INSPIRE - 100

An Emergency Ventilator Device

TekMedika

Unmatched Affordability

Unmatched Remote Monitoring via WiFi

Unmatched Ease-of-use

No need for compressed Air Pipeline

Connect to Oxygen Cylinder or Concentrator

Full range of Mainstream Respiration Parameters

Breath Synchronization for Patient Comfort

Field Upgradeable

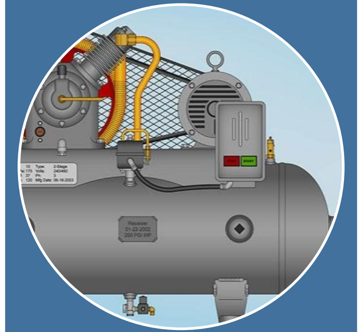
Rugged and Robust

Setting the Context

The Problem Statement

The Motivation

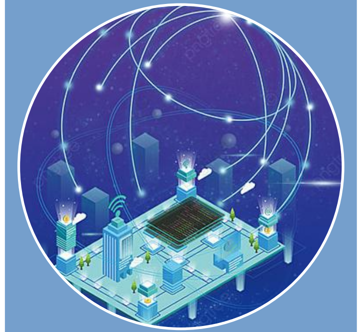
Evolution of Ventilators



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
- Touch-screen Displays

The Problem
Scarcity & Affordability

India has amongst the lowest per capita ICU beds in the World*

- 1.46 beds / 1000 people*
- 3.65 ICU beds / Lakh people*
- Only half of ICU beds are equipped with Ventilators
- A meagre 1.8 Ventilators for one lakh people*

ICU ventilators are expensive equipment

- Unaffordable in remote clinics

Ventilator Ambulances are

- Non-existent except in few urban centers,

** As per April 2020 Study by Center for Disease Dynamics, Economics & Policy at Princeton University, USA*

Respiration Assist Devices

Categories – Usage and Pricing

Features

Less than Rs 50,000

CPAP

Less than Rs 1 Lakh

BiPAP

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

Big Hole

Rs 10 Lakhs ++

ICU Ventilator

The Motivation

- Medical Colleges & Specialization (Tertiary In-patient Care)
- District Hospitals (Secondary In-patient Care)
- Subdistrict Health Complex (Out-patient & In-patient Care)
- Gram Panchayat PHC (Ambulance, Emergency, Clinic)
- Village PHC* (Out-patient Care & Referrals)

As of 2021, there were **1,56,231 Primary Health Centers (PHCs) in India with minimal infrastructure*

- Provide a robust, portable ventilator system for facilities that lack sophisticated hospital infrastructure
- A system that requires minimum training and provides ventilation support from initiation to weaning with full range of mainstream parameters
- A system that can supplement the scarce, expensive ICU Ventilators, sparing them for more complex cases
- A system within the budget of the bottom of the pyramid at a fraction of the cost of an ICU Ventilator
- A system to bridge the gap between nothing and an expensive ICU ventilator
- A system that works in harsh uncontrolled environments and as a travel ventilator

INSPIRE-100 Details

System Components

Technical Details

Elegance in Simplicity

- *Simple, Easy-to-read Front Control Panel*
- *Prominent, Always-on Parameters Display*
- *Menu-driven HMI*
- *Prominent, Tactile Control Buttons*
- *LCD Screen for Menu and Message Display*
- *Colored LEDs show System state at-a-glance*
- *Brightness and Buzzer Volume Controls*
- *Backed by Comprehensive Remote Displays*

Product Overview

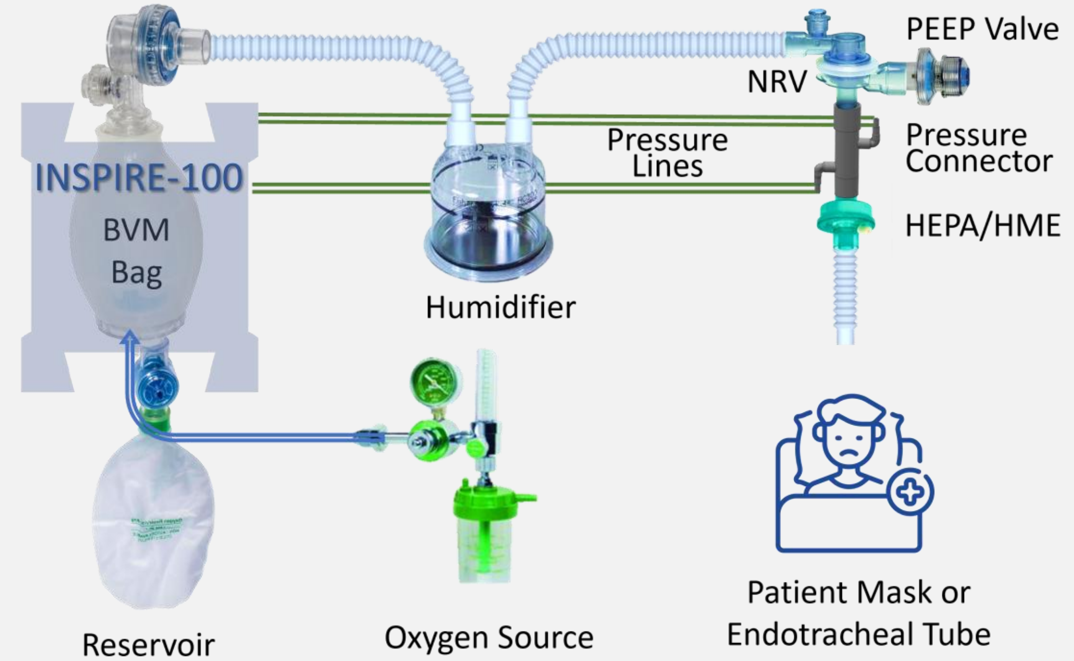
Salient Features

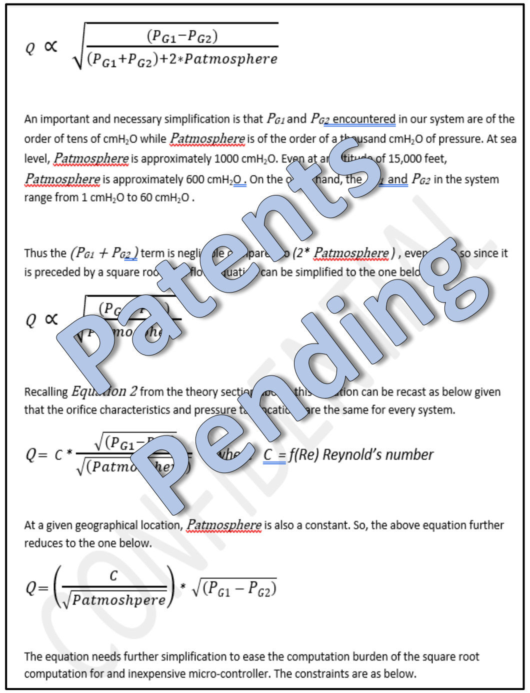
- *Exceptionally Budget Friendly*
- *Comprehensive Remote Monitoring*
- *Easy-to-use Easy-to-train Rugged & Robust*
- *Works without Compressed air or Piped O_2*
- *Complete Set of Mainstream Respiration Parameters*
- *Power Consumption 100W*

Patient Comfort

- *Mandatory Breaths synchronized with Patient-initiated Breaths*
- *No breath stacking*

Breathing Circuit





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

An important and necessary simplification is that P_{G1} and P_{G2} encountered in our system are of the order of tens of cmH_2O while *Patmosphere* is of the order of a [illegible]usand cmH_2O of pressure. At sea level, *Patmosphere* is approximately 1000 cmH_2O. Even at a[illegible]titu[illegible] of 15,000 feet, *Patmosphere* is approximately 600 cmH_2O . On the o[illegible] hand, the [illegible] and P_{G2} in the system range from 1 cmH_2O to 60 cmH_2O .

Thus the $(P_{G1} + P_{G2})$ term is negli[illegible] [illegible]pare[illegible] $(2* Patmosphere)$, eve[illegible] so since it is preceded by a square roo[illegible] flo[illegible]uati[illegible] can be simplified to the one belo[illegible]

$Q \propto$ [illegible]

Recalling *Equ[illegible]on 2* from the theory sectio[illegible] this [illegible]tion can be recast as below given that the orifice characteristics and pressure ta[illegible]catio[illegible] are the same for every system.

$Q= C *$ [illegible] *whe[illegible] C = f(Re) Reynold's number*

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.

Patents Pending

TekMedika Preliminary and Confidential

Technical Specifications

Commonly used Ventilation Modes

CMV	Continuous Mandatory Ventilation
ACV	Synchronized Assist Control Ventilation
SIMV	Synchronized Intermittent Mandatory Ventilation
PSV	Pressure Support Ventilation (BiPAP equivalent)

Full Set of Alarm Alerts

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

Volume Controlled Breaths

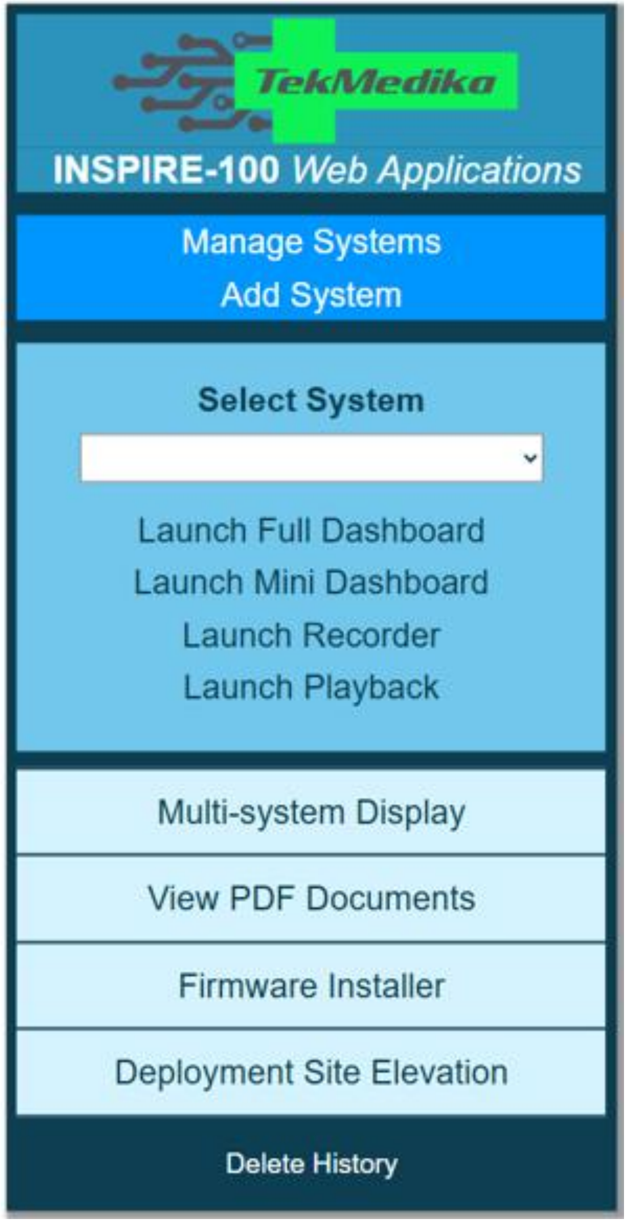
Tidal Volume 200 - 600 ml	***Respiratory Rate*** 10 - 30 bpm	***I:E Ratio*** 1:1 1:2 1:3
PEEP 4 - 15 cmH_2O	***Max Pressure*** 15 - 60 cmH_2O	***FiO_2 Support*** System Managed Externally Controlled

Pressure Supported Breaths

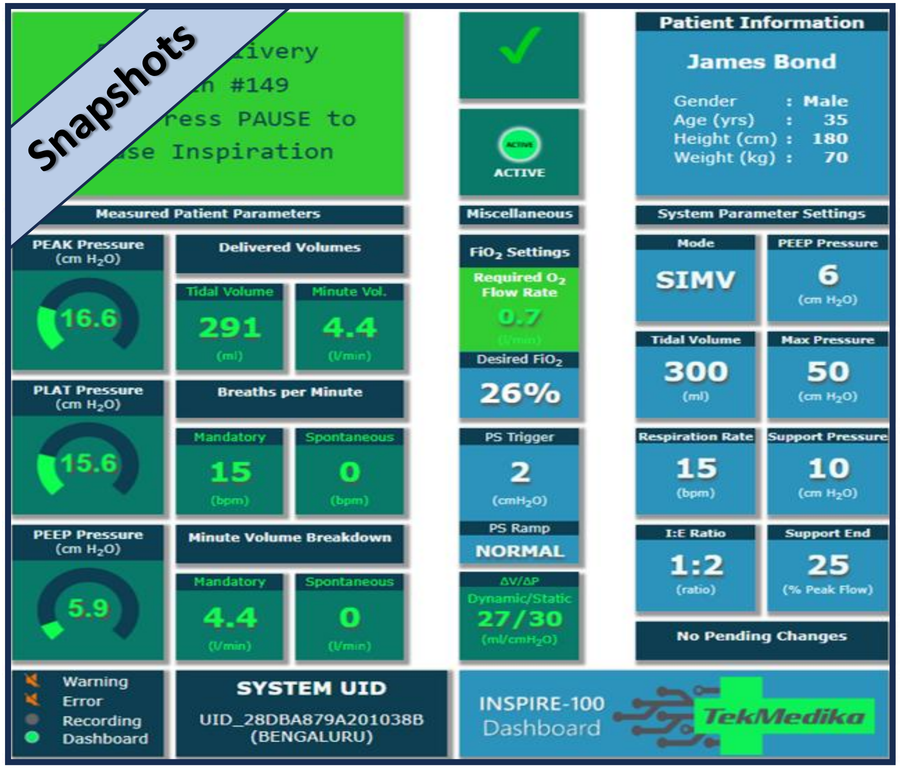
Support Pressure	5 - 20 cmH_2O
Support Pressure Termination	Flow Triggered 10 – 60%

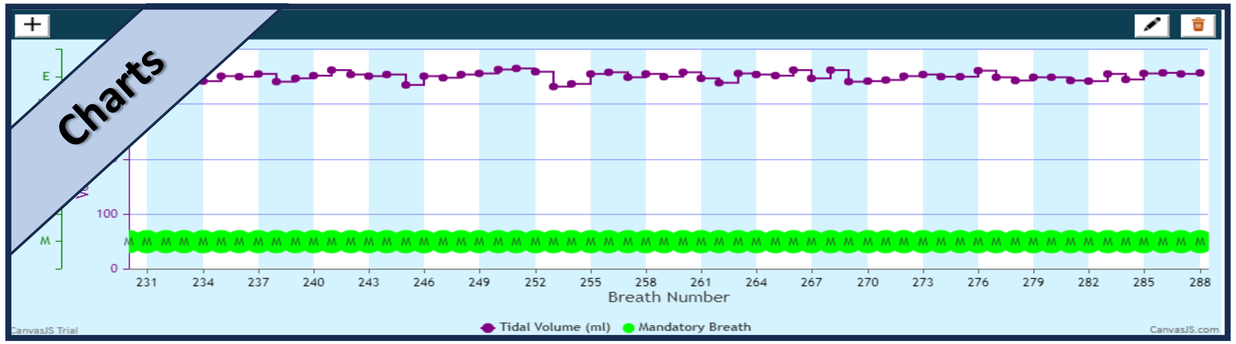
Elaborate Remote Monitoring

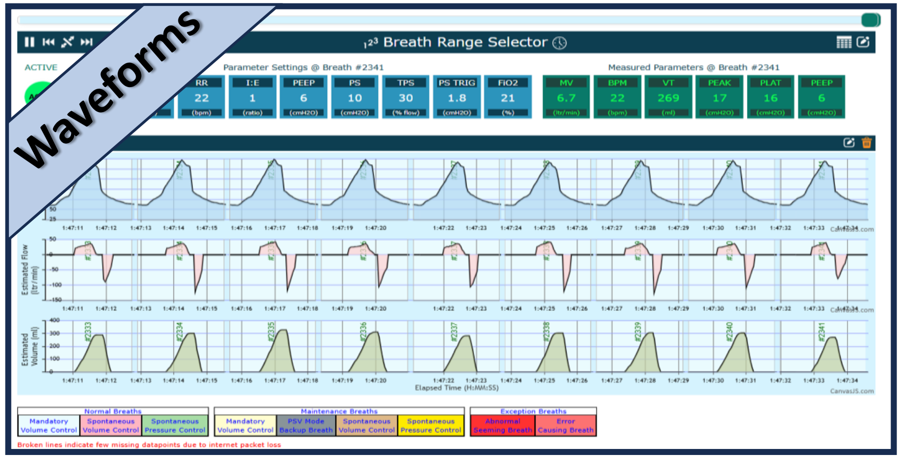
- Live Dashboard
- Detailed Breath Waveforms
- Charts for all Parameters
- Detailed Statistics
- System Alerts and Alarms
- Recording and Playback
- Multi-system Display

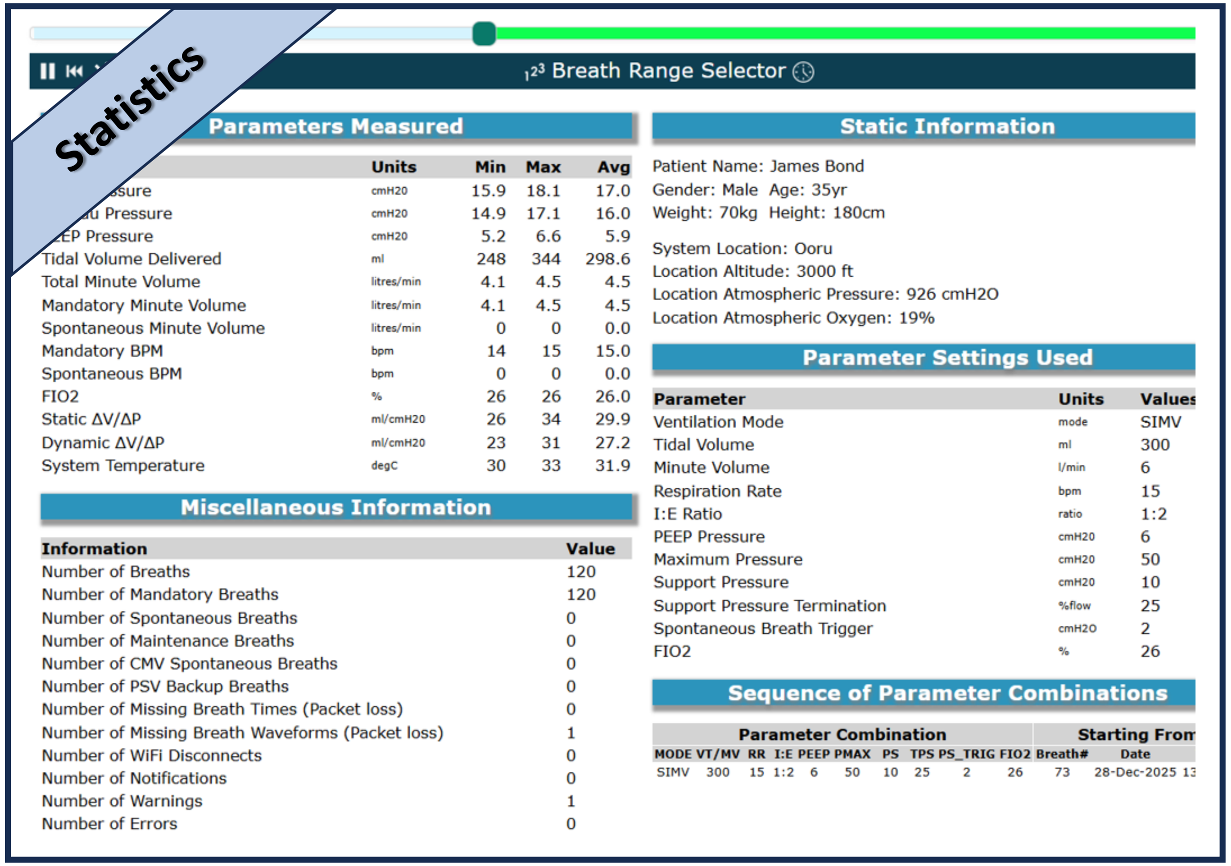


Remote Monitor Screenshots





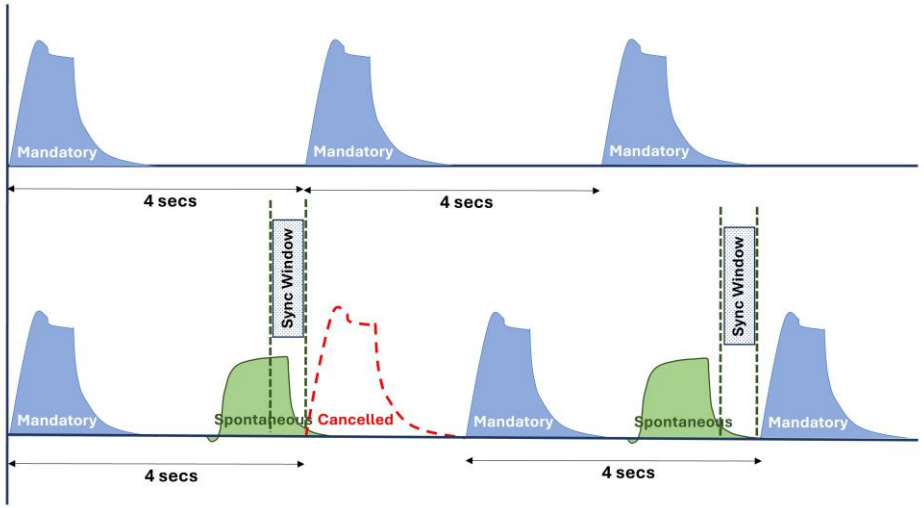




Synchronize Mandatory breaths with Spontaneous breaths
Prevent breath stacking

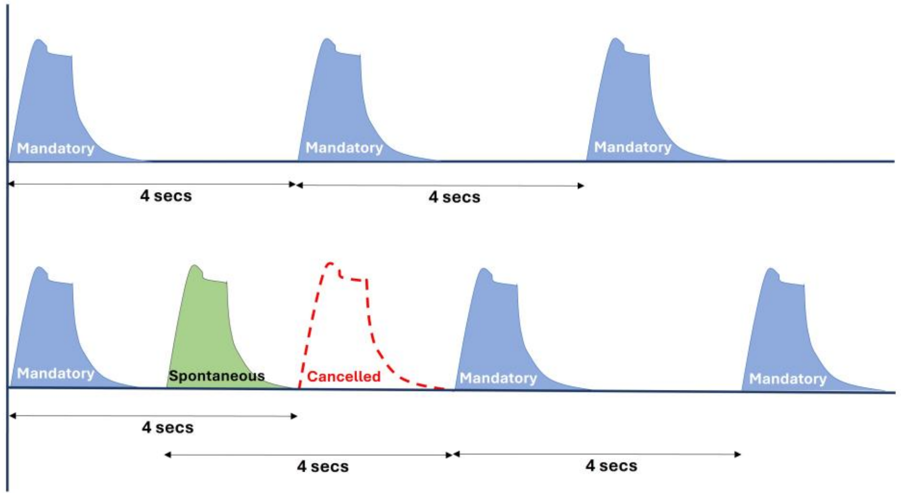
Breath Synchronization in SIMV Mode

e.g. RR=15 bpm (4 secs per breath)



Breath Synchronization in ACV Mode

e.g. RR=15 bpm (4 secs per breath)



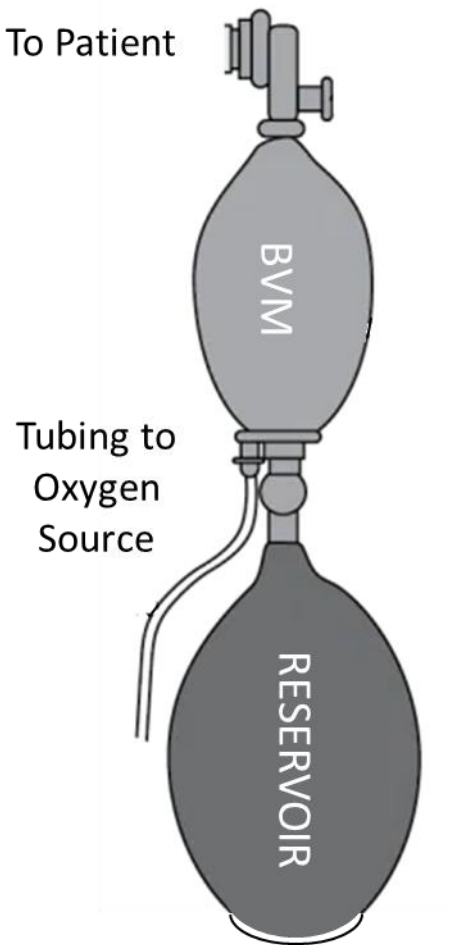
FiO_2 Settings

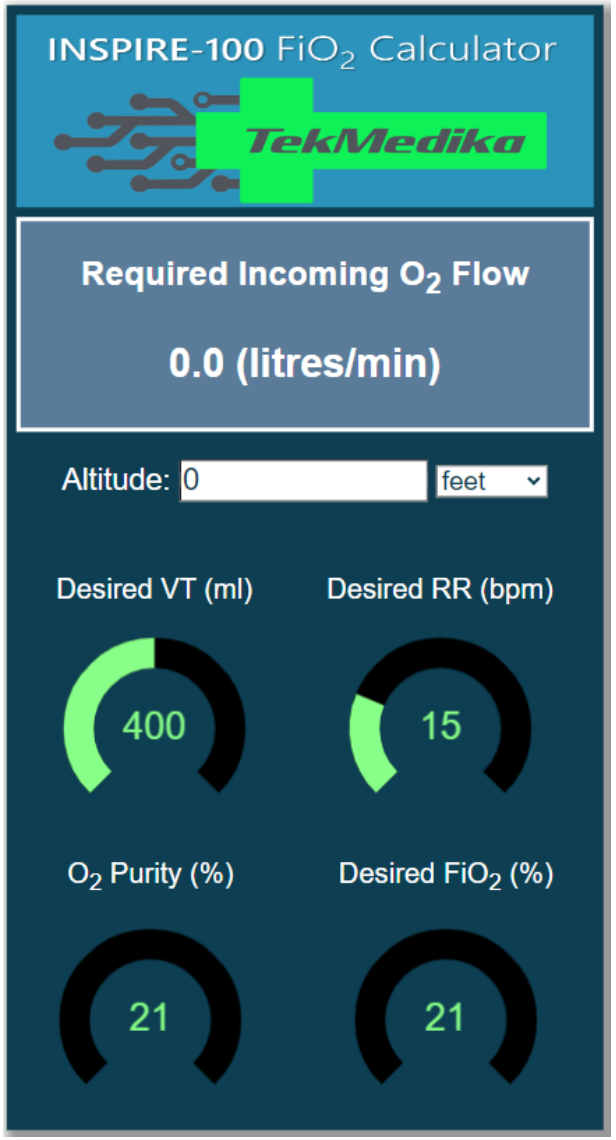
Without the Reservoir bag, FiO_2 delivered is the Atmospheric O_2 content at site

FiO_2 delivery with the Reservoir bag is mathematically modelled, calibrated and verified in the Lab to provide +/- 10% 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 an O_2 concentrator as an O_2 source (purity < 100%)





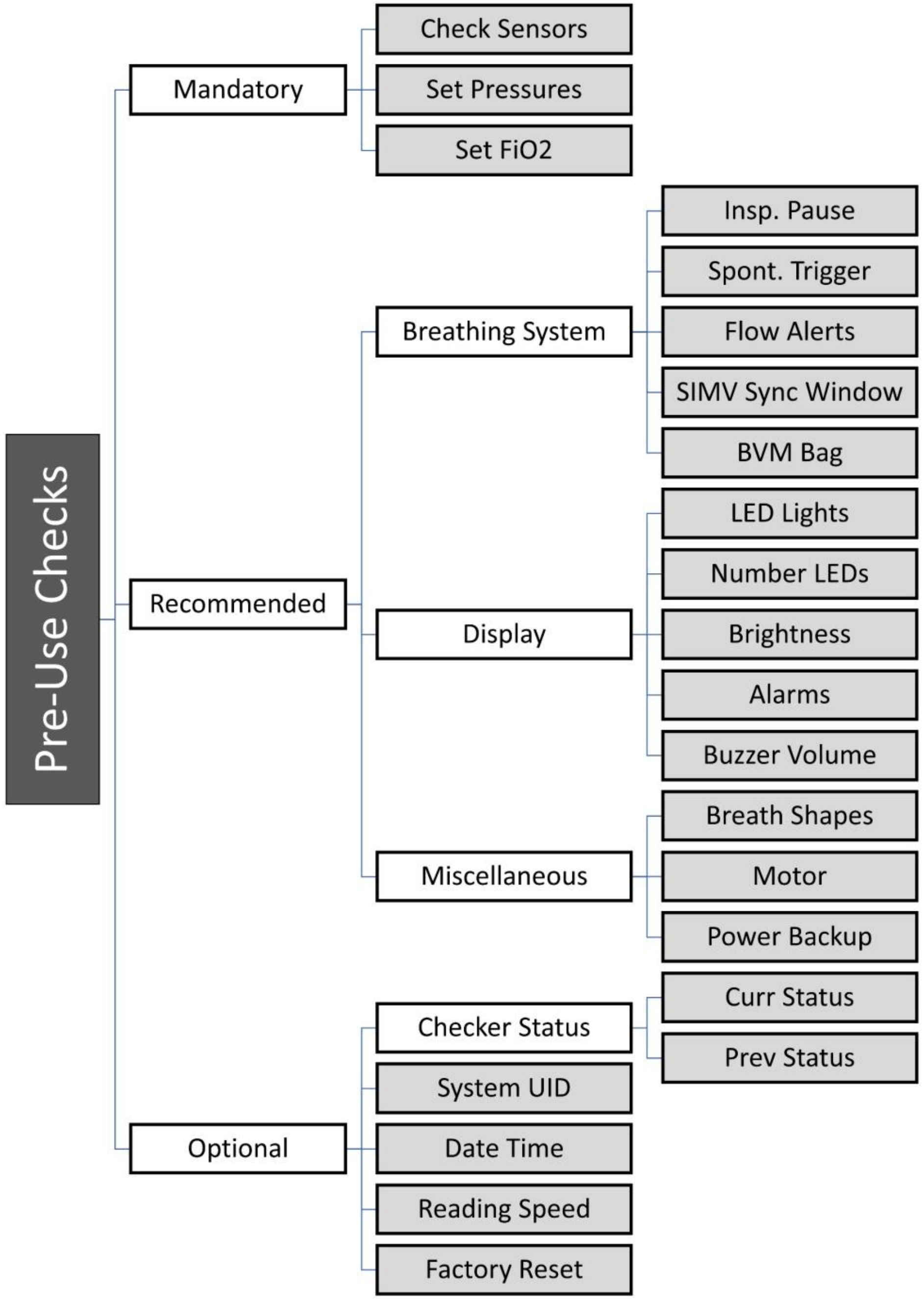
Alarms & Safety Features

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 …



Extensive Automated Testing

AutoTest Controls

1. Select PEEP
2. Run all combinations for Selected ranges of
   - Ventilation Modes
   - Respiration Rates
   - I:E ratios
3. # Breaths per Combination
4. % Spontaneous Breaths

AutoTest

Micro-controller Code

CSV Data File
Detailed Data for
Each delivered breath

AutoTest Analyzer

Windows Code

RESULTS

BACKUP

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