POLITECNICO DI MILANO

Misure Meccaniche e Termiche

Misure di pressione sonora

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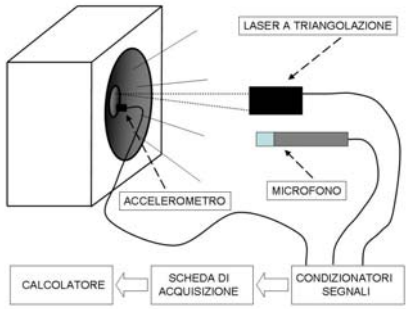
Introduzione

Scopo:
- capire i concetti dell'acustica
- usare e tarare un fonometro

Sistema da misurare:
- cassa acustica



Caratteristiche degli strumenti

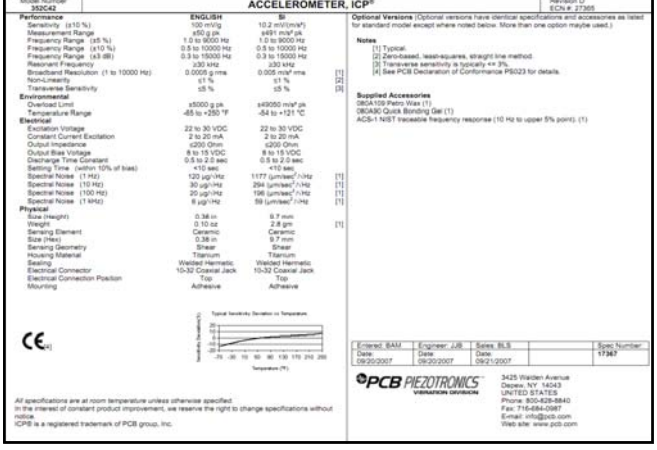
Prima di utilizzare qualunque strumento, è importante conoscere le caratteristiche nominali degli strumenti in uso. (vedere manuali, datasheet, internet)

Caratteristiche degli strumenti			
	Laser	**Accelerometro**	**Fonometro**
Misura di	spostamento	accelerazione	pressione sonora
Marca	MEL	PCB piezotronic	Bruel&Kjaer
Modello	M5L/10	352C42	2238 Mediator (con microfono 4188)
N° di serie		78303	
Fondo scala [V]	±10 V		
Fondo scala [u.i.]	±5 mm	500 m/s²	15.8 dB - 146 dB
Sensibilità [V/u.i.]	2 V/mm	10.35 mV/(m/s²)	-30.2 dB re 1V/Pa 32.4 mV/Pa **ma esce diverso, misurare!!!**
Range di frequenze [Hz]	<500 Hz	1 Hz - 9 kHz	8 Hz - 12.5 kHz

Laser a triangolazione

Technical Data Types M5 / LED sensors		M5/2	M5/4	M5/10	M520	M5/100	M5/200
Range (mm)		± 1	± 2	± 5	± 10	± 50	± 100
Stand-Off Distance (mm)		24	24	45	65	220	340
Linearity error (µm)*		6	12	30	60	300	600
Resolution (Noise) (µm)*		0,5	1	3	6	30	60
Spot Diameter (mm)		0,8	0,8	2	2	8	10
Light Source		LED, wavelength infrared 900 nm -not visible					
Sample Frequency		2,5 kHz					
Analog Output	Voltage	± 10V DC, max. ± 14 V					
	Impedance	< 0,1 Ω (10 mA max.)					
	Angle Error	0,5% @ tilted Object 30°, A-axis					
	response time	1 ms, 2 ms or 20 ms selectable					
	Bandwidth	**500 Hz,** 200 Hz or 20 Hz (3 db decline)					
	Temp. Coeff.	0,03% / °K					
	Reflected Light	1 to10 VDC, Max. 0 to 13 VDC					
Switching Outputs	MIN	+24 VDC / 10 mA, active if below MIN, yellow LED on					
	MIN (optional)	Relay 0,5A/100V~, n.o.					
	OK	+24 VDC / 10 mA, if inbetween MIN and MAX levels, green LED					
	OK (optional)	Relay 0,5A/100V~, n.o.					
	MAX	+24 VDC / 10 mA, active if above MAX, red LED on					
	MAX (optional)	Relay 0,5A/100V~, n.o.					
	Hysteresis	approx. 0,5% of range					
Alarm Output	F1	+24 VDC / 10 mA, active if not enough refl. light, yellow LED on					
	F2	+24 VDC / 10 mA, active if too much refl. light, red LED on					
Ambient light		max. 20.000 Lux					
Life expectancy		50.000 h for Power LED					
Isolation Voltage		200 VDC, Ground to case					
Max. Vibration		10g 1kHz (sensorhead, 20g optional)					
Operating Temperature		0 to +70°C / 32 to 158°F					
Storage Temperature		- 20 to +70°C / -4 to 158°F					
Humidity		< 90 % RH					
Protection Class		Sensorhead IP 64, Electronic module IP40					
Power Supply		+24 VDC / 200 mA, (21 to 28VDC)					
Connector		25 pin D- Connector					
Sensor Cable length		2 m					

Accelerometro



ACCELEROMETER, ICP®

Model Number 352C42 — Revision D, ECN #: 27365

Performance	ENGLISH	SI
Sensitivity (±10 %)	100 mV/g	10.2 mV/(m/s²)
Measurement Range	±50 g pk	±491 m/s² pk
Frequency Range (±5 %)	1.0 to 9000 Hz	1.0 to 9000 Hz
Frequency Range (±10 %)	0.5 to 10000 Hz	0.5 to 10000 Hz
Frequency Range (±3 dB)	0.3 to 15000 Hz	0.3 to 15000 Hz
Resonant Frequency	≥30 kHz	≥30 kHz
Broadband Resolution (1 to 10000 Hz)	0.0005 g rms	0.005 m/s² rms [1]
Non-Linearity	≤1 %	≤1 % [2]
Transverse Sensitivity	≤5 %	≤5 % [3]
Environmental		
Overload Limit	±5000 g pk	±49050 m/s² pk
Temperature Range	-65 to +250 °F	-54 to +121 °C
Electrical		
Excitation Voltage	22 to 30 VDC	22 to 30 VDC
Constant Current Excitation	2 to 20 mA	2 to 20 mA
Output Impedance	≤200 Ohm	≤200 Ohm
Output Bias Voltage	8 to 15 VDC	8 to 15 VDC
Discharge Time Constant	0.5 to 2.0 sec	0.5 to 2.0 sec
Settling Time (within 10% of bias)	<10 sec	<10 sec
Spectral Noise (1 Hz)	120 µg/√Hz	1177 (µm/sec²)/√Hz [1]
Spectral Noise (10 Hz)	30 µg/√Hz	294 (µm/sec²)/√Hz [1]
Spectral Noise (100 Hz)	20 µg/√Hz	196 (µm/sec²)/√Hz [1]
Spectral Noise (1 kHz)	6 µg/√Hz	59 (µm/sec²)/√Hz [1]
Physical		
Size (Height)	0.38 in	9.7 mm
Weight	0.10 oz	2.8 gm [1]
Sensing Element	Ceramic	Ceramic
Size (Hex)	0.38 in	9.7 mm
Sensing Geometry	Shear	Shear
Housing Material	Titanium	Titanium
Sealing	Welded Hermetic	Welded Hermetic
Electrical Connector	10-32 Coaxial Jack	10-32 Coaxial Jack
Electrical Connection Position	Top	Top
Mounting	Adhesive	Adhesive

Optional Versions (Optional versions have identical specifications and accessories as listed for standard model except where noted below. More than one option maybe used.)

Notes
[1] Typical.
[2] Zero-based, least-squares, straight line method.
[3] Transverse sensitivity is typically <= 3%.
[4] See PCB Declaration of Conformance PS023 for details.

Supplied Accessories
080A109 Petro Wax (1)
080A90 Quick Bonding Gel (1)
ACS-1 NIST traceable frequency response (10 Hz to upper 5% point). (1)

Entered: BAM	Engineer: JJB	Sales: BLS		Spec Number:
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All specifications are at room temperature unless otherwise specified.
In the interest of constant product improvement, we reserve the right to change specifications without notice.
ICP® is a registered trademark of PCB group, Inc.

Microfono

4188 - ½-inch free-field microphone, 8 Hz to 12.5 kHz, prepolarized

Overview | Specifications | Accessories | Services

Type 4188 is designed for free-field measurements where an economy microphone with medium sensitivity is required. Being prepolarized, Type 4188 can be used with both DeltaTron™ and classical preamplifiers.

Uses
- Medium class sound level meters
- Equipment complying with IEC 61672 class 1
- Random-incidence measurements
- Portable sound measuring equipment

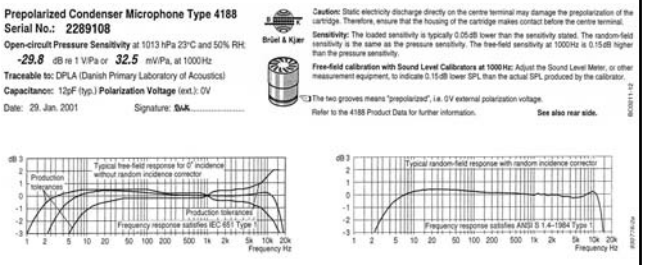
Features
- Sensitivity: 31.6 mV/Pa
- Frequency: 8 Hz - 12.5 kHz
- Dynamic Range: 15.8 - 146 dB
- Temperature: - 30 to +125° C (- 22 to +257° F)
- Prepolarized

4188 - ½-inch free-field microphone, 8 Hz to 12.5 kHz, prepolarized

Overview | Specifications | Accessories | Services

Capacitance	12 pF
Diameter	1/2 inch
Dyn. Range	15.8 - 146 dB
Freq. Range	8 - 12500 Hz
Inherent Noise	14.2 dB A
Lower Limiting Frequency -3dB	5 Hz
Optimised	Free field
Polarization	Prepolarized
Polarization Voltage	0 V
Preamplifier Included	
Pressure Coefficient	-0.021 dB/kPa
Sensitivity	31.6 mV/Pa
Standards	
TEDS UTID	
Temperature Coefficient	0.005 dB/°C
Temperature Range	-30 - 125 °C
Venting	Rear
Input Type	Classic

Microfono



Esperienza 1

Misurare lo spostamento della cassa con:

- accelerometro
- laser

a diverse frequenze e verificare che diano lo stesso valore (integrare o derivare per poter confrontare).

$A_{acc}=A_{spost}*(2\pi f)^2$

Esperienza 2

Tarare il microfono tramite calibratore.

$L_{p,calib}=94$ dB

$p_{calib}=p_{rif}*10\text{^}(L_{p,calib}/20)=1$ Pa

$S_{mic}=p_{mis}/p_{calib}$

Esperienza 3

Misure contemporanee di suono e spostamento.

Correlare spostamento e pressione sonora.

$|FdT_a|=A_{acc}/A_{mic}$

$|FdT_v|=A_{vel}/A_{mic}$

$|FdT_s|=A_{spost}/A_{mic}$

Provare a misurare la FdT della cassa acustica sollecitata con uno sweep di ampiezza costante (e confrontarla con quella di targa).

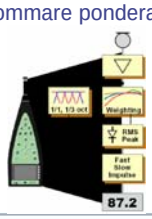
Esperienza 4

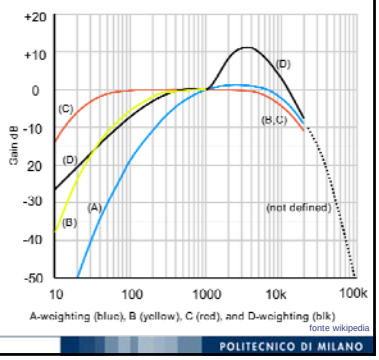
Misurare il livello di pressione sonora ponderata A col fonometro e confrontarlo con quanto mostrato sul display.

Misurare p_{mic}

Calcolare $L_{p,mic}$

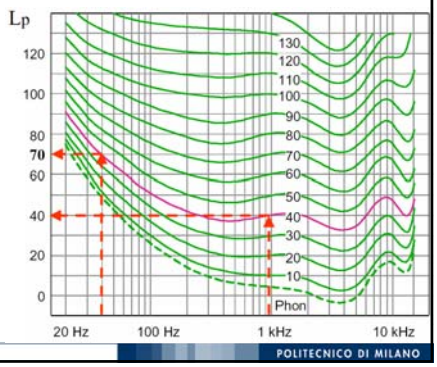
Sommare ponderazione





Esperienza 5

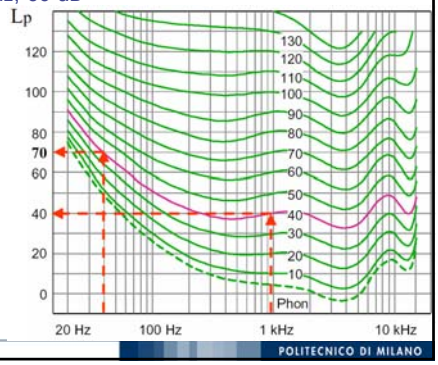
Ascoltare suoni al limite di udibilità (20 Hz - 20 kHz).



Esperienza 6

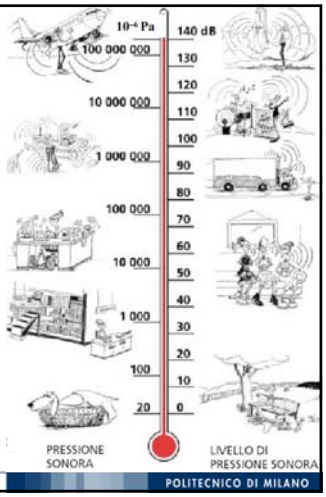
Misurare sperimentalmente la isofonica 60 dB.

- partire da 1 kHz, 60 dB
- provare:
  - 500 Hz
  - 200 Hz
  - 100 Hz
  - 50 Hz



Esperienza 7

Misurare diversi livelli di pressione sonora: silenzio, chiacchiere, baccano, musica, ...



Calcolo del valore RMS

Il valore che rappresenta il contenuto energetico del fenomeno acustico è il valore RMS (Root Mean Square) così definito:

$$RMS = 20\log_{10}\left(\sqrt{\frac{1}{\tau}\int_{t-\tau}^{t}\left(\frac{\rho(t)}{\rho_0}\right)^2 dt}\right)$$

Il valore RMS rappresenta una media energetica in un tempo (τ), questo tempo viene chiamato costante di tempo (SLOW, costante di tempo τ=1 s; FAST, costante di tempo τ=0.125 s).

Per l'esercitazione in oggetto viene richiesto di valutare l'andamento del valore RMS (apprezzando la differenza tra il calcolo effettuato con le due costanti di tempo) delle storie temporali acquisite, tenendo conto che essendo il segnale discreto, e non continuo, l'integrale degenera in una sommatoria.

Esperienza 8

Misura RMS con fonometro di fenomeni non stazionari.

Confrontare misure con costante FAST o SLOW.

$$RMS = 20\log_{10}\left(\sqrt{\frac{1}{\tau}\int_{t-\tau}^{t}\left(\frac{\rho(t)}{\rho_0}\right)^2 dt}\right)$$