Peaceful Pillow

Team 6

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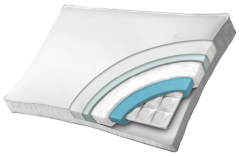
Problem Statement:

The purpose of our project is to create a comfortable device to help educate sleepers of their sleeping habits and gently wake them. The device will enable its users to gain valuable information about their sleeping patterns while asleep.

Benchmarking Related Solutions:

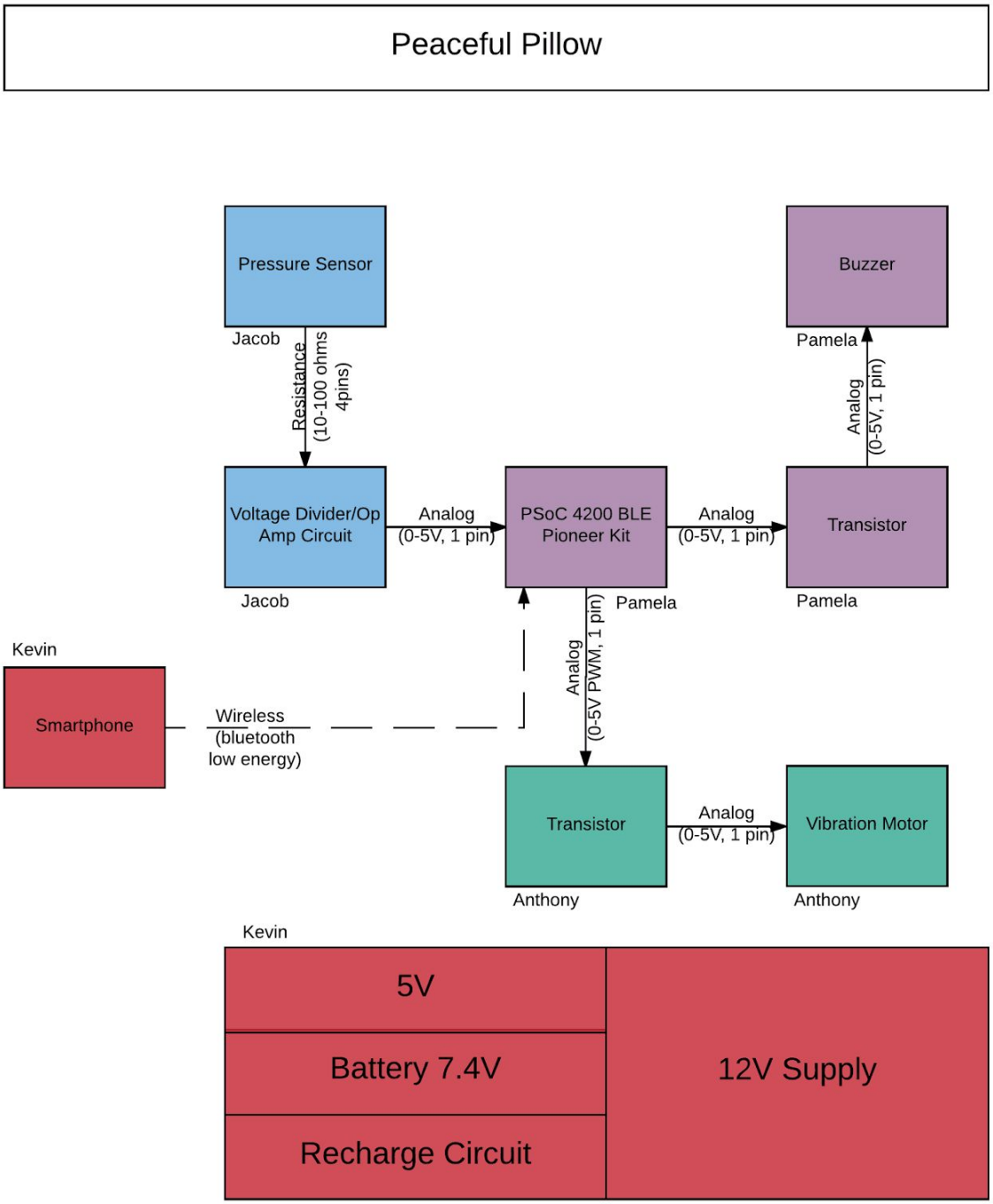
Solution	Description	Pros	Cons
iComfort Hybrid Triple Effects Pillow ($109) 	The iComfort Pillow solves the problem of poor sleep by providing pressure point relief where needed, supports proper body alignment despite your sleeping angle, and regulates body temperature.	• Adaptive • Simple • Comfortable	• Expensive • Doesn't give feedback • Works best with the same brand mattress
Oittm Smart Pillow Mat ($25.99) 	The Oittm Smart Pillow Mat solves the problem of poor sleeping by playing music to aid sleeping from the user's smartphone, tracking the user's sleep patterns, and coordinating an alarm with the user's sleep patterns to awake them at the ideal time.	• Numerous features (alarm, music, and tracking) • Integrated sensors and speakers	• Wired connection to smartphone • Must be placed under existing pillow (separate purchase)
Somnox (499 Euro, 597.73 US) 	Somnox simulates human breathing, is able to identify sleep cycles, play music and gently wake the user.	• Eases anxiety • Bluetooth enabled • data collection	• Expensive • Limited quantity release
Sleep Cycle alarm clock App ($29.99 for 1 year premium) 	This app has your phone track your sleep states by using sound analysis to track movements during sleep. It will wake you up slowly during your lightest sleep phase.	• Low risk of harm to the user (no physical contact between phone and user). • Being slowly woken during lightest sleep phase means there is no sudden disturbance.	• Does not have in depth analysis of sleeping behaviors. • Does not have a timer for waking up at specific times.
Sleep as Android (free app) 	Sleep as Android solves the problem of waking up in the morning by playing an alarm while the user is sleeping lightly and then verifies the user has woken up by making the user complete a short puzzle to disable to alarm.	• Free • Verifies wakeup • Smart alarm goes off at optimal time	• Requires placing phone on bed • Additional purchases

Criteria and Constraints:

Criteria	Threshold *(Halt & Review)*	Target Goal *(Plan of Record)*	Stretch Goal *(Design Stop)*	Rationale
Cr-1: Variable audio alarm	>40db, <100db	80 db +- 30	80db +-60	Awake user gently (goldilocks)
Cr-2: Measure sleeping	Detect presence/absence of head Sensitivity: +/-10lbs	Detect rolling Sensitivity: +/-5lbs	Detect all movements +/- 0.5lbs	Measure user's soundness of sleeping based on head movement
Cr-3: Battery Life	12 hr battery	24 hr battery	168 hr battery	Stay powered through the night with no cords
Cr-4: Number of pressure sensor collection samples	2 samples	10 samples	100 samples	Track user's sleep cycle
Cr-5: Accuracy of keeping track of time	+/- 1 min	+/- 1 second	+/.1 second	Know how long the user is sleeping and what time it is
Cr-6: Size of entire unit	8" x 10" x 4"	6" x 8" x 3"	6" x 4" x 2"	We don't want the box to be too big and make the user's sleep uncomfortable

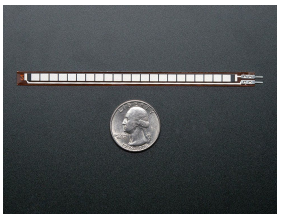
Constraints	Threshold *(Halt & Review)*	Target Goal *(Plan of Record)*	Stretch Goal *(Design Stop)*	Rationale
Co-1: Stay cool (components)	<110 degrees F	<90 degrees F	<80 degrees F	Project specific
Co-2: Material, (flame retardant)	<50 degrees F	>/= 100 degrees F	>= 200 Degrees F	Project specific
Co-3: Pillow Size	28”L x 16”W x 6”H	22”L x 14”W x 4”H	18”L x 12”W x 4”H	Project specific
Co-4: Prototype budget	<$160	$80	$40	Defined by professors
Co-5: Power supply (AC adapter, battery, or solar panel connected to voltage regulator. No USB power packs may be used)	>3.3V	5V	12V	Defined by professors
Co-6: Microcontroller (Cypress Bluetooth® Low Energy (BLE) Pioneer Kit (CY8CKIT-042-BLE-A), PSoC® 4 Pioneer Kit (CY8CKIT-042), and/or Prototyping Kit (CY8CKIT-049-42xx))	>/= 1	1	2	Defined by professors
Co-7: Sensor(s) read by a microcontroller	6	2	1	Defined by professors
Co-8: Actuator(s) controlled by a microcontroller	1	2	4	Defined by professors
Co-9: Bluetooth Low Energy communications to a phone, computer, or another device using a Cypress BLE Pioneer Kit	1-way communication with max range 5 ft	1-way communication with max range of 10 ft	2-way communication with max range of 10 ft	Defined by professors
Co-10: Custom printed circuit board ● Must be created in Cadence ● No commercial boards	1	2	3	Defined by professors
Co-11: Surface mount components ● Size 0805 or larger recommended	0	6	100	Defined by professors
Co-12: Programmed in C or C++	Programmed in C	Programmed in C	Programmed in C	Defined by professors

Current Design



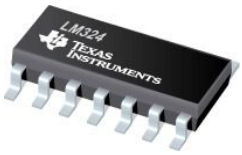
Major Component Selections

Pressure Sensor

Solution	Pros	Cons
Flex Sensor 	• Works with softer pillows • Can be placed off to side • Wide range of supply voltages	• Smaller • Requires more sensors to cover pillow • More expensive

Rationale: Flex sensors will be easier to embed in the pillow because they can be distributed throughout our pillow to measure different locations. This will be useful for detecting movement of the user. They will also sensitive since they measure deformation rather than force.

Sensor Op Amp Circuit

Solution	Pros	Cons
LM324 4 channel Op Amp 	• Recommended by flex sensor data sheet • 4 channels • Wide supply voltage range	• Medium-small package size • More expensive • Lower frequency band

Rationale: This is the best because it allows for more advanced customization since it includes 4 operational amplifiers allowing us to use more flex sensors in our pillow. This was recommended by the flex sensor data sheet, so it will be compatible with our sensor.

Buzzer

Solution	Pros	Cons
Siren 	• Quality datasheet • Simple - no audio file • No Op-Amp required • 4000 Hz freq	• Price per unit • Transistor required • Limited control of volume

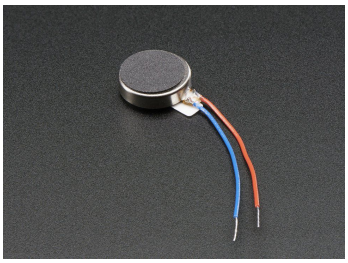
Rationale: This the best choice for sound emission. The siren does not require any audio file which makes it simpler to code. The compact size of the siren allows it to be surface mounted.

Transistor

Solution	Pros	Cons
TIP31C TRANS NPN 100V 3A TO-220 	• Excellent datasheet • Comparable to recommended part for siren • VCEO - 45V	• Collector cut-off of 0.1 μA • IC 100 mA • Surface mount

Rationale: This is the best choice to handle the current required to pass through the transistor to the buzzer/motor. Although option one has a higher per unit cost, the benefits will outweigh the costs and is comparable to the recommended transistor from the buzzers datasheet.

Vibration Motor

Solution	Pros	Cons
Vibration Motor 	• 2-5V • Light • Cheap • Explanation for use with transistor	• No official datasheet • No test data • No part number

Rationale: While this motor doesn't have a detailed datasheet all of the information needed is provided via the adafruit website. This motor also will operate on the 5V power rail that we have decided to use and is very powerful for its size.

Peaceful Pillow Power Budget

Team Number: 6	Team Members: Jacob Knaup, Kevin Lam, Pamela Lombardi, Anthony Spencer	Project Name: Peaceful Pillow	Version: 1

1. List major components

Component Name	Part Number	Supply Voltage Range	Quantity	Absolute Maximum Current (mA)	Total Current (mA)	
Op Amp	LM324	3.0-32V	1	60	60	mA
Buzzer	CMT-8540S-SMT-TR	1-6 V	1	150	150	mA
Vibration Motor	1201	2V-5V	3	100	300	mA
PSoC™ 4 BLE Module	CY8CKIT-042-BLE	3.3V/5V	1	200	200	mA
5V Regulator	MC7805	5-18 V	1	2200	1000	mA

2. Assign major components to power rails. Try to minimize the number of power rails necessary. Add additional voltage rails if needed.

5V Power Rail

Component Name	Part Number	Supply Voltage Range	Quantity	Absolute Maximum Current (mA)	Total Current (mA)	
PSoC™ 4 BLE Module	CY8CKIT-042-BLE	3.3V/5V	1	200	200	mA
Op Amp	LM324	3.0-32V	1	60	60	mA
Vibration Motor	1201	2V-5V	3	100	300	mA
Buzzer	CMT-8540S-SMT-TR	1-6 V	1	150	150	mA
				Subtotal	710	mA
				Safety Margin	25%	
5V Regulator			***Total Current Required on 5V Rail***		887.5	mA
5V Regulator	ADP3338	2.7-8 V	1	1000	1000	mA

3. Calculate Power Supply Requirements

Component Name	Part Number	Supply Voltage Range	Quantity	Absolute Maximum Current (mA)	Total Current (mA)	
5V Regulator	ADP3338	2.7-8 V	1	1000	1000	mA

Power Supply Selection

12V Power Supply

Solution	Pros	Cons
VEL18 Series 	• Easy to use • Good voltage output • Can plug into wall	• Limited input voltage • Single output • Output voltage options limited

Rationale: This has just enough current output and works with our battery charger, also can be plugged into wall, so it is easy to use.

3.3-12V Battery

Solution	Pros	Cons
7.4V lithium ion battery 	• Safe from fire and leakage • Easy to find charger • Easy to use	• Needs its own special charger • Expensive • Poor data sheet

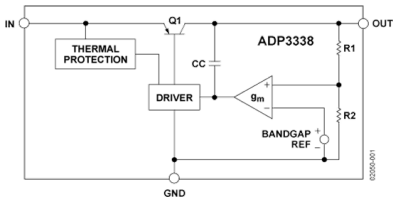
Rationale:This is the best choice for the battery, because not only is this battery smaller but so is the charger, and there is more voltage.

Recharge Circuit

Solution	Pros	Cons
B6 LiPro Balance Charger 	• Safe • Ease of use • Not bulky	• Expensive • Fragile • Lots of settings

Rationale: This is the best choice because using this charger is a simple process and there are not many parts to worry about.

5V Regulator

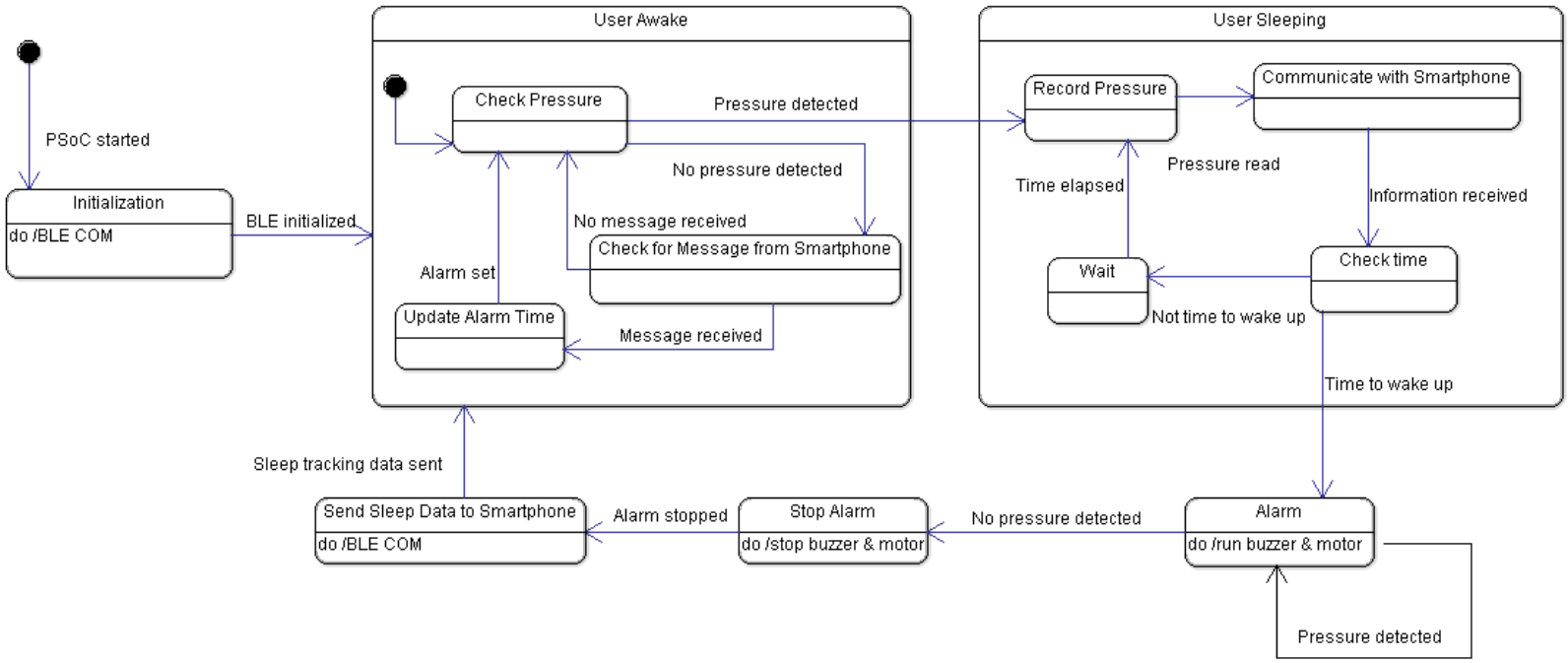
Solution	Pros	Cons
MC7805 	• High current (2.2 A) • 5V output • Large input range	• Lower Temperature Range • Lower Output Range

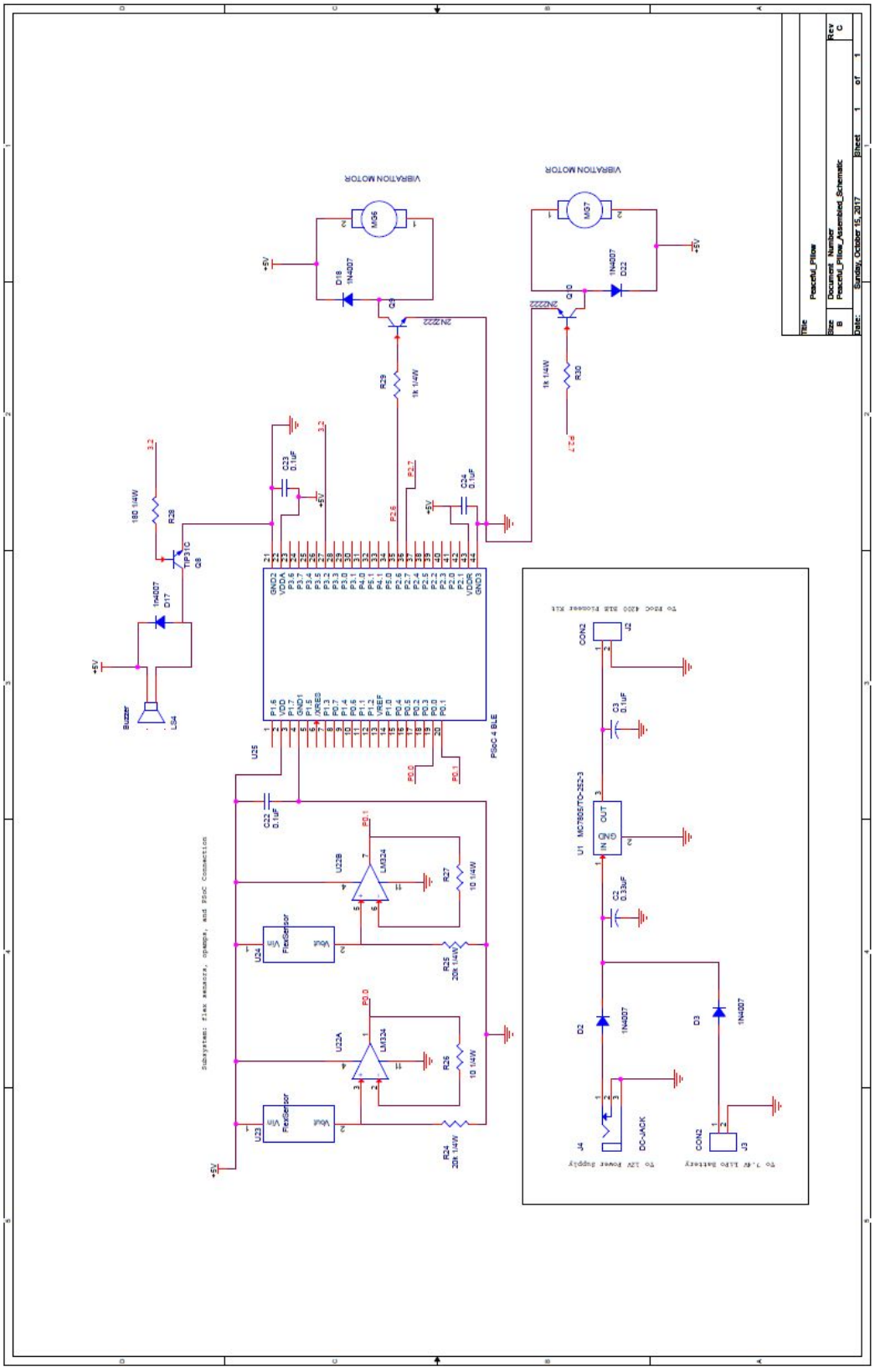
Rationale:This choice provides a higher maximum output current, which will be a useful precaution to ensure we can source enough current to run all of our components at once. Although it has a lower supply voltage range, our battery still fits within this range.

Proof of Major Parts

Team 6: Peaceful Pillow; Jacob Knaup, Kevin Lam, Pamela Lombardi, Anthony Spencer; Version:1

Part Name/Description	Unit Quantity	Unit Prototype Cost	Total Prototype Cost	Unit Production Cost	Total Production Cost	Manufacturer	Manufacturer Part #	Supplier	Supplier Part #	# Ordered	Date Ordered	# Received	Surplus	Schematic Reference Designators
VEL18US120 - 12V Power Supply	1	$12.75	$12.75	$12.75	$12.75	XP Power	VEL18US120-US-JA	Digi-Key	1470-3157-ND	1	9/22/2017	1	-1	
Lithium Ion Battery - 2200 mAh 7.4V	1	$15.95	$15.95	$15.95	$15.95	KingMax	RC02269	Sparkfun	PRT-11856	1	9/21/2017	1	-1	
Li-ion/Polymer Battery Charger/Balancer	1	$32.95	$32.95	$32.95	$32.95	iMax	U1B600A113	Sparkfun	PRT-10473	1	9/21/2017	1	-1	
Flex Sensor	2	$12.95	$25.90	$10.36	$20.72	Spectra Symbol	FSL0095103ST	Adafruit	182	3	9/22/2017	2	-2	U23,U24
Vibrating Mini Motor Disc	2	$1.95	$3.90	$1.56	$3.12	Adafruit	1201	Adafruit	1201	4	9/22/2017	2	-2	MG6,MG7
Quadruple Operational Amplifier	1	$0.40	$0.40	$0.16	$0.16	Texas Instruments	LM324AN	Digi-Key	296-9542-5-ND	4	9/22/2017	4	-1	U22
AUDIO MAGNETIC XDCR 1-6V SMD	2	$4.59	$9.18	$2.37	$4.74	CUI Inc	CMT-8540S-SMT-TR	Digi-Key	102-3746-1-ND	2	9/22/2017	2	-2	LS4
PSoC 4 BLE Module	1	$0.00	$0.00	$14.96	$14.96	Cypress	CY8CKIT-143A	PRLTA Lab	PRLTA Lab	1	9/20/2017	2	1	U25
Two Pin Header	4	0.01	$0.04	$0.01	$0.01	PRLTA Lab	PRLTA Lab	PRLTA Lab	Header	2	9/21/2017	2	2	J2,J3,U23,U24
DC Jack	1	0.01	$0.01	$0.01	$0.01	PRLTA Lab	PRLTA Lab	PRLTA Lab	PJ-102A	1		1	1	J4
Resitor 2k Ohm	2	0.01	$0.02	$0.01	$0.01	PRLTA Lab	PRLTA Lab	PRLTA Lab	2k Ohm	2	9/21/2017	2	2	R24,R25
Resitor 10 Ohm	2	0.01	$0.02	$0.01	$0.01	PRLTA Lab	PRLTA Lab	PRLTA Lab	10k Ohm	2	9/21/2017	2	2	R26,R27
Resitor 1k Ohm	2	0.01	$0.01	$0.01	$0.01	PRLTA Lab	PRLTA Lab	PRLTA Lab	1k Ohm	2	9/21/2017	2	2	R28
Resitor 180 Ohm	1	0.01	$0.01	$0.01	$0.01	PRLTA Lab	PRLTA Lab	PRLTA Lab	180 Ohm	1	9/21/2017	1	1	R29,R30
Capacitor 0.33uF	1	0.01	$0.01	$0.01	$0.01	PRLTA Lab	PRLTA Lab	PRLTA Lab	0.33uF	1	9/21/2017	1	1	C2
Capacitor 0.1uF	4	0.01	$0.04	$0.01	$0.01	PRLTA Lab	PRLTA Lab	PRLTA Lab	0.1uF	4	9/21/2017	4	4	C3,C22,C23,C24
Diode	5	0.01	$0.05	$0.01	$0.01	PRLTA Lab	PRLTA Lab	PRLTA Lab	1N4007	5	9/21/2017	5	5	D2,D3,D17,D18,D22
Transistor TIP31C	1	0.01	$0.01	$0.01	$0.01	PRLTA Lab	PRLTA Lab	PRLTA Lab	TIP31C	1	9/21/2017	1	1	Q8
Transistor 2N2222	1	$6.00	$6.00	$6.00	$6.00	Adafruit	PN2222	Adafruit	2n2222	1	10/12/2017	1	1	Q9,Q10
Voltage Regulator	1	0.01	$0.01	$0.01	$0.01	PRLTA Lab	MC7805	PRLTA Lab	LM7805	1	10/12/2017	1	1	U1


User Awake
User Sleeping
PSoC started
Initialization
do /BLE COM
BLE initialized
Check Pressure
Pressure detected
No pressure detected
No message received
Check for Message from Smartphone
Alarm set
Update Alarm Time
Message received
Record Pressure
Communicate with Smartphone
Pressure read
Time elapsed
Information received
Wait
Check time
Not time to wake up
Time to wake up
Sleep tracking data sent
Send Sleep Data to Smartphone
do /BLE COM
Alarm stopped
Stop Alarm
do /stop buzzer & motor
No pressure detected
Alarm
do /run buzzer & motor
Pressure detected


VIBRATION MOTOR
VIBRATION MOTOR
PSoC 4 BLE
Subsystem: flex sensors, opamps, and PSoC Connection
To 12V Power Supply
To 7.4V LiPo Battery
DC-JACK
Buzzer
Title
PeacefulPillow
Size: B
Document Number
PeacefulPillow_Assembled_Schematic
Rev C
Date: Sunday, October 15, 2017
Sheet 1 of 1


AT&T
10:01 AM
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CANCEL
OK