ISSN: 2278 – 909X
International Journal of Advanced Research in Electronics and Communication Engineering (IJARECE)
Volume 5, Issue 3, March 2016

Intelligent Inhaler for Asthma Patients

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***Abstract*—Over 300 million people are affected with asthma worldwide. The difficulty in breathing and airflow obstruction caused by inflammation and constriction of the airways is experienced due to Asthmatics. Home monitoring of lung function is the preferred course of action to give physicians and asthma patients a chance to control the disease jointly. Hence there is a need to develop the accurate and efficient asthma monitoring device. It should be easy for the patients to use it, and also it should be portable. It should be built as a hand held device for the complete clinical care for the asthma patients. The device should be designed in such a way so as it is able to diagnose the breath level by sensing and correlating the values from the pressure, co_2, dust level it classify and so intimate/warn the patient. It is an automatic device to feeds the different level of inhale doses according to diagnosed patient breath level. The proposed project is an energy efficient device and hence can be used in many places such as ambulance etc., It is also provided with facilities of recording the relevant data and the facility of transporting it to other electronic devices through ports are also possible.**

***Index Terms*—Asthma, Wheezing, Lung monitoring, Nebulizer**

I. Introduction

In worldwide more than 300 million people affected by the Asthma. Asthma is a chronic disease involving the airways in the lungs cause the breathing problem of wheezing, Shortness of breath, Chest tightness or pain. Asthma was diagnosed by the spirometer it's a device measure the pressure of exhale air from the lungs. The patients who had the asthma problem mostly they affected by the dust and pollution in the air which makes the inner walls of lungs becomes swollen, so that the patient takes less air to his/her lungs which feels the shortness in breath and leads to the wheezing, also leads the patient to die if he/she not taken any treatment.

The essential treatment for the asthma was by inhale the dose with air , there two types of asthma inhales for the normal wheezing they use Pressurized metered dose inhalers (MDIs) or dry powder dose inhalers for normal wheezing, if he/she was in severe attacks Nebulizers were used. Were the challenge behind the asthma patients was they can't predict the asthma attack, judge the purity of environment and so they don't know how much dose to inhale , sometimes in severe even they don't have strength to hold the inhalers , old people may leads to unconscious in few minutes.

So our device will solve these challenging problems of the asthma patient. yes, it's sense the environment purity and warn the patient if necessary and its wearable. Whenever the patient in wheezing/severe attach they just enough to wear this. It will automatically diagnose and feeds the dose dynamically according the wheezing level also this intelligent system had the both type of doses MDIs and Nebulizers so it feeds the right one for the patient according the diagnosed parameters.

II. Literature Review

An assessment of the impairment domain for determining the severity of disease (in patients on no long-term-control treatment before treatment is initiated) or the level of control (after treatment is selected) usually can be elicited by careful, directed history and lung function measurement. Standardized questionnaires like the Asthma Control Test (ACT) (Nathan et al. 2004), the Childhood Asthma Control Test (Liu et al. 2007), the Asthma Control Questionnaire (Juniper et al. 1999b), the Asthma Therapy Assessment Questionnaire (ATAQ) control index (Vollmer et al. 1999), and others have been developed to facilitate and standardize the assessment of the impairment domain of asthma control. Some patients, however, appear to perceive the severity of airflow obstruction poorly (Bijl-Hofland et al. 2000; Kikuchi et al. 1994). These patients may have unconsciously accommodated to their symptoms, or perhaps they have mistakenly attributed these symptoms to other causes, like aging, obesity, or lack of fitness, so that they do not report them readily. For these patients, some other measure, such as spirometry, may identify that the degree of airflow obstruction is poorly recognized or perceived by the patient. A trial of therapy can be initiated and lead to unexpected improvement in quality of life ("I did not realize how much better I could feel until my asthma was treated.").

Assessment of the risk domain—that is, of adverse events in the future, especially of exacerbations and of progressive, irreversible loss of pulmonary function—is more problematic. Some assessment of the risk of exacerbations can be inferred

Manuscript received March 2016.

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from the medical history. Patients who have had exacerbations requiring emergency department (ED) visits, hospitalization, or intensive care unit (ICU) admission, especially in the past year, have a great risk of exacerbations in the future (Adams et al. 2000; Eisner et al. 2001; Lieu et al. 1998). Conversely, the achievement of good control of asthma symptoms and airflow obstruction from treatment with an inhaled corticosteroid (ICS) lowers the risk for asthma exacerbations in the future (Bateman et al. 2004). It is not known, however, whether the minimum treatment to control symptoms necessarily reduces the risk of exacerbations. Some patients who have few current symptoms or impairment of quality of life may still be at grave risk of severe, even life-threatening exacerbations (Ayres et al. 2004). Finally, little is known about the prevalence of a heightened risk of progressive loss of pulmonary function among patients who have asthma or whether any current treatment can prevent it.The test most used for assessing the risk of future adverse events is spirometry, especially forced expiratory volume in 1 second (FEV_1) expressed as a percent of the predicted value or as a proportion of the forced vital capacity (FVC) or FEV_1/FVC. The need for a simple, easily applied, more accurate test has prompted study of "biomarkers" whose deviations from normal might correlate with the severity of risk. Many biomarkers have been proposed—airway hyperresponsiveness, blood or sputum eosinophils or eosinophilic cationic protein (ECP), fractional exhaled nitric oxide concentration (FeNO), serum immunoglobulin E (IgE), number of positive skin tests, concentration of hydrogen ion, inflammatory mediators, or various metabolites in an exhaled breath condensate (EBC). Few studies, however, have validated or "anchored" assessment of these markers by analyzing their relationship to the rate of adverse events or decline in pulmonary function over time. Further complicating the matter is that the relationship between normalization of a biomarker and normalization of risk of an adverse event may depend on the specific treatment given. What is found true for treatment with an ICS may not be true for treatment with a leuktotriene receptor antagonist (LTRA) or an inhaled long-acting $beta_2$-agonist (LABA), or vice versa.In the future, assessment of a combination of historical features and of biomarkers may allow accurate estimation of the risk of future adverse events, but it must be kept in mind that laboratory tests only indirectly estimate control of risk. In the end, only symptoms, exacerbations, and quality of life over time are the measures of asthma control. Assessment of response to therapy is important, but there is inconsistency about the definition and measurement of "response." In general, response to therapy describes the ease with which adequate control is achieved by therapy. In a randomized controlled trial (RCT) of interventions to achieve asthma control, decreased symptoms, decreased use of short-acting $beta_2$-agonist (SABA) for quick relief, improved functioning, improvement in FEV_1, reduction in exacerbations, fewer ED visits, and decreased side effects from medication were equally weighted to develop a composite score that defines a responder to therapy (Bateman et al. 2004). The investigators observed that a composite definition of a responder correlates with asthma control. In a recent editorial, Stempel and Fuhlbrigge (2005) noted that, in published clinical trials, response to therapy based on pre- or postbronchodilator FEV_1 varied widely in statistical significance, depending on the research design and number of subjects included to attain statistical power. Furthermore, when response is defined solely by FEV_1, it can be influenced by disease activity independent of the intervention. It may be significant to characterize other responses, such as decreased airway responsiveness as measured by the response to methacholine, frequency of exacerbations, and decrease in nighttime awakening. This area of work is currently developing and will be influenced by the outcome measures chosen by researchers conducting intervention studies. Agreement is needed on what clinically significant outcomes characterize response to therapy. Agreement is also needed on the time needed to assess response accurately (Zhang et al. 2002), but this time may vary according to treatment. It will take longer to determine whether a patient has responded to a treatment whose principal benefit is reduction in the rate of exacerbations, such as an anti-IgE monoclonal antibody (Bousquet et al. 2004), than to a treatment that acts as an acute bronchodilator.Another concept closely related to assessing and predicting response to therapy is *resistance to therapy*. Of adult patients who have asthma, approximately 5 percent have poorly controlled asthma, with frequent symptoms and exacerbations despite use of high-dose ICS (Barnes and Woolcock 1998). Little is known about why some patients who have asthma do not respond well to therapy. A high prevalence of comorbidity—such as uncontrolled gastroesophageal reflux disease (GERD), allergic rhinitis, and psychiatric illness—has been described in this population (Heaney et al. 2003). Patients who have a poor response to appropriate therapy require referral to and consultation with an asthma specialist.

Classic spirometry is currently the best way to capture a complete picture of airflow obstruction and lung function, the machines are bulky and generally require supervision. Portable peak flow meters are available but are inconvenient to use. There also exist no portable inexpensive exhaled breath biomarker devices commercially available to simultaneously measure concentrations of multiple chemical biomarkers.

III. Proposed Methodology

The mechanical construction of the asthma hand held device was shown in the figure it's a handy device which can be easily tie with the back bag/hand bag. The air flow chamber was divided in two half's for inhale and exhale, and so in the one end it has the mask for breath with a elastic rope. Each chamber had a manual valve (open in normal) near mask which allows air in unidirectional during inhale/exhale. On the other end it has a bidirectional electronic valve which is controlled by the RENESAS micro controller via the driver circuit. Also a tactile switch was placed in the Manuel valve it identifies the inhale and exhale. The two types of dose feeder had attached in the inhale chamber and its triggers are wired and controlled with RENESAS micro controller. The sensors are placed in the

exhale chamber and its connected with RENESAS micro controller. The controller circuit battery display buzzer is constructed side to the chamber.

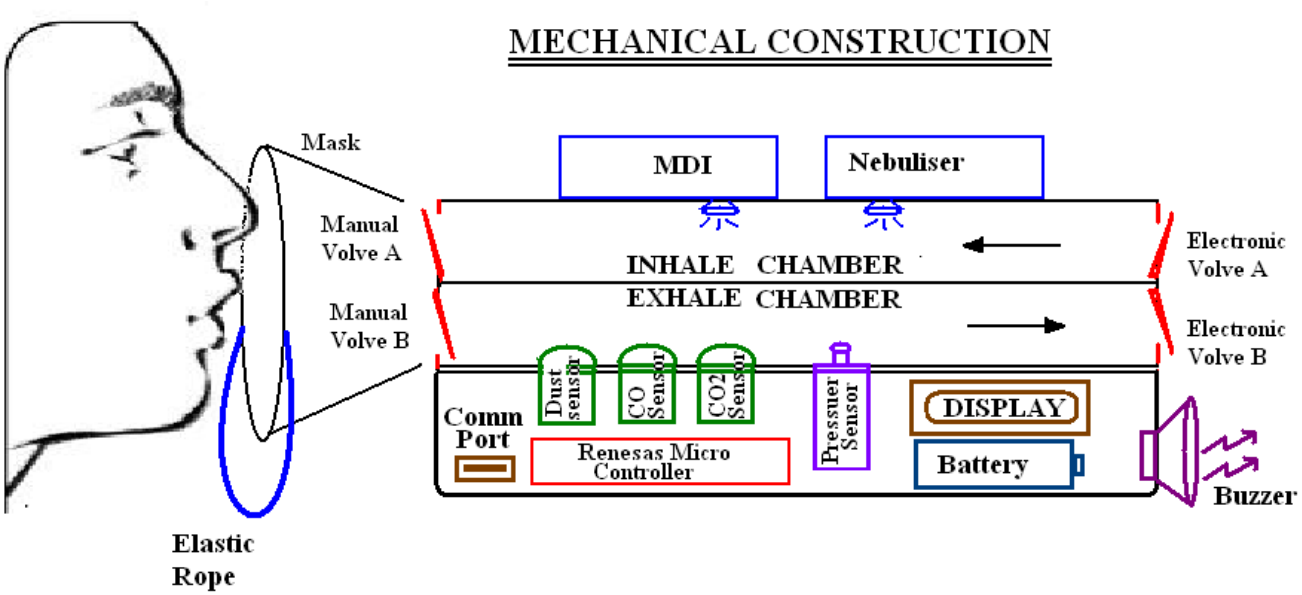

Figure 1. Mechanical Construction of Intelligent Inhaler

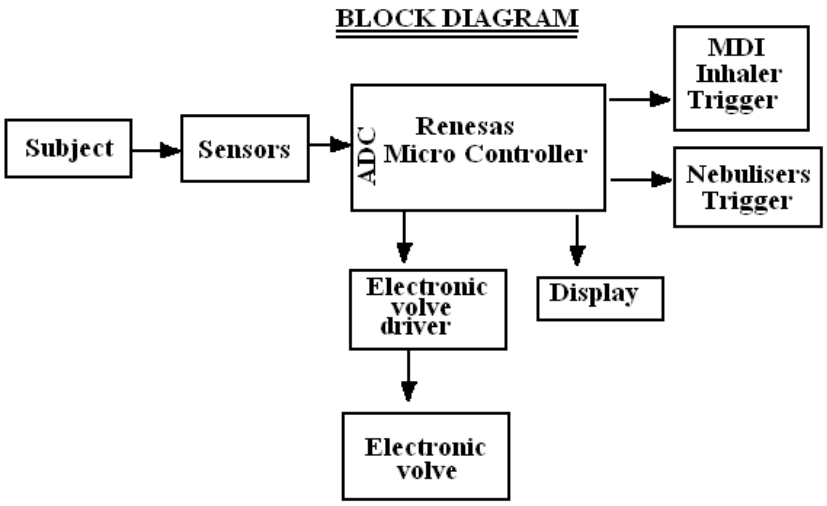

Figure 2. Block Diagram of the Proposed Inhaler

IV. OPERATION

The block diagram of the circuit construction was shown in the below figure. The working function of the device was classified in to three modes, Idle, diagnose and Feed.

A. Idle Mode

It's a battery powered handy device we advice the patient to tie the device with their back bag/hand bag in the open air. In this idle condition the exhale valves are in open, so the free atmosphere air was flown in to it. Basically the controller

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battery operated devices. The controller checks the parameters co2, co, and dust level for a periodic time

intervals if the parameters exceeds the threshold its beeps and warn the patient to leave the that place.

B. Diagnose Mode

Whenever the patient feels wheezing or shortness in breath he/she is advice to were the device in the face, while in the

first exhale the manual valve in the inhale chamber was closed and tactile switch identify this and the diagnose process was started by the RENESAS micro controller(RMC) and also there is push button for start diagnose by force if necessary . The RMC will close the exhale out let electronic valve and measure the pressure and co,co2 gas levels(these connected to RMC ADC pins) for the two/three consequent breathes it identify the patient condition and display the relevant data in the LCD display.

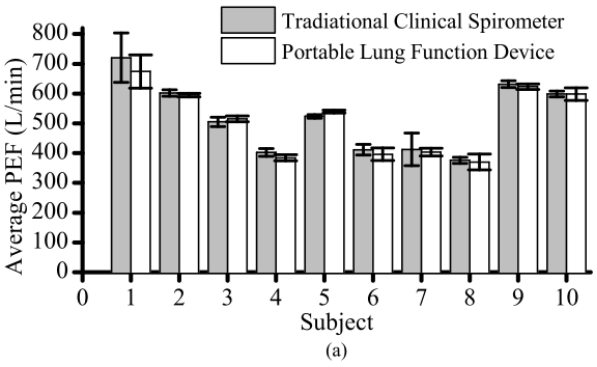
C. Feed Mode

With the diagnosed parameters its know the patient condition weather it's an normal or severe wheezing. Then it's open the exhale electronic valve and close the inhale electronic valve and trigger the MDI dose inhaler in the inhale chamber for the normal wheezing or Nebulizers' for severe wheezing. After the few breaths it's again check the patient condition and do the same until he/she gets good breathing.

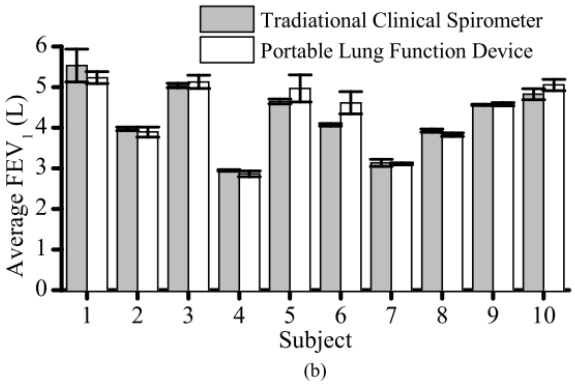
This device records (with time and date) the entire sensor parameters from sensor and results from the diagnose process, feeded dose levels and breath counts. These recorded data's are can be transferred to the PC or any other electronic devices through the RENESAS communication ports.

TABLE 1. Comparison of Asthma Monitoring Device with Clinical Spirometer.

	Subject	Avg from Device (n=3)	Std Dev from Device	Avg from Clinical Spiro-meter (n = 3)	Std Dev from Clinical Spiro-meter	% Error
PEF	1	674.387	56.102	720.600	83.302	6.413
	2	595.135	5.884	601.800	11.031	1.108
	3	515.900	10.097	505.200	15.908	2.118
	4	384.115	10.352	402.800	13.164	4.639
	5	539.630	5.119	523.400	5.574	3.101
	6	396.307	20.744	411.400	17.721	3.669
	7	403.452	12.923	412.600	54.443	2.217
	8	370.357	26.643	376.000	10.569	1.501
	9	623.365	9.073	631.800	10.948	1.335
	10	598.394	21.413	598.800	9.656	0.068
FEV_1	1	5.233	0.147	5.533	0.405	5.422
	2	3.893	0.126	3.970	0.042	1.940
	3	5.129	0.163	5.043	0.055	1.705
	4	2.868	0.071	2.946	0.021	2.648
	5	4.966	0.333	4.646	0.057	6.888
	6[a]	4.613	0.274	4.070	0.034	13.342
	7	3.114	0.023	3.136	0.085	0.702
	8	3.831	0.043	3.926	0.041	2.420
	9	4.577	0.039	4.563	0.015	0.307
	10	5.052	0.138	4.823	0.135	4.748
FEV_6	1	5.575	0.322	6.253	0.260	10.843
	2[b]	4.117	0.127	4.980	0.113	17.329
	3[c]	5.741	0.118	6.593	0.148	12.923
	4	3.272	0.138	3.670	0.010	10.845
	5	5.856	0.373	6.320	0.046	7.342
	6	4.776	0.263	4.836	0.130	1.241
	7	3.628	0.071	3.920	0.052	7.449
	8	4.669	0.121	4.956	0.042	5.791
	9	5.228	0.209	5.763	0.047	9.283
	10	6.348	0.118	6.980	0.056	9.054



(a)



(b)

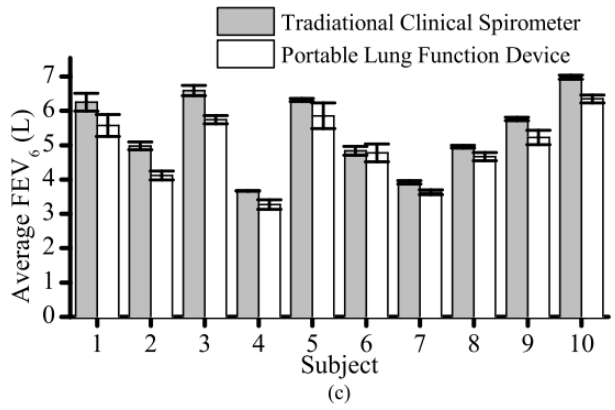


Figure 3 (a) Average PEF values from all subjects using the asthma monitoring device and a clinical spirometer. (b) Average FEV1 values from all subjects using the asthma monitoring device and a clinical spirometer. (c) Average FEV6 values from all subjects using the asthma monitoring device and a clinical spirometer.

V. CONCLUSION AND FUTURE WORK

It's a complete handy device for the asthma patients which helps their everyday survival. This device can be used by personal, hospital and so especially in ambulance. In this device the warning, diagnose, feed and communication everything was controlled through the single RENESAS controller. It's a battery operated system so no need of external power sources also it's long lost because of RENESAS low power technology. It records the all data's and they are easily transfer to the other electronic devices which helps the doctors to know the history of the patient which helps them for the further treatment.

The device can be enhanced with oximetry (to measure oxygen dissolve in blood) and digital stethoscope /micro phone (record the chest sound) sensors which helps and increase the accuracy of the diagnose process in the severe condition. Also it can be implemented with the communication device like GSM/GPRS to send the data directly to the hospital severs and its alerts the patient's relatives when patient in severe condition.

ACKNOWLEDGEMENT

The authors wish to thank Mr. P. Palaniraj, Research Scholar at Anamalai University, for his contributions towards the work.

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