

# Smart Phone Based Toco Transducer and Tocodynamometer



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Projects that Matter  
Design Competition  
&  
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Competition

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## Table of Contents

<b>Introduction</b>	<b>2</b>
Problem definition	2
Impact in developing world	2
<b>Background Knowledge</b>	<b>3</b>
Theory of Uterine Contraction	3
Theory of Tocodynamometer	4
Current Device	4
<b>Design Techniques</b>	<b>5</b>
Required performance specifications	5
Implementation of prototype	7
Proof of Performance	unfinished
<b>Business plan for manufacture and distribution of technology</b>	<b>unfinished</b>
<b>Reference</b>	<b>10</b>

## Table of Figures

- Figure 2. Basic contraction patterns during uterine activity (Sandy Warner, 2011)
- Figure 3. Multiphasic contraction due to over saturation of oxytocin receptor sites. There are coupling or tripling constructive wave occurs (Sandy Warner, 2011)
- Figure 4. Philips Smart Transducer Family, different generation of Toco transducer
- Figure 5. Grafco Toco transducer specifications
- Figure 6. Philips/PH Fetal Monitoring – Series 50XM Toco transducer specifications
- Figure 7. Performance of Smartphone On-Board Accelerometers For Recording Activity (Jared D. Sieling and Jon K. Moon, PhD; MEI Research, Ltd)
- Figure 8. Our TOCO APP
- Figure 9. APP start page
- Figure 10. APP main page
- Figure 11. APP data page

## **1. Introduction**

### **1-1. Problem definition**

EWB statement of Tocodynamometer:

*“The tocodynamometer is a component of external monitoring in childbirth. The goal of this project is to use a smart phone with a built-in accelerometer and a software application to act as a toco transducer and recording tocodynamometer. The device would be used to record the duration of uterine contractions and the duration between them”* (Projects that matter, 2013).

Uterine contraction pattern is an essential bio-signal that should be frequently monitored and recorded during laboring. Tocodynamometer is one of the investigated items of pregnancy. Normally fetal monitors consist of two important vital factors, one is fetal cardiograph; and, the other one is uterine activity which is currently monitored with Toco transducer.

### **1-2. Impact in Developing world**

Two main deficiencies of developing countries or rural area are “distance” and lack of “resources”. According to the statistics, hospitals or primary medical facilities are unevenly distributed between rural and urban regions. The smart phone based Tocodynamometer that we are developing is to solve the problem of low accessibility of labored health care in resource poor areas. The residents can therefore use this device to receive early notification of laboring and prevent the danger caused by premature births. The cost of smart phone based Tocodynamometer can sufficiently lowered and will be relatively affordable comparing to equipment of fetal monitor. In conclusion, the smart phone based Tocodynamometer offers the long distance labored care with its high portability and low cost.

## **2. Background Knowledge**

### **2-1. Theory of Uterine Activity**

The uterus is a myogenic organ, which is the smooth muscle contained within it is able to contract without nervous or hormonal input (Wray, 1993). Base on the theories, the cyclic depolarization and repolarization of the muscle-cell membranes cause the sequence of contraction

and relaxation of the myometrium (Holger Maul al et, 2003). Basically for labor at term, uterine contractions and cervix dilatation usually precedes due to biomedical changes in the cervical connective tissue. One of the importances of constant tracking uterine activities is to recognize preterm labor which defined as labor before 37 weeks of gestation – the most common obstetrical complication – occurs in about 20% of pregnant women (Holger Maul al et, 2003).

## 2-2. Theory of Tocodynamometer

Timing contractions includes frequency, duration, and intensity three components. The beginning of one contraction until next contraction starts is counted as one complete uterine contraction, and the frequency is the measure of how many uterine contractions complete in one second. Furthermore, the duration is to assess the time spending from a beginning of contraction to the end of same contraction. Last, the firmness of contraction is determined as the intensity, which is equivalent to the amplitude of Tocodynamometer. Several terminologies that are used to describe different patterns of uterine activity are Normal, Hypotonus, Hypertonus (Figure 2), Multiphasic-dysfunctional, and Tachysystole. Hypertonus means insufficient relaxation between

contractions. In other word, Uterus does not between each contraction, normally below 20mmHg on the pressure sensor. Moreover, the phenomenon of multiphasic contraction (Figure 3) may be caused by over saturation of uterine oxytocin receptor sites.

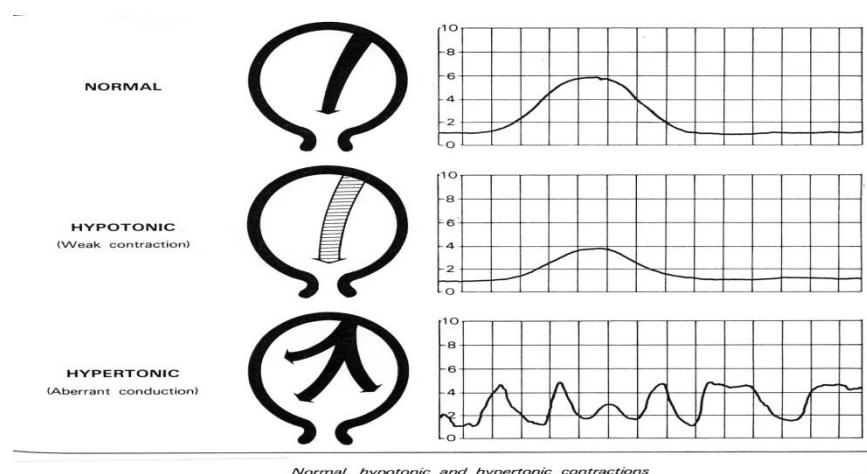


Figure 2. Basic contraction patterns during uterine activity (Sandy Warner, 2011)

Tachysystole is a condition of excessively frequent uterine contractions during pregnancy

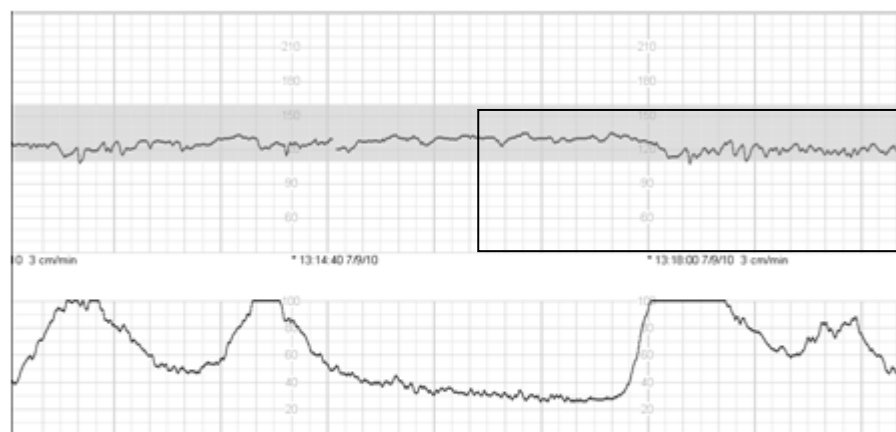


Figure 3. Multiphasic contraction due to over saturation of oxytocin receptor sites - There are coupling or tripling constructive wave occurs. (Sandy Warner, 2011)

It normally defined as 6 contractions in a 10 minutes period. To restate the uterine hypertonus is described as a single contraction lasting longer than 2 minutes. Uterine hyperstimulation is when either condition leads to a nonreassuring fetal

heart rate pattern (Strasser SM, 2009).

## 2-3. Current Device

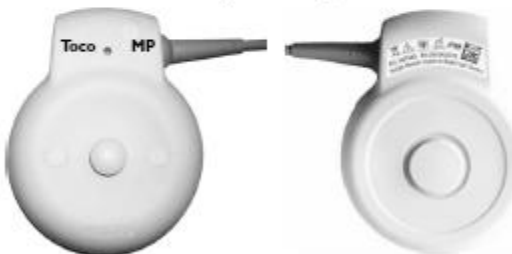
### I. Philips Avalon Fetal Monitoring – Avalon Smart Transducers

#### The Smart Transducer Family

**Toco Transducer (M2734A)**



**Toco MP Transducer (M2734B)**



**Figure 4. Philips Smart Transducer Family, different generation of Toco transducer**

### II. Grafc0 Fetal Monitoring

#### Grafc0 - Specification

Contraction (External TOCO)	TOCO Range: 0% - 100%, 135g strength corresponding to 100%
	Sensitivity: 3.7uV/V/mmHg
	Non-linear Error: $\leq \pm 10\%$
	Resolution: 1%
	Zero Mode: Automatic / Manual
	Earth Leakage Current: <10 uA @ 264 VAC applied to transducer
	Dielectric Strength: >4000 Vrms
TOCO Transducer	System: Passive strain gauge
	Weight: .33 lb (150g)
	Cable Length: 98 in. (2.5m)
	Dimensions: 4.0 x 2.0 in. (102 x 50 mm)
	Latex free



**Figure 5. Graeco Toco transducer specifications**

### III. Philips/PH Fetal Monitoring – Series 50XM

frequency band 1 to 40 Hz. The toco channel has a sensitivity of  $40 \mu\text{V} / \text{V} / \text{mmHg}$ , and by using high sensitivity transducer, it can be  $5 \mu\text{V} / \text{V} / \text{mmHg}$ . The strain gauge transducer is excited with  $0.25 \text{ V}_{\text{rms}}$  for  $40 \mu\text{V} / \text{V} / \text{mmHg}$  at 2.4 kHz. The frequency response of this channel is  $3 \text{ Hz} \pm 0.5 \text{ Hz}$ .

## PHILIPS/HP® SERIES 50XM INTRAPARTUM FETAL MONITOR

- Fully integrated fetal and maternal monitoring system
- For use with high risk patients or patients receiving anesthesia during labor and delivery



Typical Manufacturer's Picture

**Figure 6. Philips/PH Fetal Monitoring – Series 50XM Toco transducer specifications**

## 3. Design Techniques

### 3-1. Required performance specifications

#### Accelerometer:

The implementation of the hardware and software for each make and model lead to different characteristics of accelerometer signals, even with the same accelerometer chip. The table summarizes results of testing the ActiPal™ application on nine recent model smartphones.

## On-board Accelerometer Performance

Phone	Release Date	Clock Freq.	Max Accel Rate	Thres -hold	Interval Std. Dev
htc Nexus One	01/2010	800 MHz	50 Hz	No	9 ms
Samsung Galaxy S	06/2010	1 GHz	20 Hz	No	8 ms
Motorola Droid X	07/2010	1 GHz	125 Hz	Yes	12 ms
Motorola Dely	11/2010	800 MHz	40 Hz	Yes	22 ms
htc Thunderbolt	03/2011	1 GHz	100 Hz	No	7 ms
Samsung Nexus S	05/2011	1 GHz	20 Hz	No	5 ms
htc EVO	06/2011	800 MHz	50 Hz	Yes	8 ms
Motorola Droid 3	07/2011	1 GHz	125 Hz	Yes	8 ms
Motorola Bionic	09/2011	1 GHz	125 Hz	Yes	9 ms

**Figure 7.** Performance of Smartphone On-Board Accelerometers For Recording Activity  
Jared D. Sieling and Jon K. Moon, PhD; MEI Research, Ltd

There are some specification for smartphone. If it want to suit for our device, portability and ease of use are important. Smartphone contain a tri-axial accelerometer and numerous other sensors that collect objective data. Other than Android, the systems are limit access to sensors and background operations.

The various sizes, weights, and preferences people have for carrying phones lead to very different mechanical coupling with the body.

	Samsung Galaxy S III	hTC ONE X	hTC J	Sony Xperia V	Sony Xperia T
Size(mm)	136.6 × 70.6 × 8.6	134.4 × 69.9 × 8.9	131.5 × 66 × 9.95	129 × 65 × 10.7	129.4 × 67.3 × 9.4
Weight(g)	133	130	137	120	139
CPU	SAMSUNG Exynos 4212 1.4 GHz Quad Core	NVIDIA Tegra 3 1.5GHz Quad Core	Qualcomm MSM8660A 1.5GHz Dual Core	Qualcomm S4 MSM8960 1.5GHz Dual Core	Qualcomm S4 MSM8260-A 1.5GHz Dual Core
RAM	2GB	1GB	1GB	1GB	1GB
System	Android 4.0.4	Android 4.0.4	Android 4.0.4	Android 4.0.4	Android 4.0.4
Internal storage(GB)	16 / 32	16 / 32	16	8	16

### 3-2. Implementation of prototype



**Figure 8.**Our TOCO APP



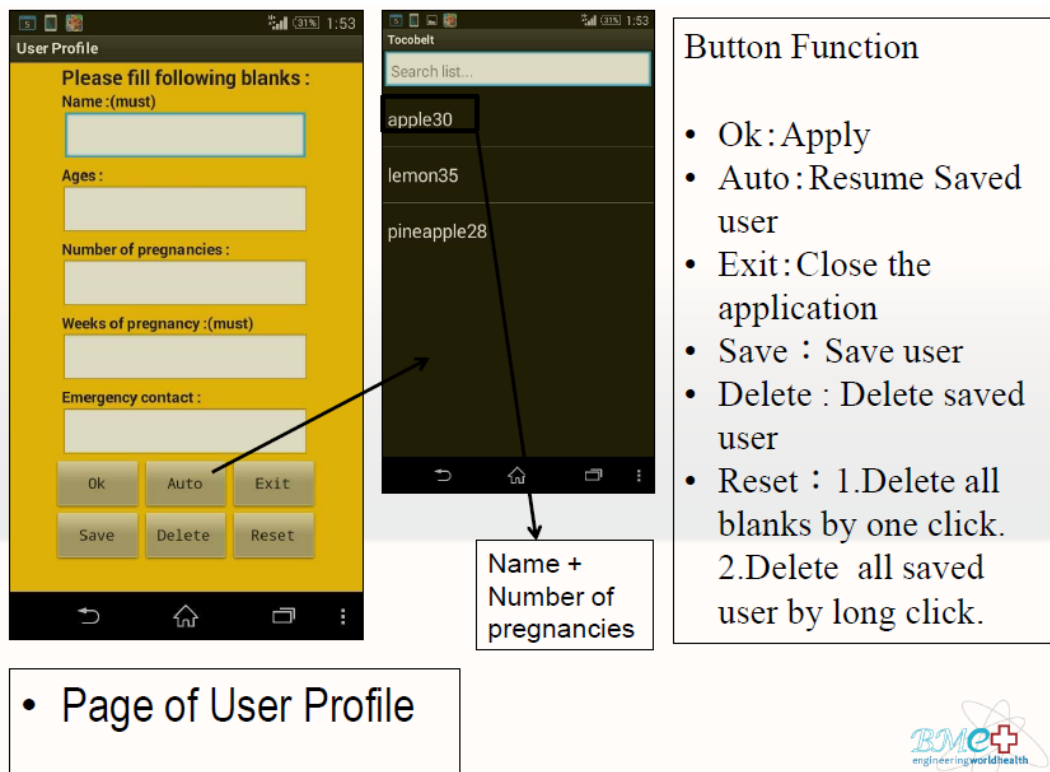


Figure 9.APP start page

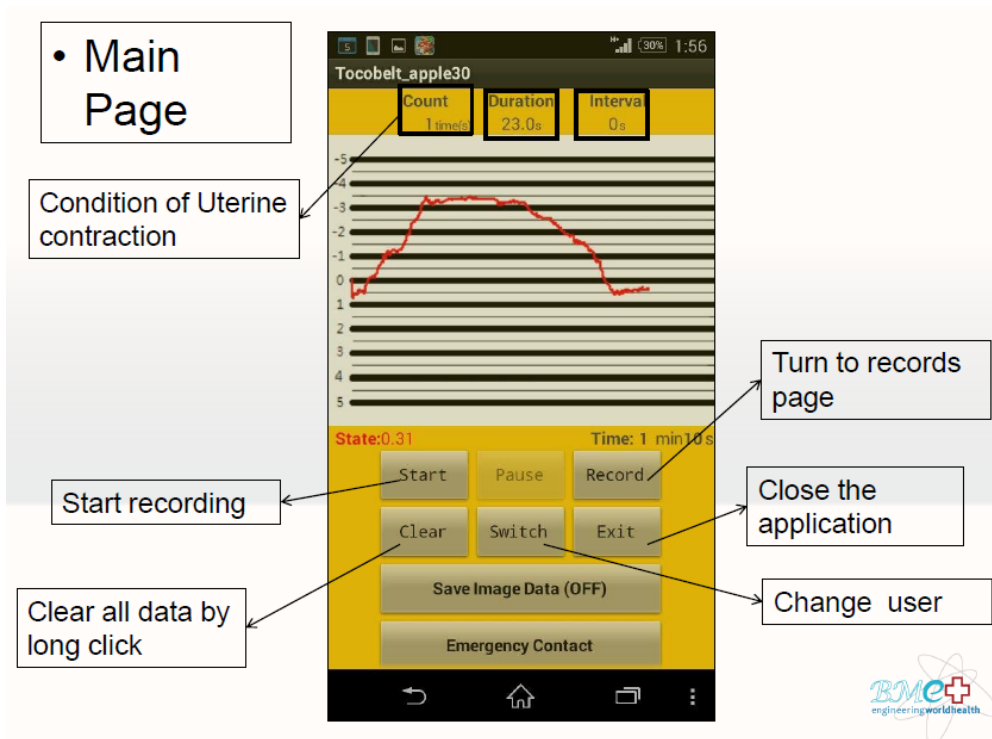
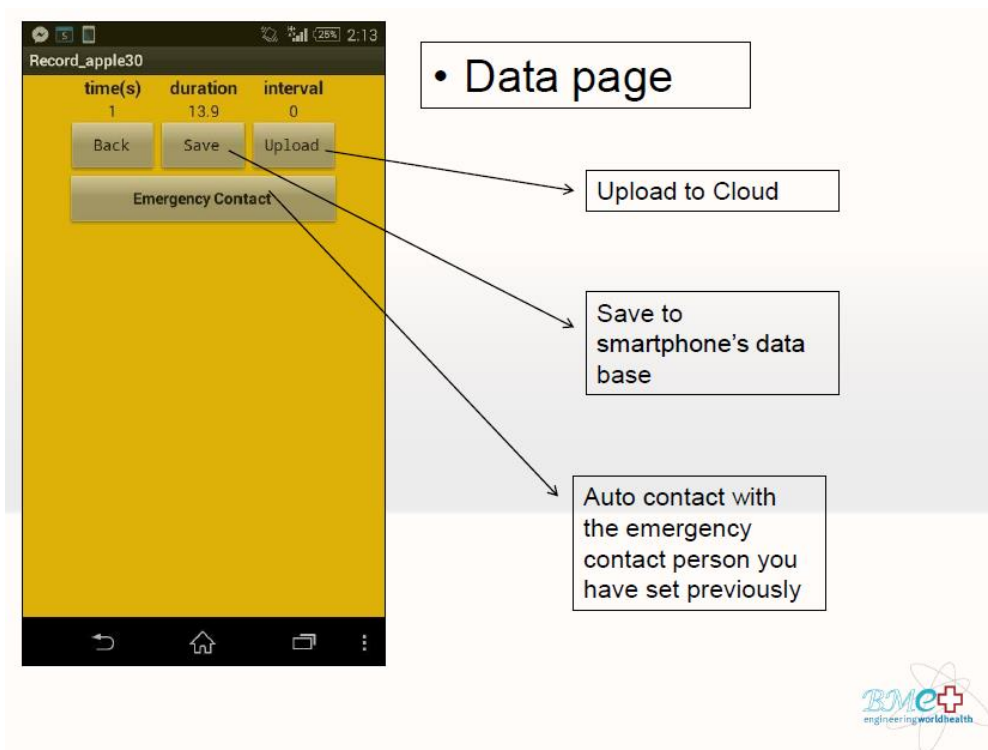


Figure 10.APP main page



**Figure 11.APP data page**

## Reference

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- [4] Holger Maul et al, 2013, The physiology of Uterine Contractions, Clinics in Perinatology,