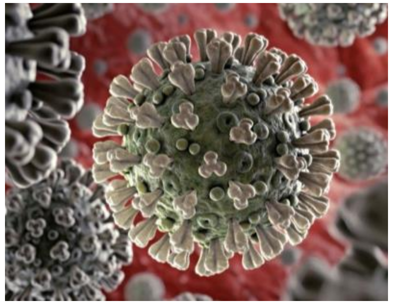
CENAM
CENTRO NACIONAL DE METROLOGÍA

SE
SECRETARÍA DE ECONOMÍA

Proyecto: Development of basic metrology infrastructure to support medical testing equipment (ventilators), SIM-PTB Project.

Actividad 2: Design and build a Lung Simulator as a basic infrastructure for the testing of mechanical ventilators

Roberto Arias



background:

Inter-institutional Collaboration MECHANICAL VENTILATORS

1

CIDESI
CIO
MABE
CIDEC

otros

Desarrollo

- ingeniería de diseño
- construcción
- integración

\+

2

CENAM

FyV
FyP

Trazabilidad de los resultados de medida

- volumen de aire
- caudal de aire
- Presión intrapulmonar

\+

3

COFEPRIS

INN

Aprobación

- Protocolo de pruebas con animales
- Pruebas con pulmones artificiales

background:

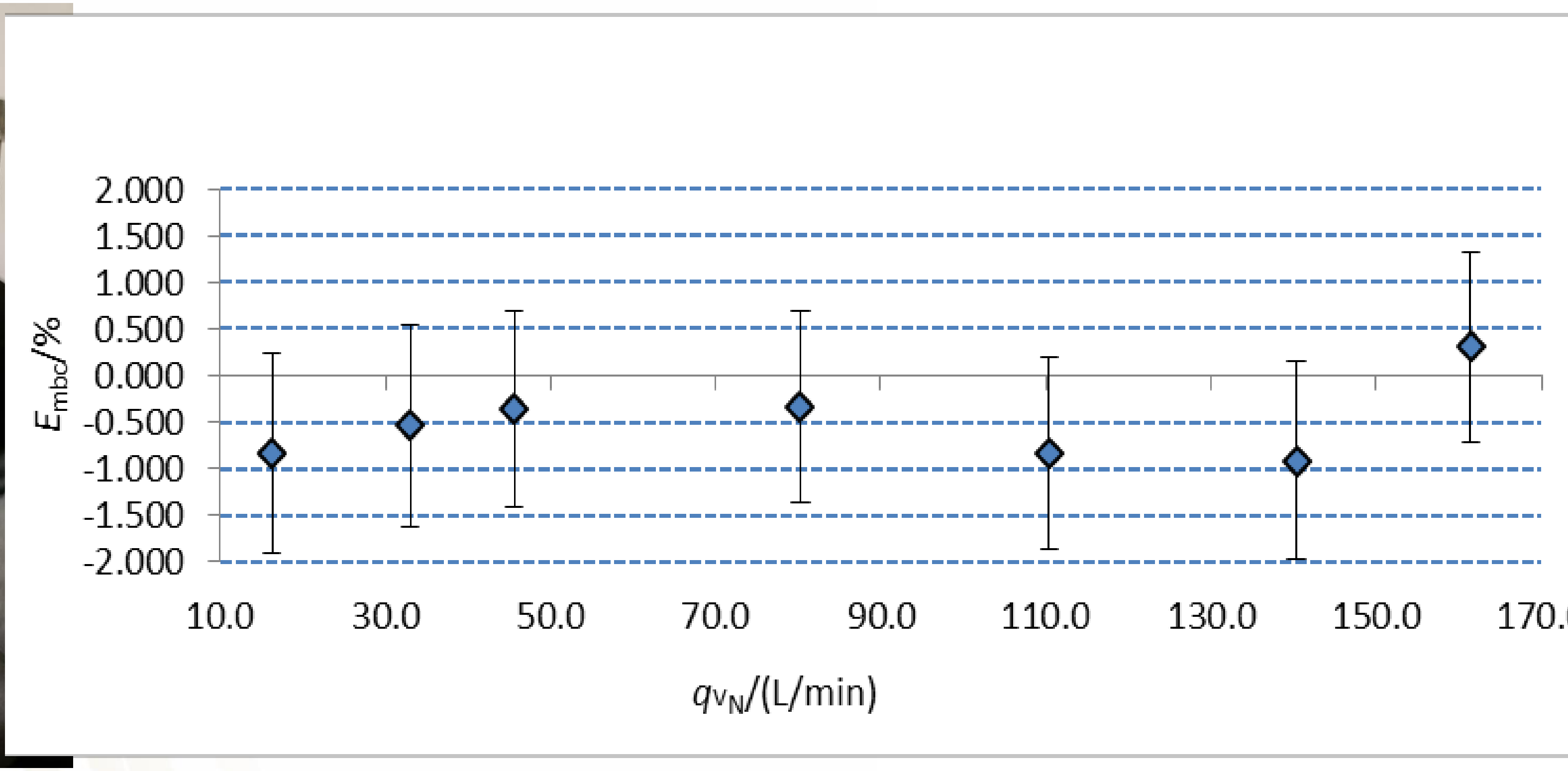
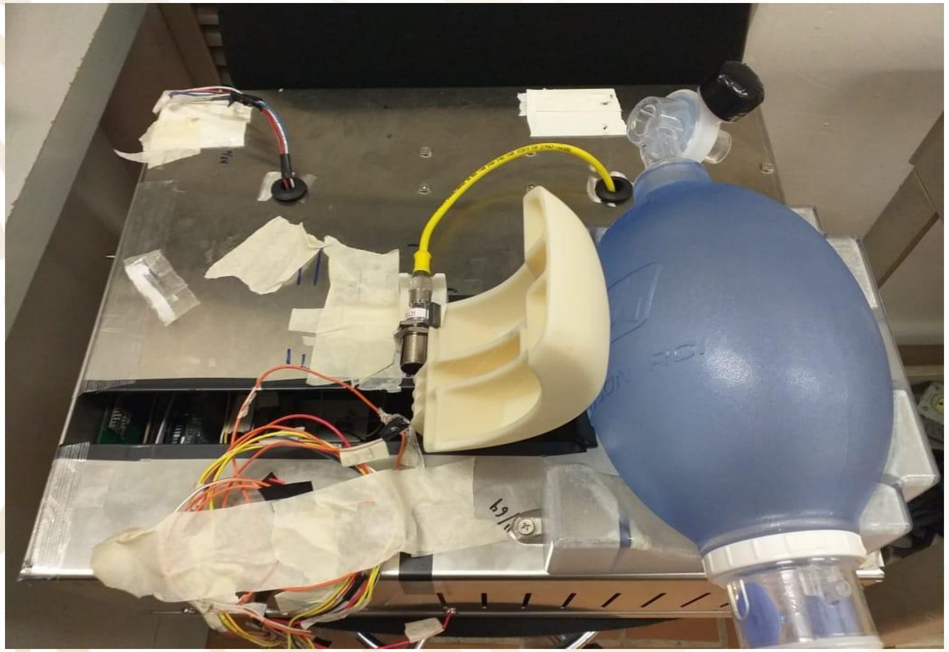


Figura 1. Calibration curve of the thermal type flowmeter; being clean air the calibration fluid.

background:



L placa – paleta/%	p_{mbp}/ kPa	p_{mbp_man}/ cm H_2O	ϑ_{mbp}/°C	q_{V_PR}/(L/min)	V_{actual}/mL	$s(V)$/mL	U/%
100	81.913	9.34	20.0	15.6	1120.0	4.8	0.8
80	81.735	7.52	20.1	13.3	772.4	6.3	1.0
60	81.539	5.59	20.2	10.5	468.0	4.3	1.4
40	81.377	4.02	20.2	8.4	223.2	6.5	1.7

Fig. Tidal volume determinations vs cam displacement

CENAM
CENTRO NACIONAL DE METROLOGÍA

collaborators:

SE
SECRETARÍA DE ECONOMÍA

Colaboradores:

CENAM
Roberto Arias R.
Carlos Ochoa D.

ITM/Querétaro
Profr. Agustín Barrera N.
Profr. Miguel A. González

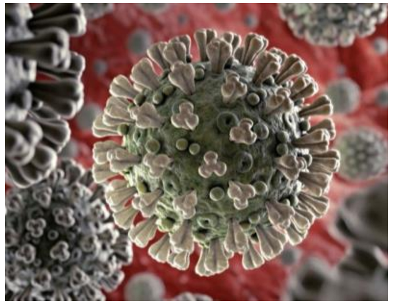
UNAM/Instituto de Matemáticas
Dr. Guillermo Ramírez S.

Contribución:

CENAM
Coordinación, integración mecánica de componentes, Caracterización metrológica

ITM/Querétaro
Integración electrónica de componentes, programación y control de componentes

UNAM/Instituto de Matemáticas
Simulación matemática



main bibliographic references

SCIENTIFIC REPORTS

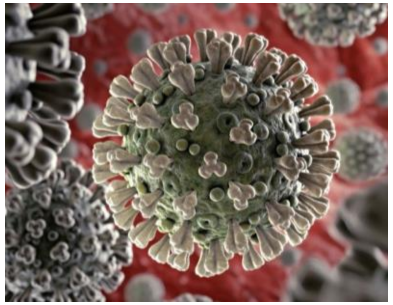
natureresearch

OPEN

Electro-mechanical Lung Simulator Using Polymer and Organic Human Lung Equivalents for Realistic Breathing Simulation

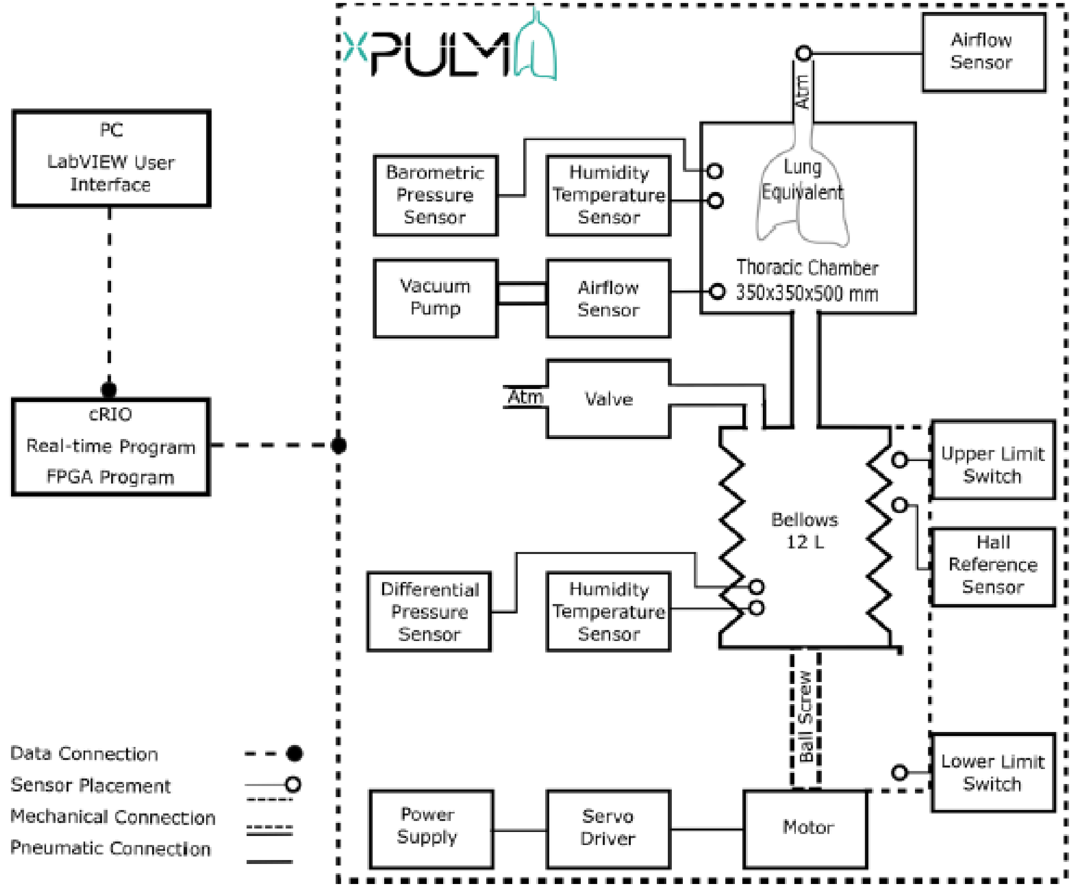
Richard Pasteka[1,2*], Mathias Forjan[1], Stefan Sauermann[1] & Andreas Drauschke[1]

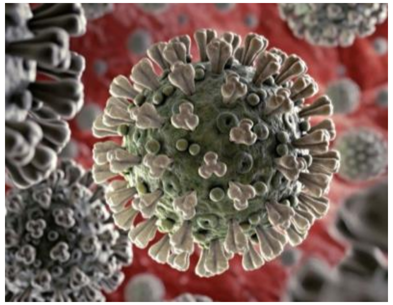
1University of Applied Sciences Technikum Wien, Department of Life Science Engineering, Vienna, 1200, Austria.



main bibliographic references

www.nature.com/scientificreports/





CENAM
CENTRO NACIONAL DE METROLOGÍA

main bibliographic references

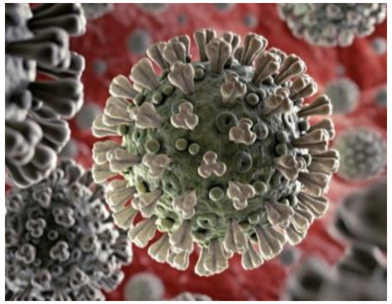
SE
SECRETARÍA DE ECONOMÍA

DE GRUYTER
Current Directions in Biomedical Engineering 2019;5(1):557-560

Florian Bautsch*, Georg Männel and Philipp Rostalski

Development of a Novel Low-cost Lung Function Simulator

Universität zu Lübeck



main bibliographic references

allows for high flexibility in the simulation, over a wide variety of patients of any age and conditions. The primary goal of this paper is to prove the basic capability of such a system to pneumatically generate a lung ventilation waveform of a spontaneously breathing patient in terms of flow going in and out of the patient.

2 Material and Methods

The design of the system was derived by using the functional analysis approach based on the requirement to control the flow in and out of the simulator with and without a ventilator attached to the system. The resulting design is shown in Figure 1. At the main port of the system the ventilator under test is attached to the lung simulator. At the port, two sensors are utilized to measure the systems in- and outgoing mass flow rate as well as the pressure, representing the condition at patient airway. Afterwards the system divides into two independent pneumatic branches each integrating a radial fan and a proportional valve. This way the airflow for the inspiration and expiration can be controlled independently.

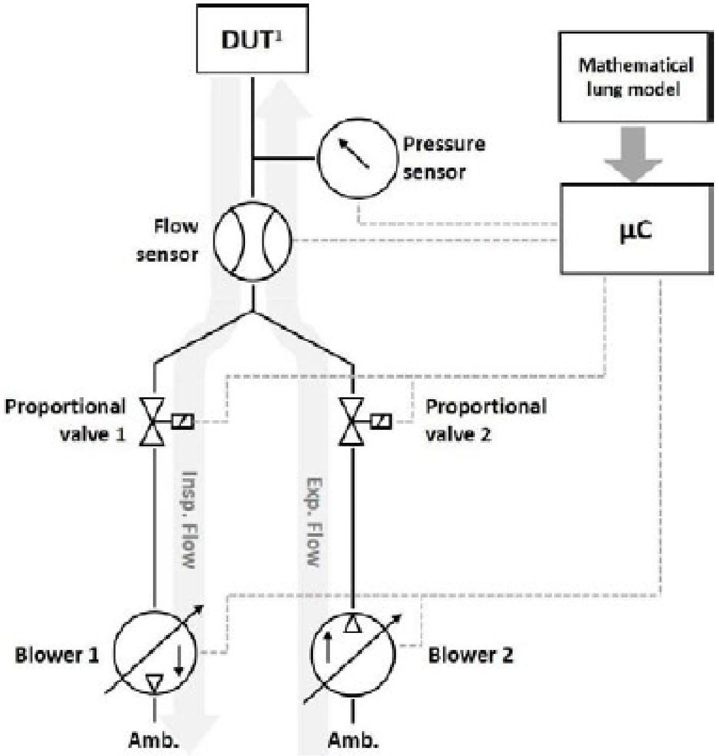
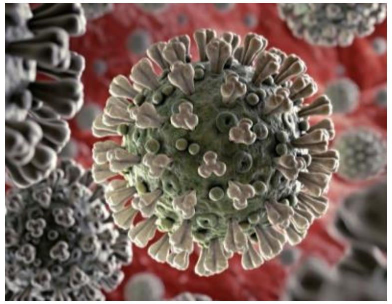
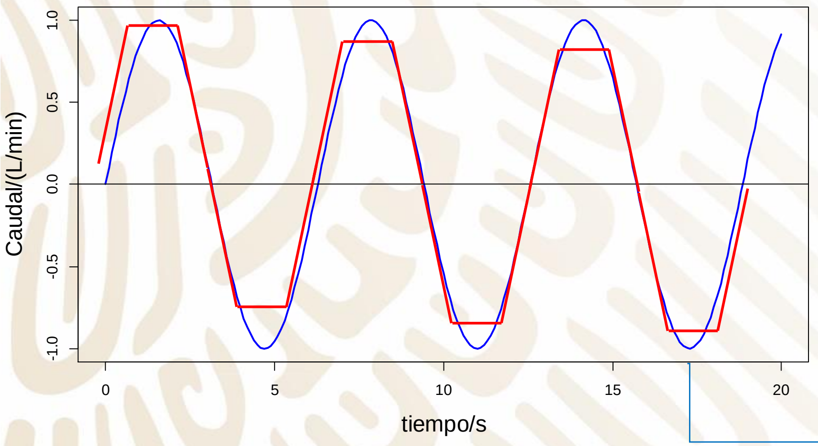


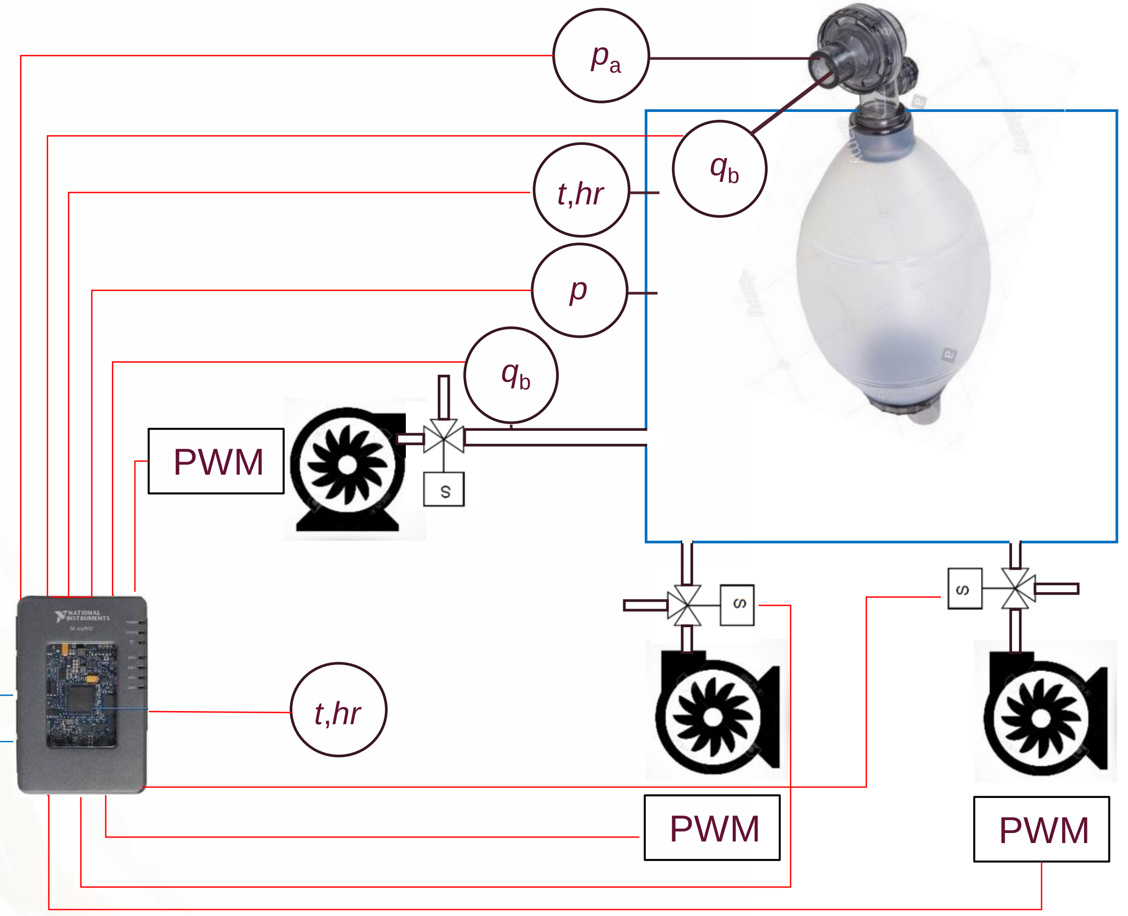
Figure 1: Pneumatic circuit diagram of the resulting system design with solid lines for tubes and dashed lines for data cables.
[1] Device under test



lung simulador design

$$\ddot{V} + K_1\dot{V} + K_2 V = K_3 p_p$$





selected components

Equipos

- IntelliBag (2)
- Miniature centrifugal blower (3)
- PWM Module (3)
- Data acquisition system
- Flow sensor (1)
- Flow sensor (1)
- Pressure sensor (3)
- Differential pressure sensor (1)
- *t* + *hr* sensor (2)
- Directional valve (2)
- Accesories
- Mechanical structure

Especificaciones

- V = 0.5 L, **resistencia y elasticidad variable**
- Q_{max} = 400 L/min, p_{max} = 100 mbar
- 10 - 50 VDC, 250 W, 5 A
- MyRio, (Processor + FPGA) Xilinx Z-7010, USB
- Thermal type Flow meter, Q_{max} = 200 L/min, ± 1 %, ⇔
- Thermal type Flow meter, Q_{max} = 20 L/min, ± 1 %,
- p_{max} = 150 kPa, ± 1 %, (4 – 20) mA
- Δp_{max} = 5 kPa, ± 1 %, (4 – 20) mA
- t ± 1 %, HR ± 5%, (4 – 20) mA
- 3 way, solenoid, low pressure

Marcas

- Hamilton Medical
- Micronel AG
- Micronel AG
- National Instruments
- Sensirion
- Honeywell
- Analog Microelectronics
- Analog Microelectronics
- Honeywell
- SMC

CENTRO NACIONAL DE METROLOGÍA

budget

Elemento	Fabricante	Modelo	Cantidad	precio unitario	Total
Centrifugal blower	Micronel	U65HN-024KS-6	3	346	1038
PWM modules	Micronel	ACB 701-01	3	561	1683
Data acquisition system	National Instruments	MyRIO-1900	1	941	941
Lung simulator	Hamilton Medical	IntelliLung 281869	2	200	400
Flow sensor, high flow	Sensirion	SFM 4200	1	200	200
Flow sensor, low flow	Honeywell	AWM5104	1	250	250
Pressure sensor	AnalogMicroelectronics	AMS 2710	2	200	400
Diferential flow sensor	AnalogMicroelectronics	AMS 2710	1	200	200
temperatura and humidity sensor	Honeywell	Humidlcon 6100	2	200	400
3 way valve	SMC	VG342	3	98	294
Accesories	varios	varios	1	500	500

Total: U$ 6 306

SECRETARÍA DE ECONOMÍA

Gracias por su atención !

Roberto Arias Romero
rarias@cenam.mx
+52-442-2110571