TekMedika

TekMedika Pvt. Ltd.

INSPIRE-100

A Streamlined Emergency Respiration Assist Device

INSPIRE-100
(Patent Pending)

Is it right for you?

Need adult respiratory support?

Budget Friendly?

Support from Initiation to Weaning?

No compressed air or piped Oxygen?

Connect to O_2 Cylinder or Concentrator?

Full range of Respiration parameters?

Breath Synchronization for Patient Comfort?

Remote monitoring capability?

Handle harsh-uncontrolled Environment?

Easy-to-use System?

NO PROBLEM

Setting the Context

The Motivation

The Problem Statement

Respiration Assist Devices
Categories – Usage and Pricing

Features

Rs 12 Lakhs ++

Less than Rs 1 Lakh

Less than Rs 50,000

Home Use

Home Use

AFFORDABLE feature set for PHC, Small Clinic, and Ambulance Use?

ICU Use

CPAP

BiPAP

Big Hole

ICU Ventilator

Evolution of Ventilators

Iron Lung Age

Pneumatic Age

µController Age

Smart "E"-Age
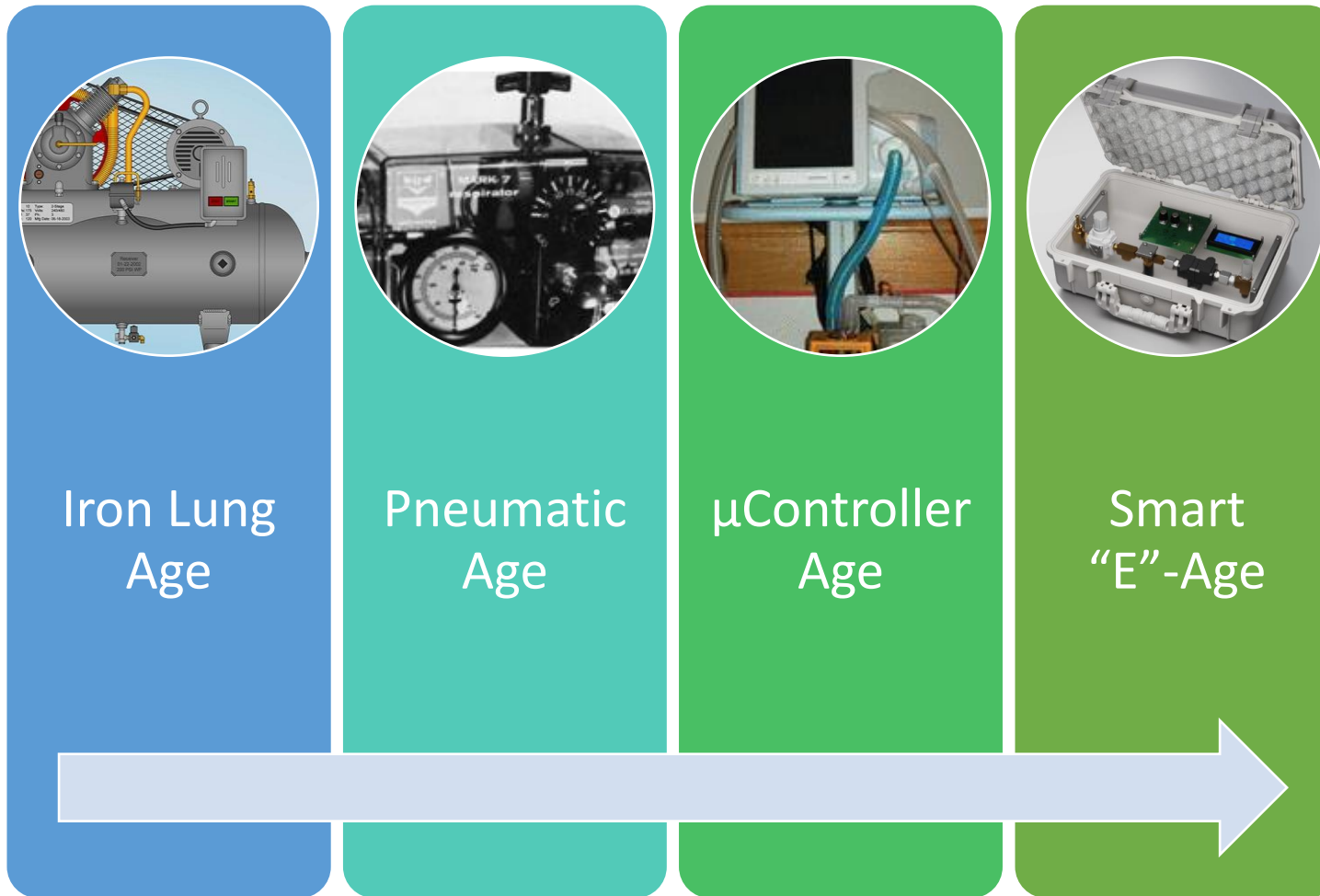
Most-used Ventilation Modes have not changed

- Volume and Pressure Control
- Control BPM, I/E, VT and PS
- Monitor pressures and flow
- Safety Alarm systems

Diminishing Returns from what has evolved …

- Exotic Ventilation modes
- Multitude of Sensors
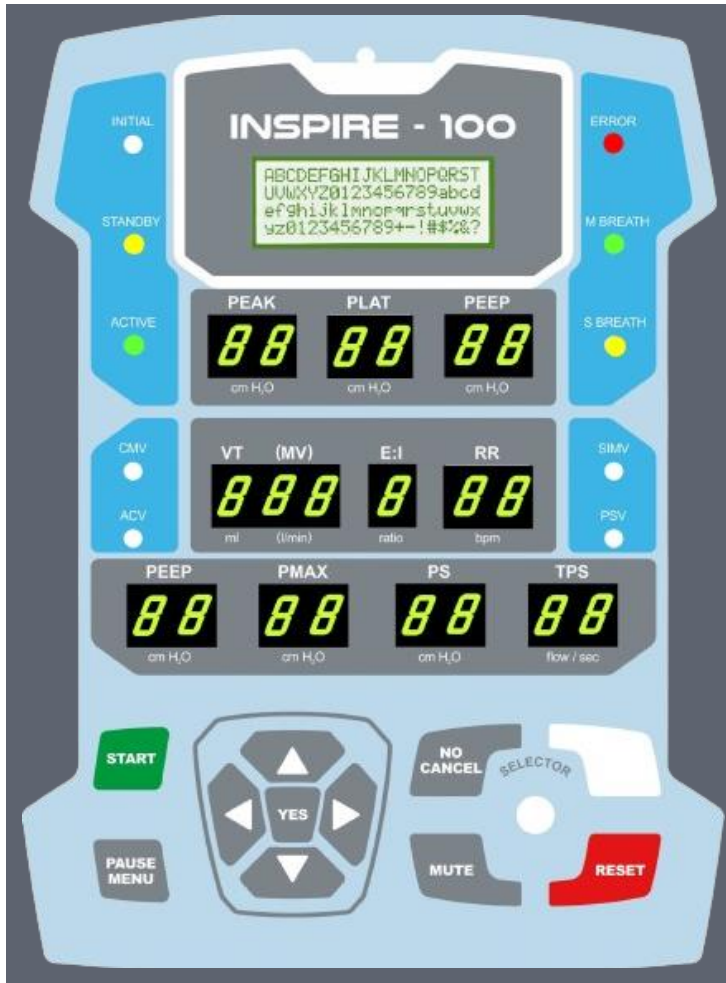- Fancy Touch-screen LCD Displays

INSPIRE-100 Details

System Components

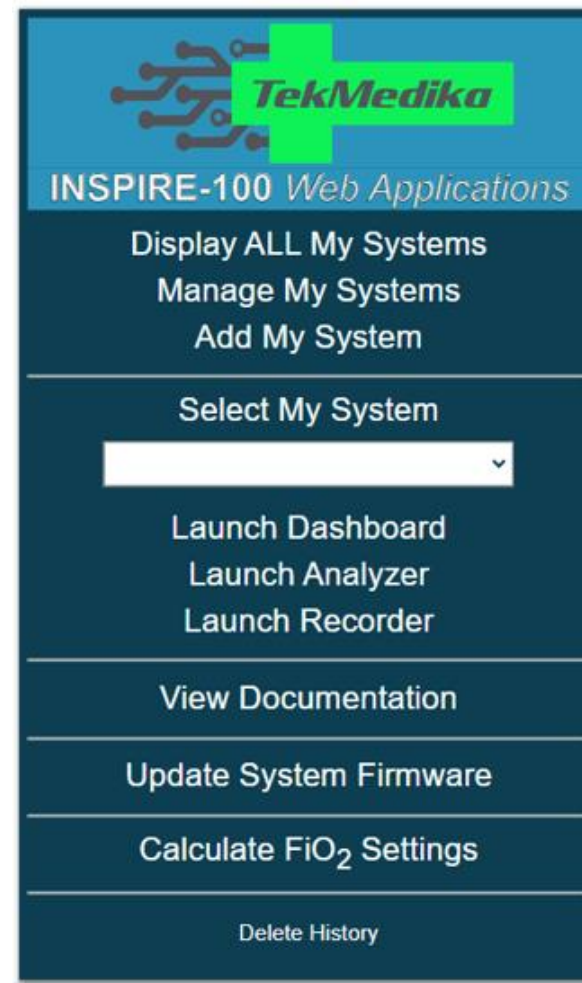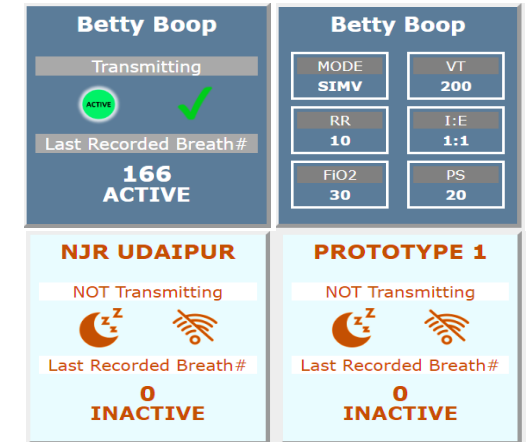Technical Details

Elegance in Simplicity

Menu-driven, Tactile, Intuitive and Easy-to-read Control Panel

Live Dashboard Recording and Analyzer

INSPIRE-100 *Web Applications*

- Display ALL My Systems
- Manage My Systems
- Add My System

Select My System

- Launch Dashboard
- Launch Analyzer
- Launch Recorder

View Documentation

Update System Firmware

Calculate FiO$_2$ Settings

Delete History

Multi-system Dashboard for Nurses' Station

Betty Boop — Transmitting — ACTIVE ✓
Last Recorded Breath# **166 ACTIVE**

Betty Boop
MODE SIMV	VT 200
RR 10	I:E 1:1
FiO2 30	PS 20

NJR UDAIPUR — NOT Transmitting
Last Recorded Breath# **0 INACTIVE**

PROTOTYPE 1 — NOT Transmitting
Last Recorded Breath# **0 INACTIVE**

Field Upgradeable

INSPIRE-100 *Update Firmware*

Step-by-step Instructions

Arduino Builder One-time Download

Select and Download Release

Version	Release Date	Get
1.0.1	30-Jan-2024	

Product Overview
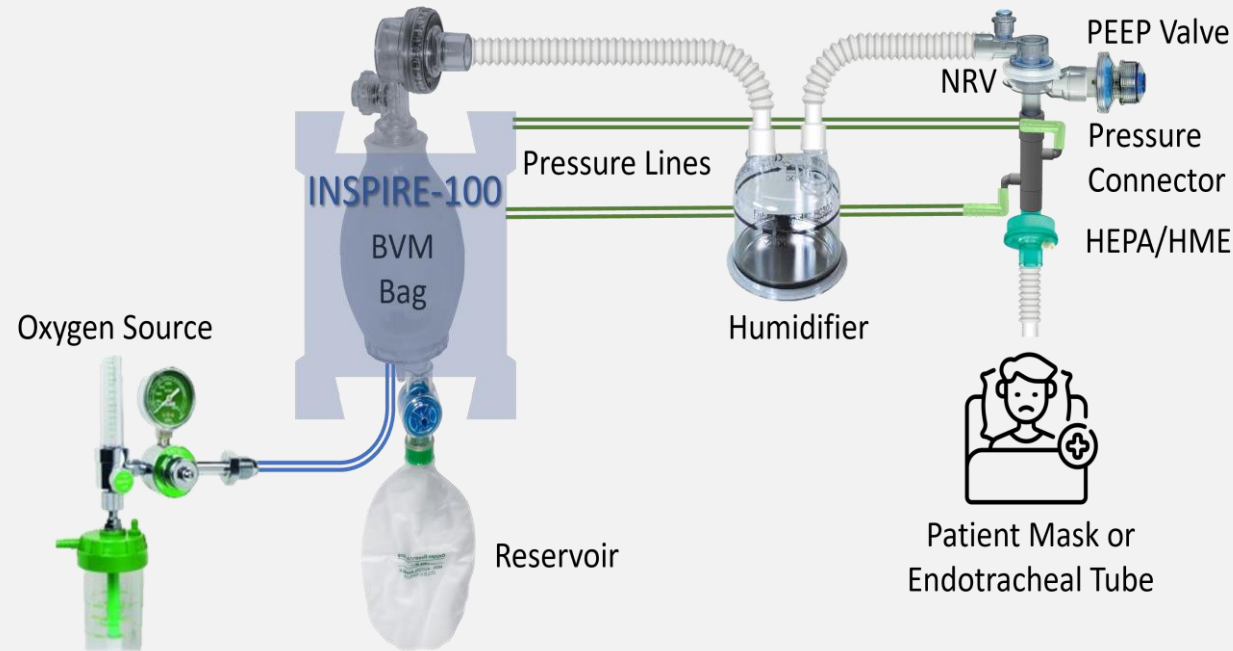
Salient Features

Exceptionally Budget Friendly	Elaborate Remote Monitoring Capabilities	Easy-to-use Easy-to-train Rugged & Robust
No Need for Compressed air or Piped O_2	Complete Set of Most-used Respiration Parameters	Power Consumption 100W

Patient Comfort

Mandatory Breaths synchronized with Patient-initiated Breaths

No breath stacking

Breathing Circuit

Labels: PEEP Valve, NRV, Pressure Connector, HEPA/HME, Pressure Lines, INSPIRE-100, BVM Bag, Humidifier, Oxygen Source, Reservoir, Patient Mask or Endotracheal Tube

$$Q \propto \sqrt{\frac{(P_{G1}-P_{G2})}{(P_{G1}+P_{G2})+2*Patmosphere}}$$

An important and necessary simplification is that P_{G1} and P_{G2} encountered in our system are of the order of tens of cmH$_2$O while Patmosphere is of the order of a thousand cmH$_2$O of pressure. At sea level, Patmosphere is approximately 1000 cmH$_2$O. Even at an altitude of 15,000 feet, Patmosphere is approximately 600 cmH$_2$O. On the other hand, the P_{G1} and P_{G2} in the system range from 1 cmH$_2$O to 60 cmH$_2$O .

Thus the $(P_{G1} + P_{G2})$ term is negligible compared to $(2* Patmosphere)$, even more so since it is preceded by a ___ root. The flow equation can be simplified to the one below.

$$Q \propto \sqrt{\frac{(\quad_{G2})}{Pa\quad osphe}}$$

Recalling Equation 2 from the theory section above, this equation can be recast as below given that the orifice characteristics and pressure tap location are the same for every system.

$$Q = C \cdot \sqrt{\frac{(P_G\quad P_G)}{(Patm\quad where)}} \quad w\quad re = \quad e\quad d's\quad m$$
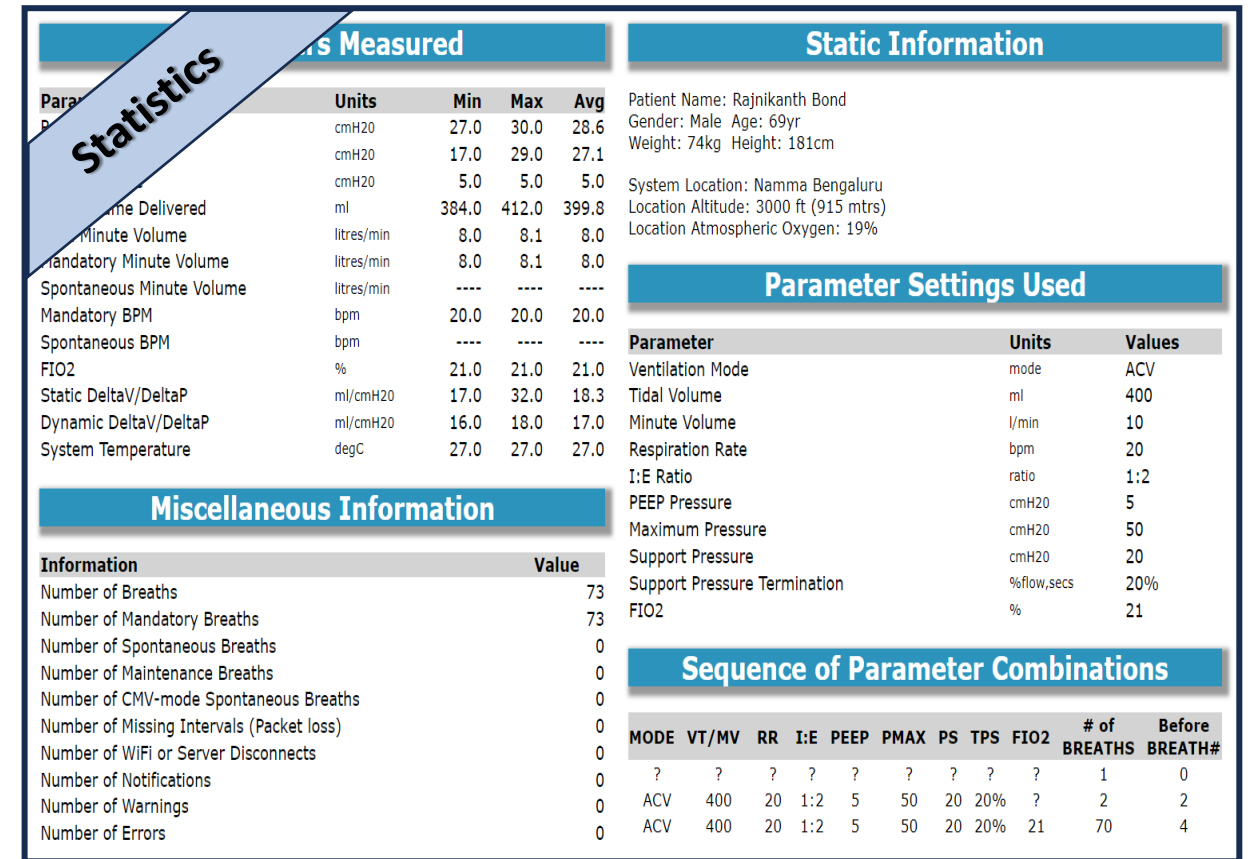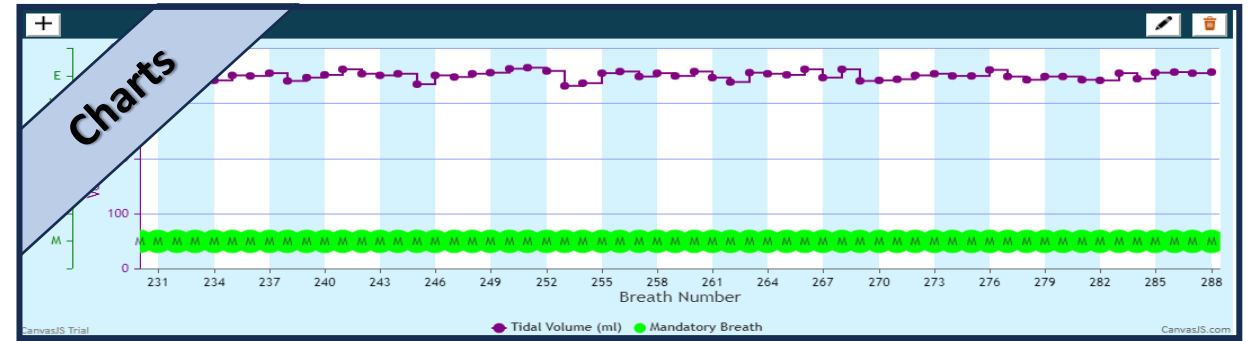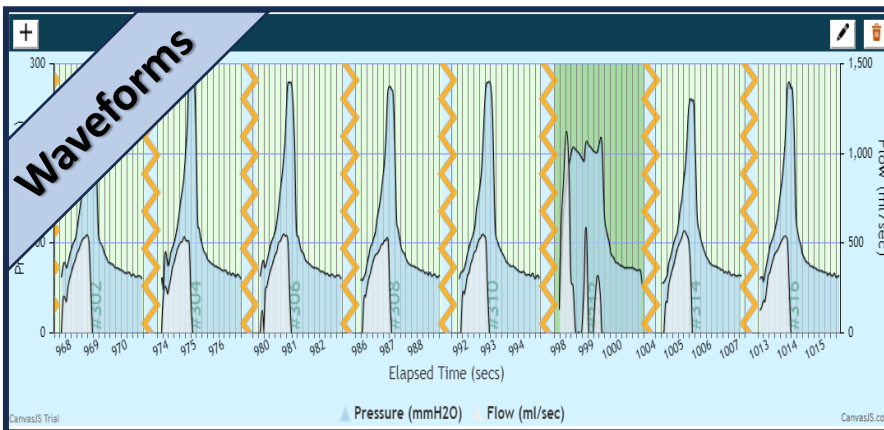
At a given geographical location, Patmosphere is also a constant. So, the above equation further reduces to the one below.

$$Q = \left(\frac{C}{\sqrt{Patmoshpere}}\right)* \sqrt{(P_{G1} - P_{G2})}$$

The equation needs further simplification to ease the computation burden of the square root computation for and inexpensive micro-controller. The constraints are as below.

Patent Pending

Snapshots

Mi... (l/min)
...1=7.9
...datory=7.9
...pontaneous=0.0

✓

ACTIVE

Measured Patient Parameters

PEAK Pressure (cm H₂O)
33

Delivered Volumes

Tidal Volume	Minute Volume
404 (ml)	8.0 (l/min)

PLATEAU Pressure (cm H₂O)
32

Breaths per Minute

Mandatory	Spontaneous
20 (bpm)	0 (bpm)

PEEP Pressure (cm H₂O)
6

Minute Volume Breakdown

Mandatory	Spontaneous
8.0 (l/min)	0.0 (l/min)

🔊 Warning
🔊 Error
○ Recording
● Dashboard

SYSTEM UID
UID_28615E07D6013C4A
(BANGALORE)

Miscellaneous

FiO₂ Settings

Required O₂ Flow Rate
2.3 (litres/min)

O₂ Source Purity
60%

Desired FiO₂
30%

DeltaV/DeltaP (ml/cmH₂O)
Dynamic
15
Static
16

INSPIRE-100 Dashboard
TekMedika

Patient Information

James Bond

Gender: Male Age: 42yr

Weight: 72kg Height: 180cm

System Parameter Settings

Mode	PEEP Pressure
ACV	6 (cm H₂O)

Tidal Volume	Max Pressure
400 (ml)	75 (cm H₂O)

Respiration Rate	Support Pressure
20 (bpm)	20 (cm H₂O)

I:E Ratio	Support End
1:2 (ratio)	20% (% Peak Flow)

No Pending Changes

Charts

E
M
100
0

231 234 237 240 243 246 249 252 255 258 261 264 267 270 273 276 279 282 285 288
Breath Number

CanvasJS Trial

● Tidal Volume (ml) ● Mandatory Breath

CanvasJS.com

Statistics

...rs Measured

Para...	Units	Min	Max	Avg
P...	cmH20	27.0	30.0	28.6
	cmH20	17.0	29.0	27.1
	cmH20	5.0	5.0	5.0
...me Delivered	ml	384.0	412.0	399.8
...Minute Volume	litres/min	8.0	8.1	8.0
Mandatory Minute Volume	litres/min	8.0	8.1	8.0
Spontaneous Minute Volume	litres/min	----	----	----
Mandatory BPM	bpm	20.0	20.0	20.0
Spontaneous BPM	bpm	----	----	----
FIO2	%	21.0	21.0	21.0
Static DeltaV/DeltaP	ml/cmH20	17.0	32.0	18.3
Dynamic DeltaV/DeltaP	ml/cmH20	16.0	18.0	17.0
System Temperature	degC	27.0	27.0	27.0

Miscellaneous Information

Information	Value
Number of Breaths	73
Number of Mandatory Breaths	73
Number of Spontaneous Breaths	0
Number of Maintenance Breaths	0
Number of CMV-mode Spontaneous Breaths	0
Number of Missing Intervals (Packet loss)	0
Number of WiFi or Server Disconnects	0
Number of Notifications	0
Number of Warnings	0
Number of Errors	0

Static Information

Patient Name: Rajnikanth Bond
Gender: Male Age: 69yr
Weight: 74kg Height: 181cm

System Location: Namma Bengaluru
Location Altitude: 3000 ft (915 mtrs)
Location Atmospheric Oxygen: 19%

Parameter Settings Used

Parameter	Units	Values
Ventilation Mode	mode	ACV
Tidal Volume	ml	400
Minute Volume	l/min	10
Respiration Rate	bpm	20
I:E Ratio	ratio	1:2
PEEP Pressure	cmH20	5
Maximum Pressure	cmH20	50
Support Pressure	cmH20	20
Support Pressure Termination	%flow,secs	20%
FIO2	%	21

Sequence of Parameter Combinations

MODE	VT/MV	RR	I:E	PEEP	PMAX	PS	TPS	FIO2	# of BREATHS	Before BREATH#
?	?	?	?	?	?	?	?	?	1	0
ACV	400	20	1:2	5	50	20	20%	?	2	2
ACV	400	20	1:2	5	50	20	20%	21	70	4

Waveforms

300

1,500
1,000
500
0

968 969 970 975 976 980 981 986 987 992 993 994 998 999 1000 1004 1005 1006 1013 1014 1015

Elapsed Time (secs)

CanvasJS Trial

▲ Pressure (mmH2O) ■ Flow (ml/sec)

CanvasJS.com

Technical Specifications

Commonly used Ventilation Modes

CMV	Continuous Mandatory Ventilation
ACV	Synchronized Assist Control Ventilation
SIMV	Synchronized Intermittent Mandatory Ventilation
PSV	Pressure Support Ventilation

Full Set of Alarm Alerts

Max Pressure	Pressure Leak	Pressure Loss
Airway Blockage	Coughing Hiccupping	Inconsistent Parameters
Extreme Parameter Combination	System Temperature	And many more ...

Volume Controlled Breaths

Tidal Volume	**Respiratory Rate**	**I:E Ratio**
200 - 600 ml	10 - 30 bpm	1:1 1:2 1:3
PEEP	**Max Pressure**	**FiO$_2$ Support**
4 - 15 cmH$_2$O	15 - 60 cmH$_2$O	System Managed Externally Controlled

Pressure Supported Breaths

Support Pressure	5 - 35 cmH$_2$O
Support Pressure Termination	Flow Triggered Time Triggered

Synchronize Mandatory breaths with Spontaneous breaths
Prevent breath stacking

Breath Syncing in SIMV mode

There is a sync-window – the next mandatory breath is rescheduled only if spontaneous breath within the sync-window
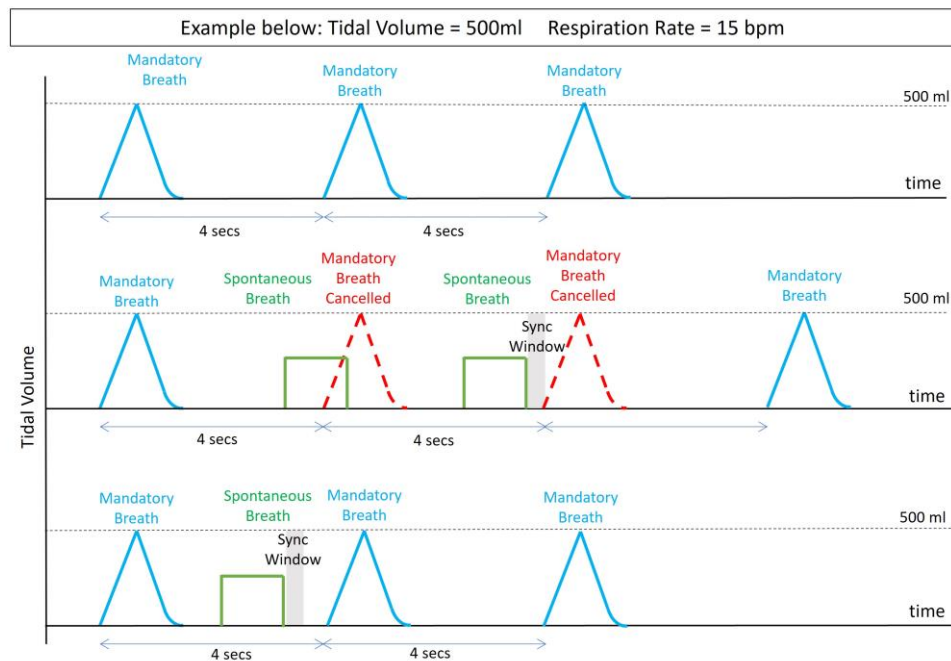
Breath Syncing in Synchronized AC Mode

There is no sync-window – the next mandatory breath is always rescheduled after a spontaneous breath

Breath Synchronization
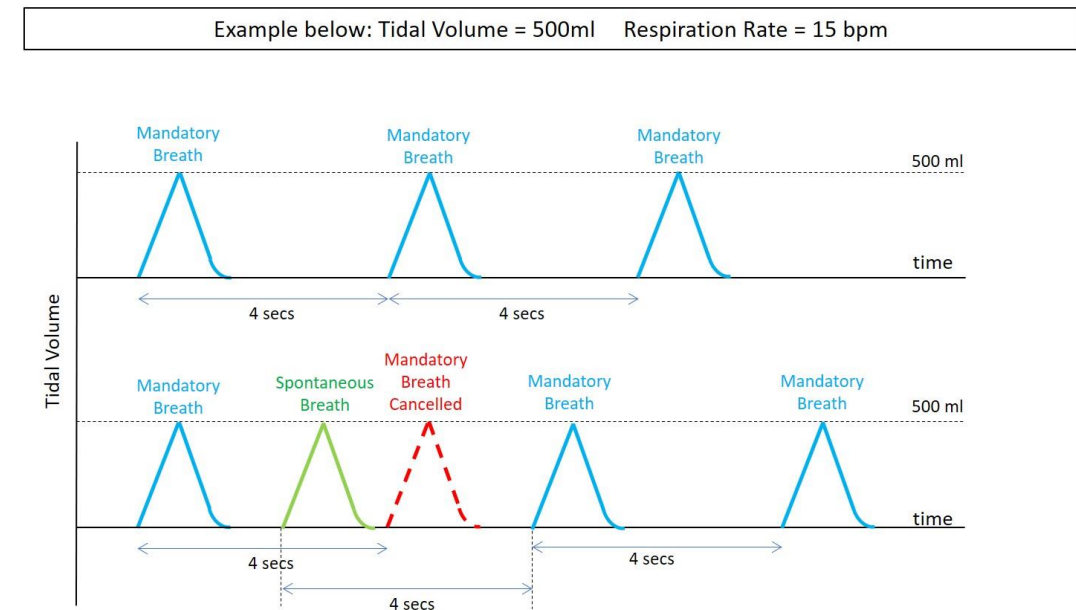
FiO$_2$ Settings

Without the Reservoir bag, FiO$_2$ delivered is the Atmospheric O$_2$ content at site

FiO$_2$ delivery with the Reservoir bag is mathematically modelled, calibrated and verified in the Lab to provide +/- 5% accuracy

Front-panel guides the user in setting the appropriate input O$_2$ flow rate from the O$_2$ source for a given FiO$_2$

The mathematical model provides for a possible O$_2$ concentrator as an O$_2$ source (purity < 100%)

Online Web-accessible FiO$_2$ calculator is also provided for exploration purposes

To Patient

BVM

Tubing to Oxygen Source

RESERVOIR
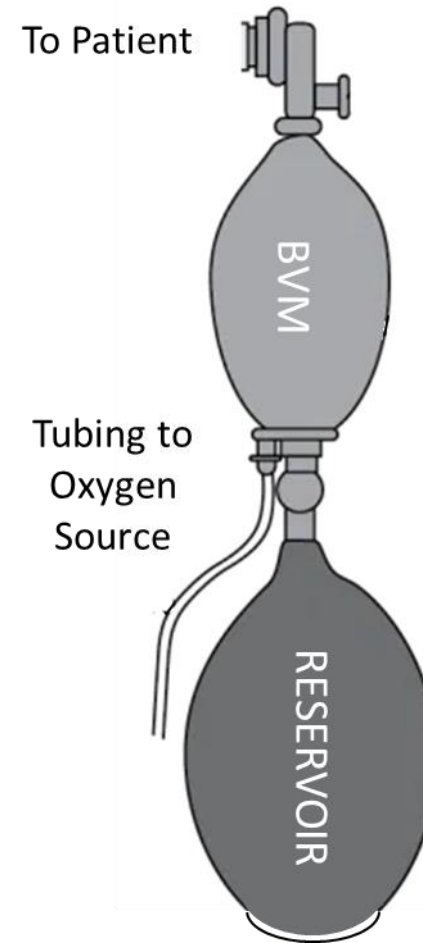
INSPIRE-100 FiO$_2$ Calculator

TekMedika

Required Incoming O$_2$ Flow

0.0 (litres/min)

Altitude: 0   feet

Desired VT (ml)   Desired RR (bpm)

400   15

O$_2$ Purity (%)   Desired FiO$_2$ (%)

21   21

Alarms & Safety Features

Enforcement of Pre-use checks

Maintenance Breaths till Alarm situation rectified

Alarms, Warnings and Notifications

- Max Pressure Alarm
- Pressure Leak Alarm
- Pressure Loss Alarm
- Airway Blockage Alarm
- System Temperature Alarm
- Sensor Failure Alarm
- Breathing Circuit Failure Alarm
- Detect coughing/hiccupping fits
- Inconsistent input parameters
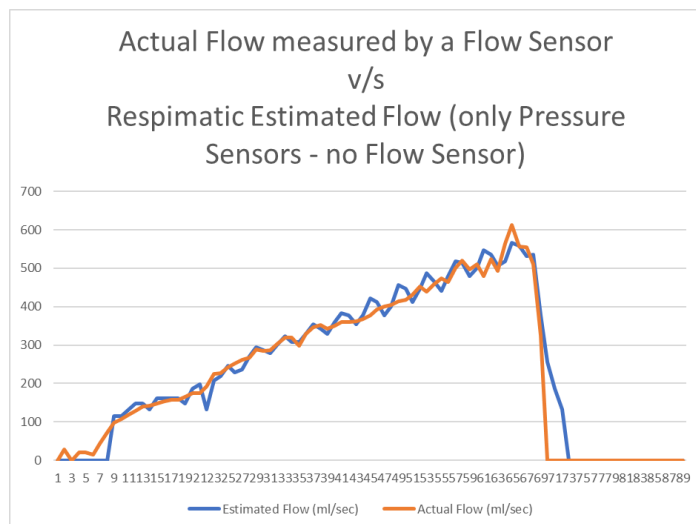- Extreme parameter combination warnings
- And many more …

Pre-Use Checks
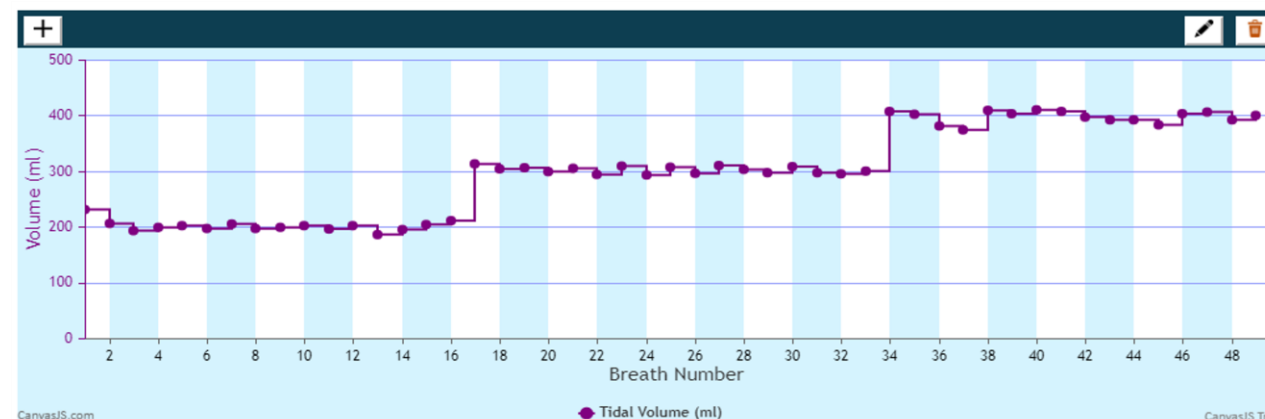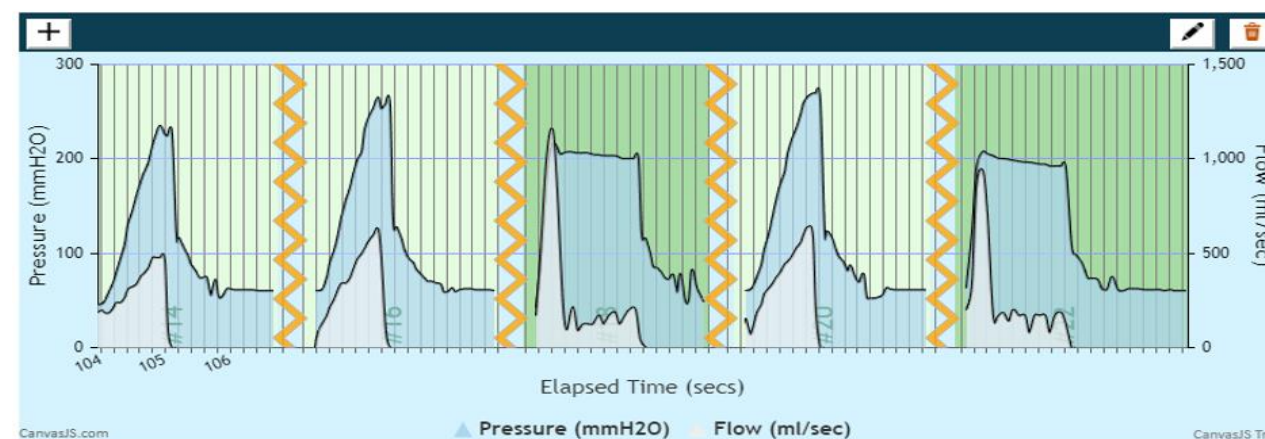
- **Mandatory**
  - Check Sensors
  - Set Pressures
  - Set FiO2
- **Recommended**
  - Breathing System
    - Insp. Pause
    - Spont. Trigger
    - Flow Alerts
    - SIMV Sync Window
    - BVM Bag
  - Display
    - LED Lights
    - Number LEDs
    - Brightness
    - Alarms
    - Buzzer Volume
  - Miscellaneous
    - Breath Shapes
    - Motor
    - Power Backup
- **Optional**
  - Checker Status
    - Curr Status
    - Prev Status
  - System UID
  - Date Time
  - Reading Speed
  - Factory Reset

Backup

Some Results

Actual Flow measured by a Flow Sensor v/s Respimatic Estimated Flow (only Pressure Sensors - no Flow Sensor)

Legend: Estimated Flow (ml/sec) — Actual Flow (ml/sec)

VT Titration for VT = 200, 300 and 400ml

Legend: Tidal Volume (ml)

A Mix of VC and PS Breaths

Legend: Pressure (mmH2O)   Flow (ml/sec)

Sample FiO2 Data					
PEEP=6,EI=2			Measured	Calculated	ERROR
VT	RR	O2 (l/min)	FiO2(%)	FiO2(%)	%
400	20	2	40.5	39	4%
400	20	2.5	45.5	43.5	4%
400	20	3	49	48	2%
400	20	3.5	54	53.5	1%
400	20	4	59.8	57	5%
400	20	4.5	63.5	61.5	3%
400	20	5	67.5	66	2%
400	30	2	33	33	0%
400	30	2.5	36.5	36	1%
400	30	3	38.5	39	1%
400	30	3.5	41.5	42	1%
400	30	4	44.5	45	1%
400	30	4.5	47.1	48	2%
400	30	5	49.8	51	2%

CPAP *v/s* BiPAP *v/s* INSPIRE-100 *v/s* ICU-VENTILATOR

CPAP	BiPAP	Respimatic 100	ICU Ventilator
Continuous Positive Airway Pressure	Continuous Bi-Level Airway Positive Pressure	Mechanical Ventilation with 4 most-used ventilation modes and controls	Mechanical Ventilation with very sophisticated modes and controls
Non-invasive	Non-invasive	Non-invasive + Invasive	Non-invasive + Invasive
High Flow + PEEP	Inspiratory Pressure + PEEP	Tidal Volume + Support Pressure + PEEP	Tidal Volume + Support Pressure + PEEP
Useful for Type 1 respiratory Failure (Hypoxemic)	Useful for Type 2 respiratory Failure (Hypercopnic)	Useful for Hypoxemic and Hypercopnic respiratory failure	Useful for Hypoxemic and Hypercopnic respiratory failure
Continuous flow of air at a constant pressure. Increases mean airway pressure to recruit collapsed alveoli	Continuous flow of air at different constant pressures during inspiration and expiration breathing phase	Independent control over the volume, the respiration rate and pressure	Independent control over the volume, the respiration rate and pressure
Useful only when patient can breathe on his own	Useful only when patient can breathe on his own	Useful when patient can or CANNOT breathe on his own	Useful when patient can or CANNOT breathe on his own
Only Spontaneous breaths that are patient triggered.	Only Spontaneous breaths that are patient triggered.	Spontaneous breaths + Mandatory breaths controlled by RR and I:E	Spontaneous breaths + Mandatory breaths controlled by RR and I:E
External FiO2 control	External FiO2 control	System assisted FiO2 control	Direct FiO2 control
Breath Synchronization N/A	Breath Synchronization N/A	Full Breath Synchronization	Full Breath Synchronization
No Tidal Volume control	Indirect Tidal Volume control (IPAP-EPAP)	Direct Tidal Volume control	Direct Tidal Volume control
No Respiration Rate control	No Respiration Rate control	Direct Respiration Rate control	Direct Respiration Rate control
No Inspiration:Expiration ratio control	No Inspiration:Expiration ratio control	Direct Inspiration:Expiration control	Direct Inspiration:Expiration control
External Humidity control	External Humidity control	External Humidity control	Direct Humidity control
No display of Peak, Plateau or PEEP	No display of Peak, Plateau or PEEP	Full display of Peak, Plateau and PEEP	Full display of Peak, Plateau and PEEP
Minimal alarm signals	Minimal alarm signals	Full set of Alarm signals	Full set of Alarm signals
No remote monitoring	No remote monitoring	Sophisticated Remote WEB Dashboard	Minimal Remote monitoring (if any)

Thank you