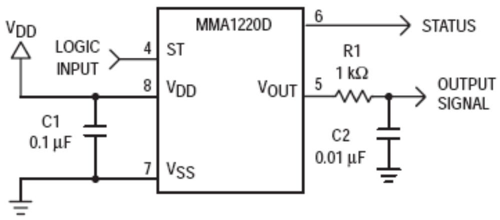


Figure 4. SOIC Accelerometer with Recommended Connection Diagram

PCB Layout

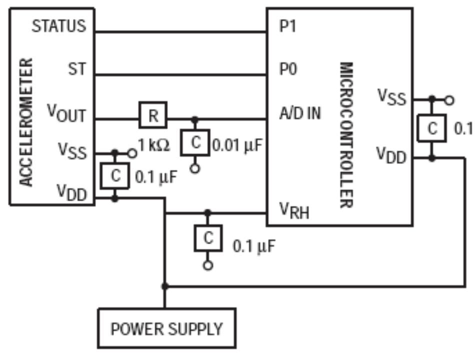


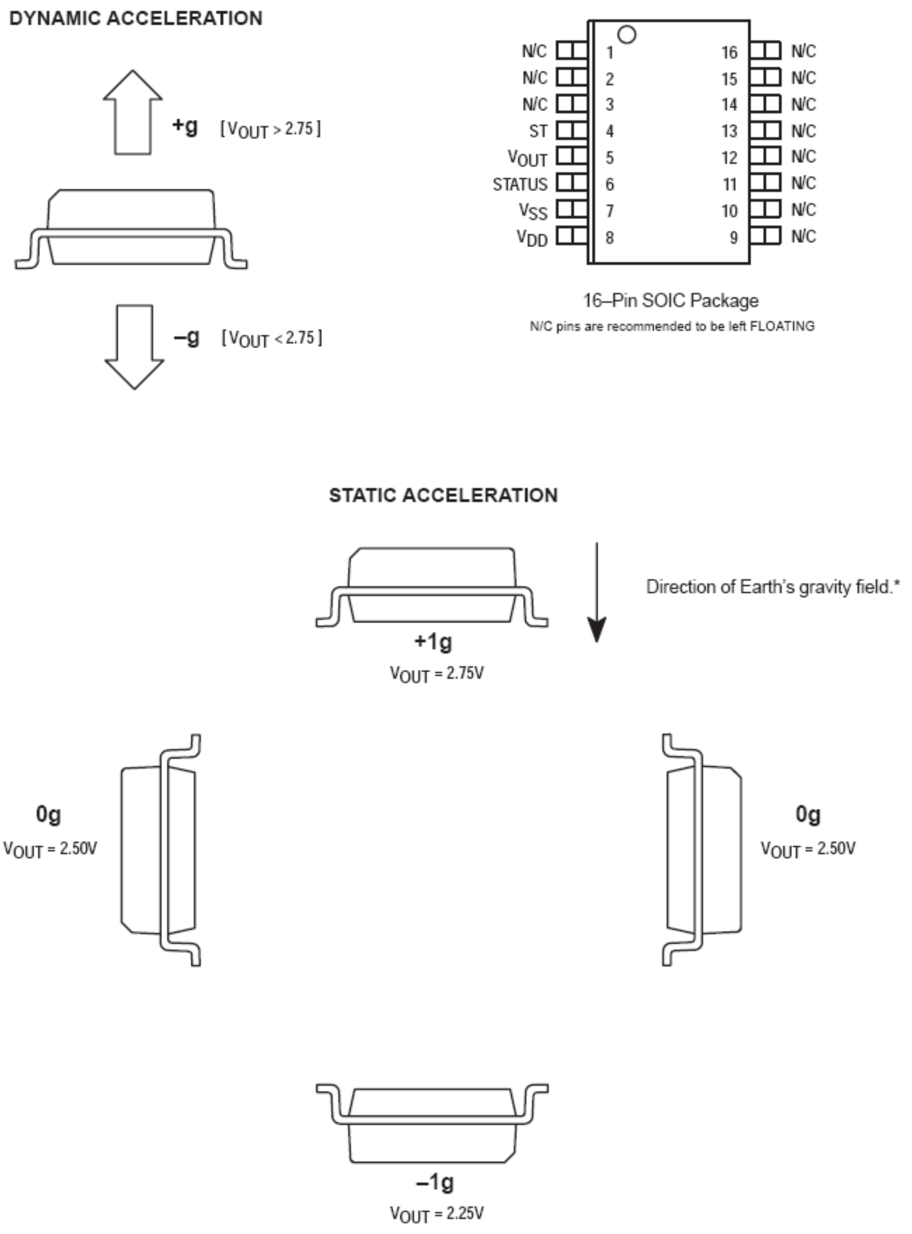
Figure 5. Recommended PCB Layout for Interfacing Accelerometer to Microcontroller

NOTES:

- Use a 0.1 µF capacitor on V_{DD} to decouple the power source.
- Physical coupling distance of the accelerometer to the microcontroller should be minimal.
- Place a ground plane beneath the accelerometer to reduce noise, the ground plane should be attached to all of the open ended terminals shown in Figure 5.
- Use an RC filter of 1 kΩ and 0.01 µF on the output of the accelerometer to minimize clock noise (from the switched capacitor filter circuit).
- PCB layout of power and ground should not couple power supply noise.
- Accelerometer and microcontroller should not be a high current path.
- A/D sampling rate and any external power supply switching frequency should be selected such that they do not interfere with the internal accelerometer sampling frequency. This will prevent aliasing errors.

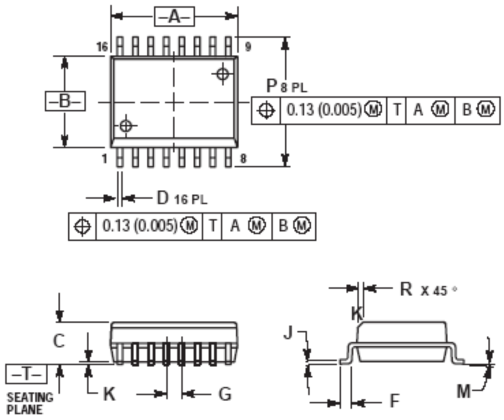
MMA1220D

ACCELERATION SENSING DIRECTIONS



* When positioned as shown, the Earth's gravity will result in a positive 1g output

PACKAGE DIMENSIONS



NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: MILLIMETER.
3. DIMENSIONS A AND B DO NOT INCLUDE MOLD PROTRUSION.
4. MAXIMUM MOLD PROTRUSION 0.15 (0.006) PER SIDE.
5. DIMENSION D DOES NOT INCLUDE DAMBAR PROTRUSION. ALLOWABLE DAMBAR PROTRUSION SHALL BE 0.13 (0.005) TOTAL IN EXCESS OF D DIMENSION AT MAXIMUM MATERIAL CONDITION.

	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	10.15	10.45	0.400	0.411
B	7.40	7.60	0.292	0.299
C	3.30	3.55	0.130	0.140
D	0.35	0.49	0.014	0.019
F	0.76	1.14	0.030	0.045
G	1.27 BSC		0.050 BSC	
J	0.25	0.32	0.010	0.012
K	0.10	0.25	0.004	0.009
M	0°	7°	0°	7°
P	10.16	10.67	0.400	0.420
R	0.25	0.75	0.010	0.029

CASE 475–01
ISSUE A
16 LEAD SOIC

How to reach us:
USA / EUROPE / Locations Not Listed: Motorola Literature Distribution; P.O. Box 5405, Denver, Colorado 80217. 1–303–675–2140 or 1–800–441–2447

Technical Information Center: 1–800–521–6274

JAPAN: Motorola Japan Ltd.; SPS, Technical Information Center, 3–20–1, Minami–Azabu. Minato–ku, Tokyo 106–8573 Japan. 81–3–3440–3569

ASIA / PACIFIC: Motorola Semiconductors H.K. Ltd.; Silicon Harbour Centre, 2, Dai King Street, Tai Po Industrial Estate, Tai Po, N.T., Hong Kong. 852–26668334

HOME PAGE: http://www.motorola.com/semiconductors/

7.2 National Semiconductor LM1830 Fluid Detector

National Semiconductor

February 1995

LM1830 Fluid Detector

LM1830 Fluid Detector

General Description

The LM1830 is a monolithic bipolar integrated circuit designed for use in fluid detection systems. The circuit is ideal for detecting the presence, absence, or level of water, or other polar liquids. An AC signal is passed through two probes within the fluid. A detector determines the presence or absence of the fluid by comparing the resistance of the fluid between the probes with the resistance internal to the integrated circuit. An AC signal is used to overcome plating problems incurred by using a DC source. A pin is available for connecting an external resistance in cases where the fluid impedance is of a different magnitude than that of the internal resistor. When the probe resistance increases above the preset value, the oscillator signal is coupled to the base of the open-collector output transistor. In a typical application, the output could be used to drive a LED, loud speaker or a low current relay.

Features

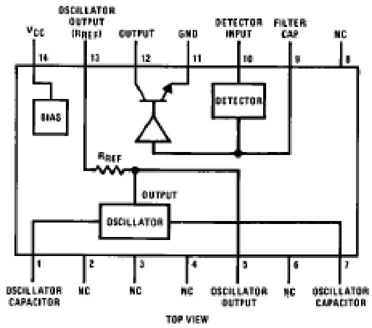
- Low external parts count
- Wide supply operating range
- One side of probe input can be grounded
- AC coupling to probe to prevent plating
- Internally regulated supply
- AC or DC output

Applications

- Beverage dispensers
- Water softeners
- Irrigation
- Sump pumps
- Aquaria
- Radiators
- Washing machines
- Reservoirs
- Boilers

Logic and Connection Diagram

Dual-In-Line Package



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Order Number LM1830N
See NS Package Number N14A

 RRD-B30M115/Printed in U. S. A.

Absolute Maximum Ratings

If Military/Aerospace specified devices are required, please contact the National Semiconductor Sales Office/Distributors for availability and specifications.

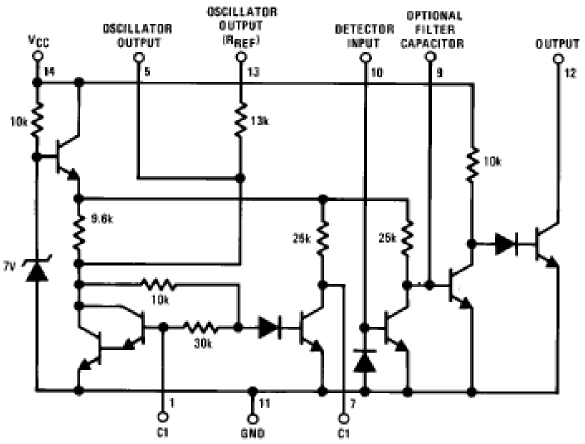
Supply Voltage	28V
Power Dissipation (Note 1)	1400 mW
Output Sink Current	20 mA
Operating Temperature Range	−40°C to +85°C
Storage Temperature Range	−40°C to +150°C
Lead Temp. (Soldering, 10 seconds)	260°C

Electrical Characteristics ($V^+ = 16V$, $T_A = 25°C$ unless otherwise specified)

Parameter	Conditions	Min	Typ	Max	Units
Supply Current			5.5	10	mA
Oscillator Output Voltage					
Low			1.1		V
High			4.2		V
Internal Reference Resistor		8	13	25	kΩ
Detector Threshold Voltage			680		mV
Detector Threshold Resistance		5	10	15	kΩ
Output Saturation Voltage	$I_O = 10$ mA		0.5	2.0	V
Output Leakage	$V_{PIN\ 12} = 16V$			10	μA
Oscillator Frequency	$C1 = 0.001\ \mu F$	4	7	12	kHz

Note 1: The maximum junction temperature rating of the LM1830N is 150°C. For operation at elevated temperatures, devices in the dual-in-line plastic package must be derated based on a thermal resistance of 89°C/W.

Schematic Diagram



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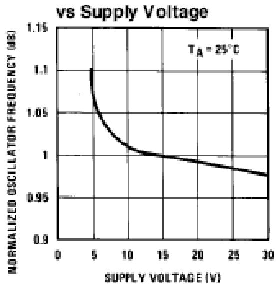
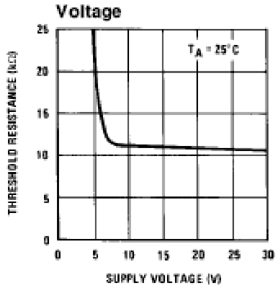
Typical Performance Characteristics

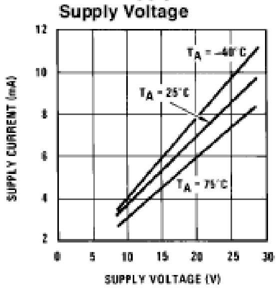
Normalized Oscillator Frequency vs Supply Voltage



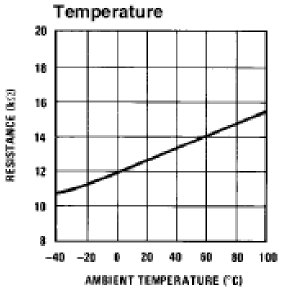
Threshold Resistance vs Supply Voltage



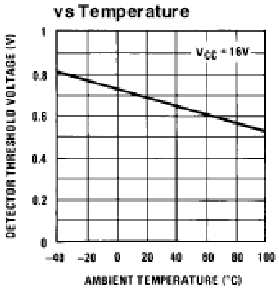
Power Supply Current vs Supply Voltage



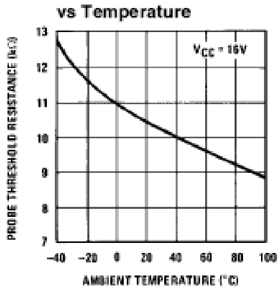
Reference Resistor vs Ambient Temperature



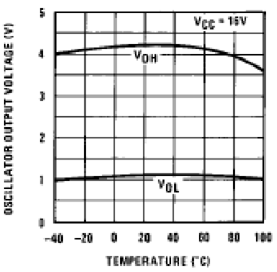
Detector Threshold Voltage vs Temperature



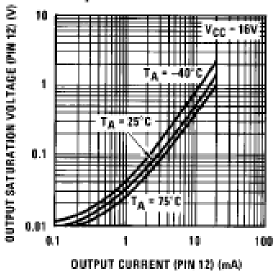
Probe Threshold Resistance vs Temperature



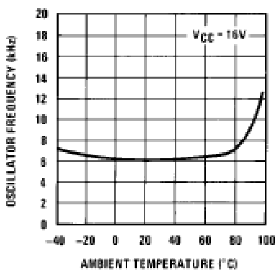
Oscillator V_{OH} and V_{OL} vs Ambient Temperature



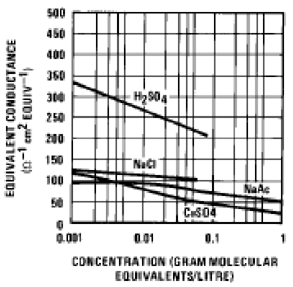
Output Saturation Voltage vs Output Current



Oscillator Frequency vs Ambient Temperature



Equivalent Resistance vs Concentration of Several Solutions



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Application Hints

The LM1830 requires only an external capacitor to complete the oscillator circuit. The frequency of oscillation is inversely proportional to the external capacitor value. Using 0.001µF capacitor, the output frequency is approximately 6 kHz. The output from the oscillator is available at pin 5. In normal applications, the output is taken from pin 13 so that the internal 13k resistor can be used to compare with the probe resistance. Pin 13 is coupled to the probe by a blocking capacitor so that there is no net dc on the probe.

Since the output amplitude from the oscillator is approximately 4 V_{BE}, the detector (which is an emitter base junction) will be turned "ON" when the probe resistance to ground is equal to the internal 13 kΩ resistor. An internal diode across the detector emitter base junction provides symmetrical limiting of the detector input signal so that the probe is excited with $\pm 2\ V_{BE}$ from a 13 kΩ source. In cases where the 13 kΩ resistor is not compatible with the probe resistance range, an external resistor may be added by coupling the probe to pin 5 through the external resistor as shown in *Figure 2*. The collector of the detecting transistor is brought out to pin 9 enabling a filter capacitor to be connected so that the output will switch "ON" or "OFF" depending on the probe resistance. If this capacitor is omitted, the output will be switched at approximately 50% duty cycle when the probe resistance exceeds the reference resistance. This can be useful when an audio output is required and the output transistor can be used to directly drive a loud speaker. In addition, LED indicators do not require dc excitation. Therefore, the cost of a capacitor for filtering can be saved.

In the case of inductive loads or incandescent lamp loads, it is recommended that a filter capacitor be employed.

In a typical application where the device is employed for sensing low water level in a tank, a simple steel probe may be inserted in the top of the tank with the tank grounded. Then when the water level drops below the tip of the probe, the resistance will rise between the probe and the tank and the alarm will be operated. This is illustrated in *Figure 3*. In situations where a non-conductive container is used, the probe may be designed in a number of ways. In some cases a simple phono plug can be employed. Other probe designs include conductive parallel strips on printed circuit boards.

It is possible to calculate the resistance of any aqueous solution of an electrolyte for different concentrations, provided the dimensions of the electrodes and their spacing is known.

The resistance of a simple parallel plate probe is given by:

$$R = \frac{1000}{c.p} \bullet \frac{d}{A}\ \Omega$$

where A = area of plates (cm^2)
d = separation of plates (cm)
c = concentration (gm. mol. equivalent/litre)
p = equivalent conductance
($\Omega^{-1}\ cm^2$ equiv. $^{-1}$)

(An equivalent is the number of moles of a substance that gives one mole of positive charge and one mole of negative charge. For example, one mole of NaCl gives $Na^{+} + Cl^{-}$ so the equivalent is 1. One mole of $CaCl_2$ gives $Ca^{++} + 2Cl^{-}$ so the equivalent is 1/2.)

Usually the probe dimensions are not measured physically, but the ratio d/A is determined by measuring the resistance of a cell of known concentration c and equivalent conductance of 1. A graph of common solutions and their equivalent conductances is shown for reference. The data was derived from D.A. MacInnes, "The Principles of Electrochemistry," Reinhold Publishing Corp., New York., 1939.

In automotive and other applications where the power source is known to contain significant transient voltages, the internal regulator on the LM1830 allows protection to be provided by the simple means of using a series resistor in the power supply line as illustrated in *Figure 4*. If the output load is required to be returned directly to the power supply because of the high current required, it will be necessary to provide protection for the output transistor if the voltages are expected to exceed the data sheet limits.

Although the LM1830 is designed primarily for use in sensing conductive fluids, it can be used with any variable resistance device, such as light dependent resistor or thermistor or resistive position transducer.

The following table lists some common fluids which may and may not be detected by resistive probe techniques.

Conductive Fluids	Non-Conductive Fluids
City water	Pure water
Sea water	Gasoline
Copper sulphate solution	Oil
Weak acid	Brake fluid
Weak base	Alcohol
Household ammonia	Ethylene glycol
Water and glycol mixture	Paraffin
Wet soil	Dry soil
Coffee	Whiskey

Typical Applications $V_{CC} = 16V$

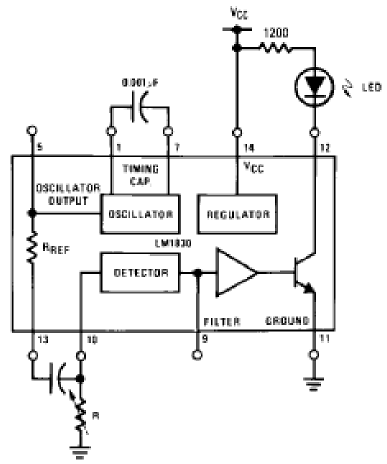


FIGURE 1. Test Circuit

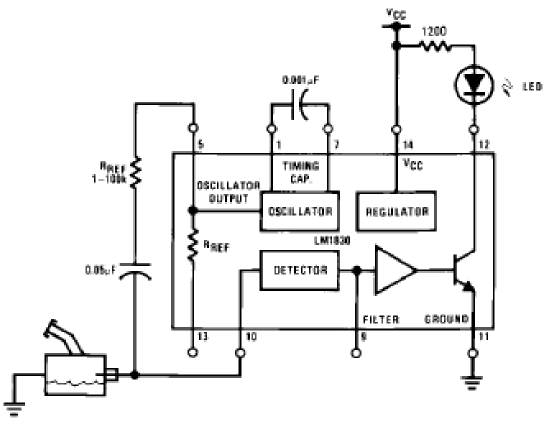


FIGURE 2. Application Using External Reference Resistor

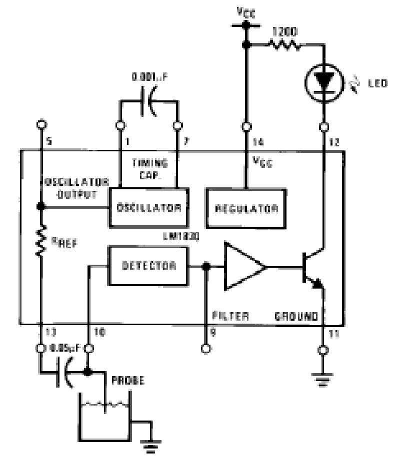
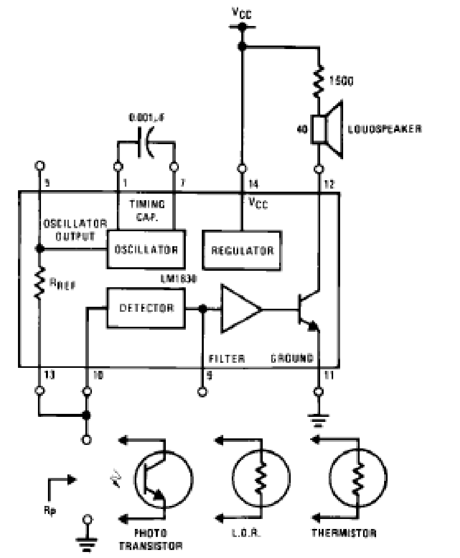


FIGURE 3. Basic Low Level Warning Device with LED Indication



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Output is activated when R_p is approximately greater than $\frac{1}{3}$ R_{REF}

FIGURE 4. Direct Coupled Applications

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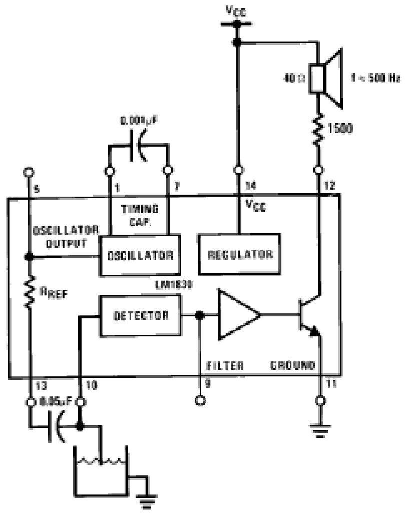
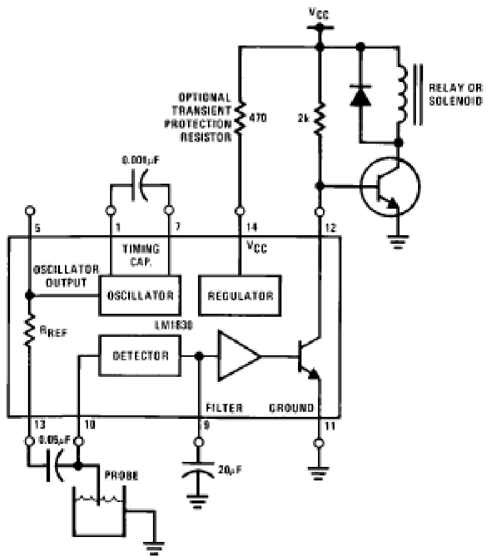
Typical Applications V_{CC} = 16V (Continued)

Low Level Warning with Audio Output



High Level Warning Device



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The Output is suitable for driving a sump pump
or opening a drain valve, etc.

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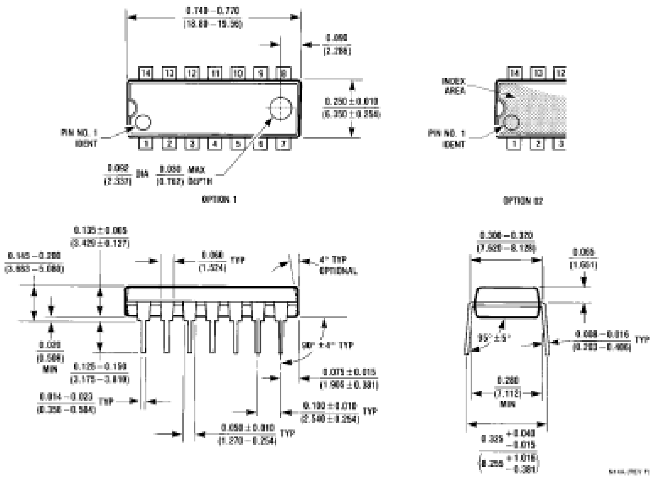
Physical Dimensions inches (millimeters)



Molded Dual-In-Line Package (N)
Order Number LM1830N
NS Package Number N14A

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