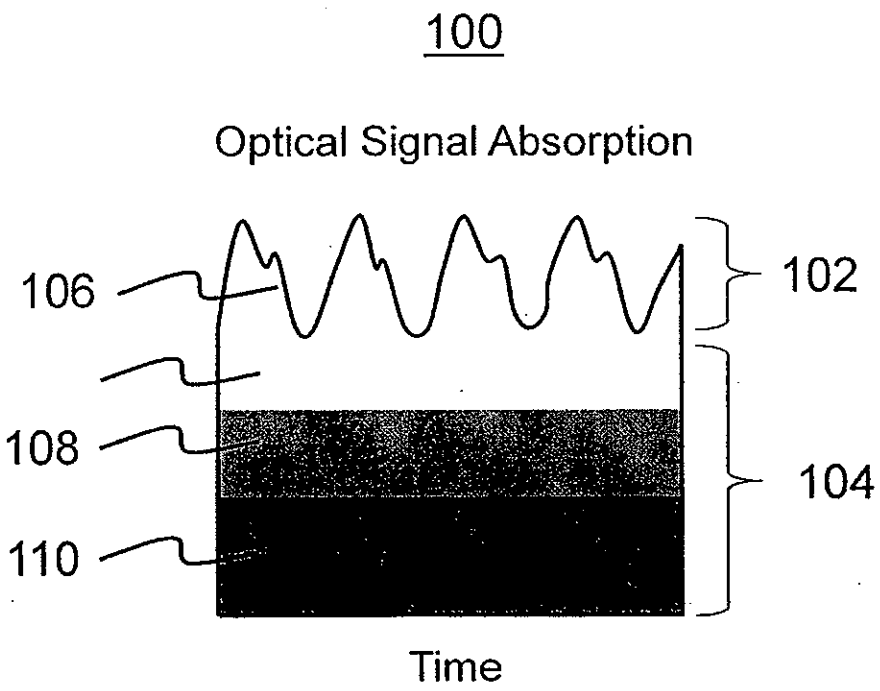


Figure 1

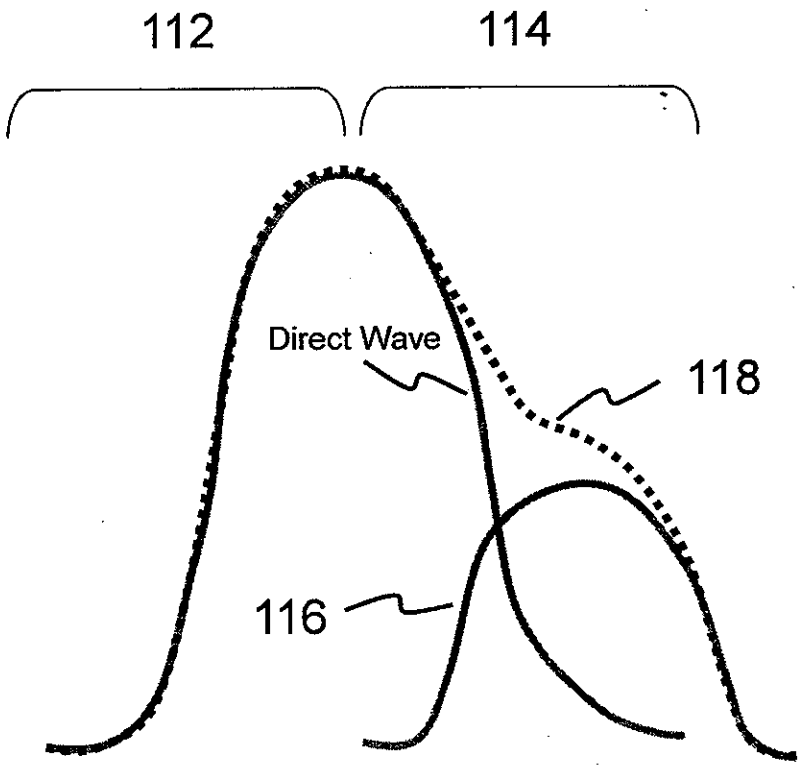


Figure 2

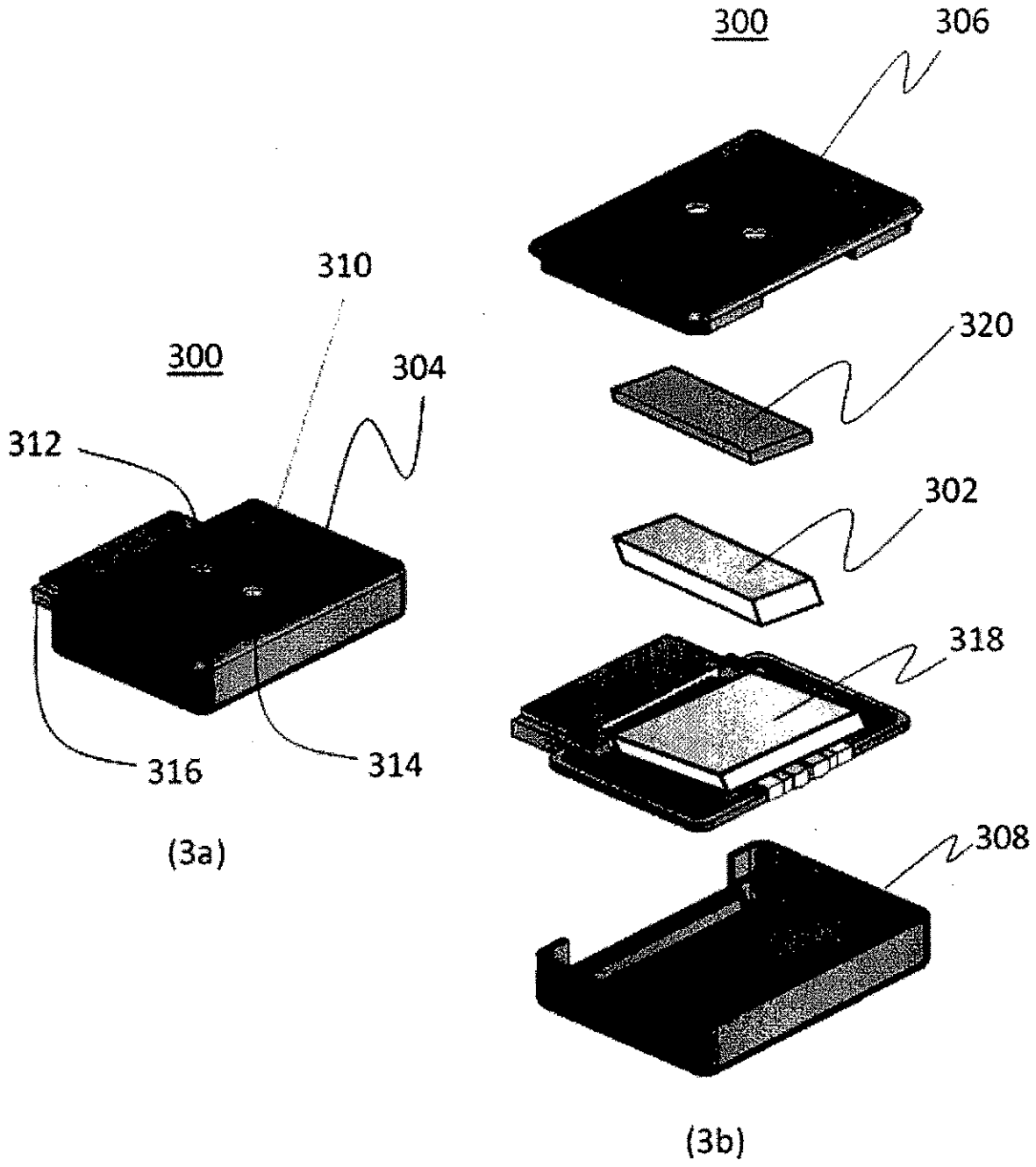


Figure 3

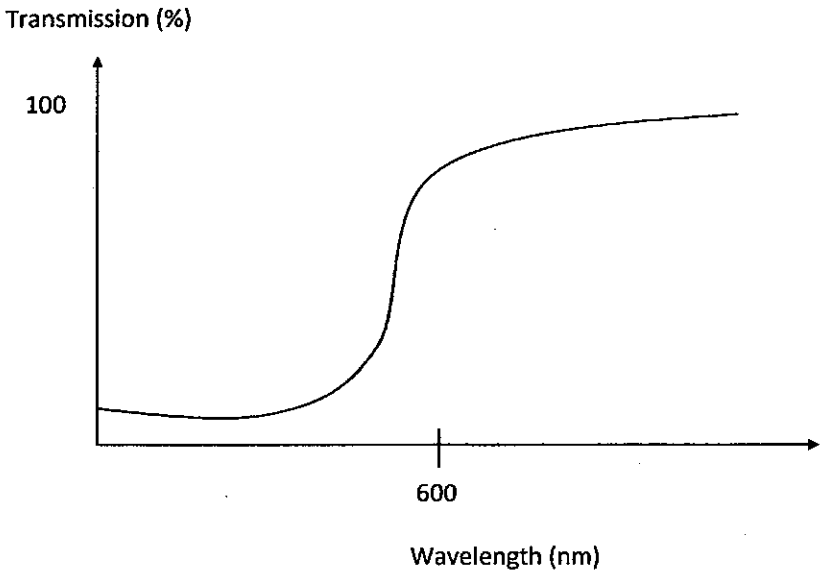


Figure 3 (c)

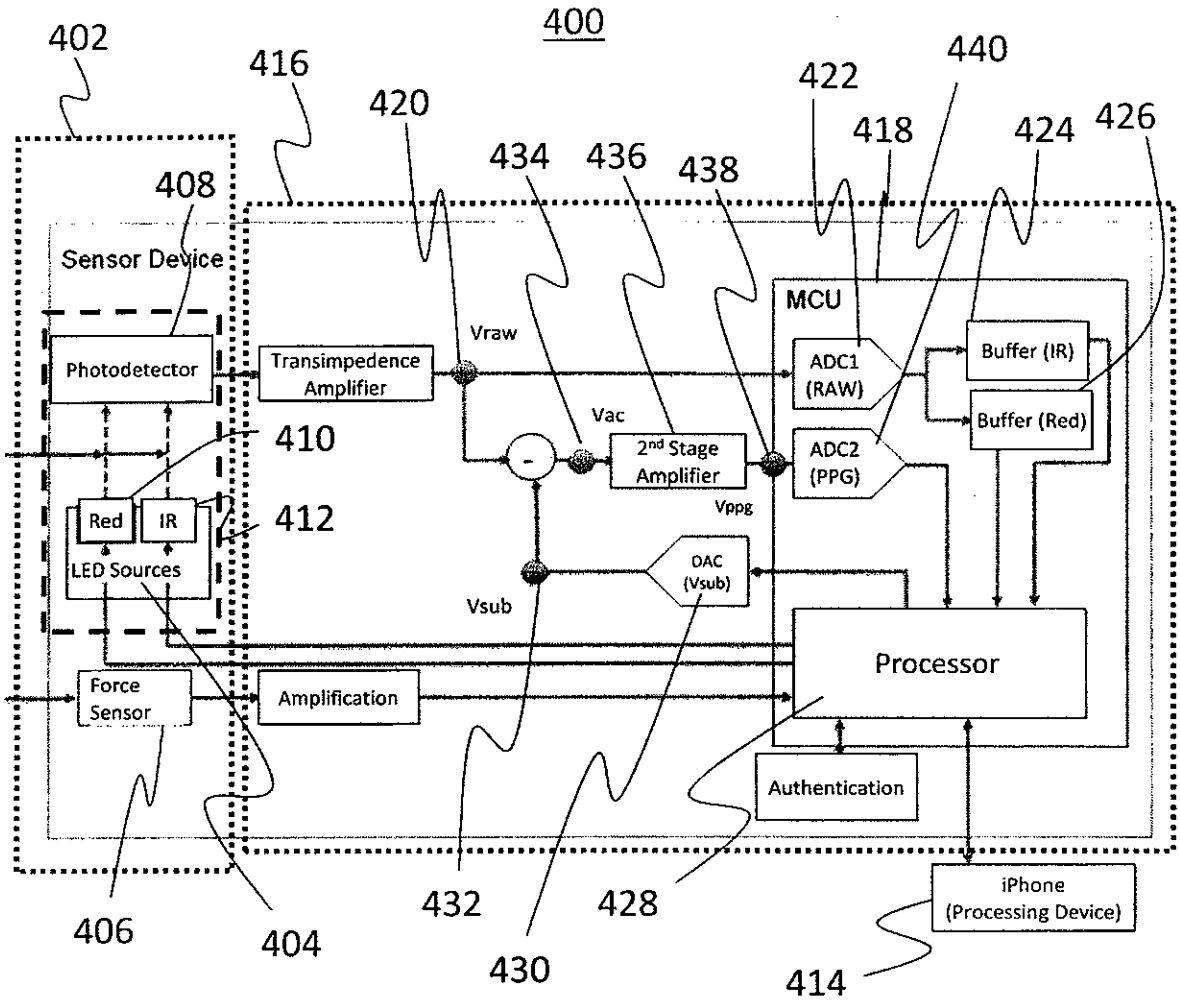

400
402
416
420
422
440
418
424
426
434
436
438
408
Sensor Device
MCU
Photodetector
Transimpedence Amplifier
Vraw
ADC1 (RAW)
Buffer (IR)
Buffer (Red)
Vac
410
2nd Stage Amplifier
ADC2 (PPG)
Vppg
412
Red
IR
LED Sources
DAC (Vsub)
Vsub
Processor
Force Sensor
Amplification
Authentication
iPhone (Processing Device)
406
404
432
428
430
414

Figure 4

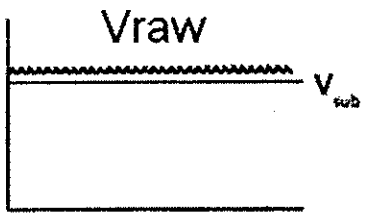


Figure 5(a)

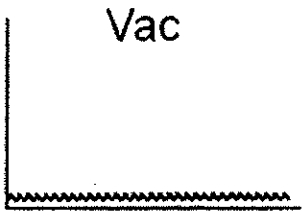


Figure 5(b)

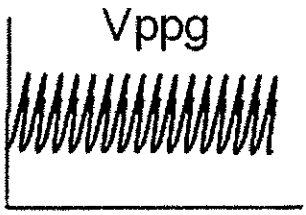


Figure 5(c)

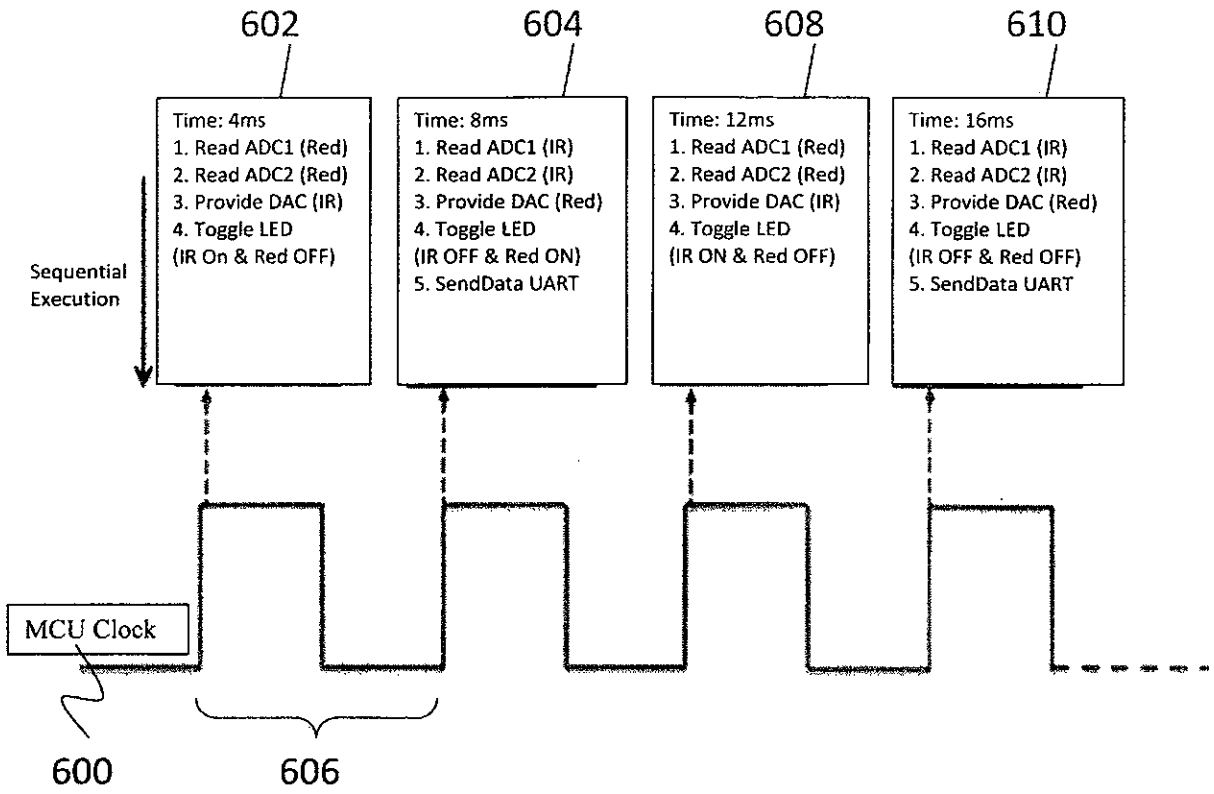

602
604
608
610
Time: 4ms
1. Read ADC1 (Red)
2. Read ADC2 (Red)
3. Provide DAC (IR)
4. Toggle LED
(IR On & Red OFF)
Time: 8ms
1. Read ADC1 (IR)
2. Read ADC2 (IR)
3. Provide DAC (Red)
4. Toggle LED
(IR OFF & Red ON)
5. SendData UART
Time: 12ms
1. Read ADC1 (Red)
2. Read ADC2 (Red)
3. Provide DAC (IR)
4. Toggle LED
(IR ON & Red OFF)
Time: 16ms
1. Read ADC1 (IR)
2. Read ADC2 (IR)
3. Provide DAC (Red)
4. Toggle LED
(IR OFF & Red OFF)
5. SendData UART
Sequential Execution
MCU Clock
600
606

Figure 6

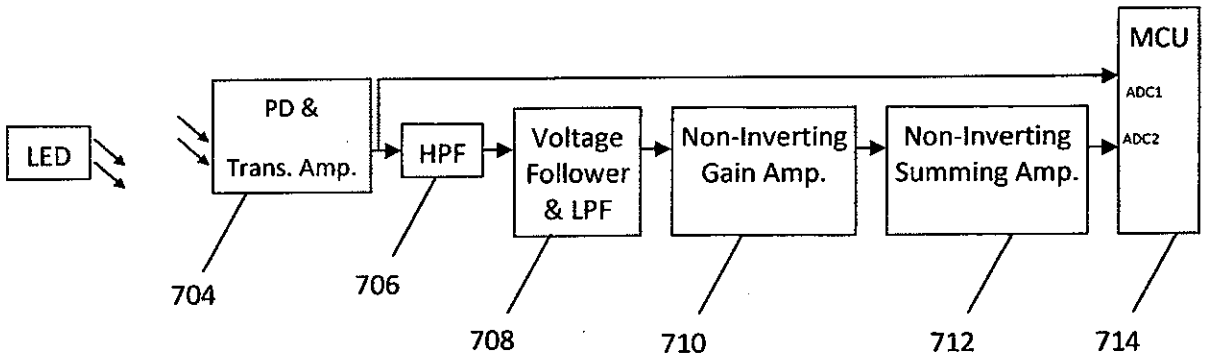

LED
PD &
Trans. Amp.
HPF
Voltage
Follower
& LPF
Non-Inverting
Gain Amp.
Non-Inverting
Summing Amp.
MCU
ADC1
ADC2
704
706
708
710
712
714

Figure 7

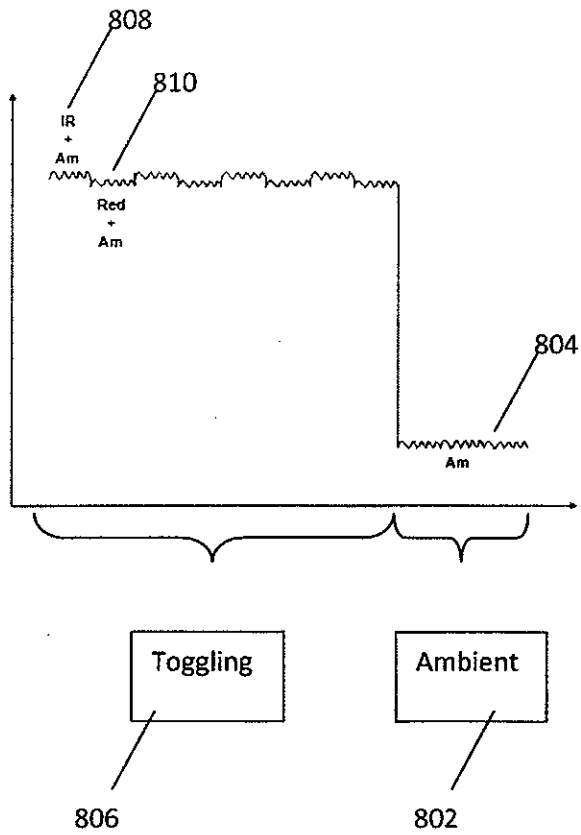


Figure 8

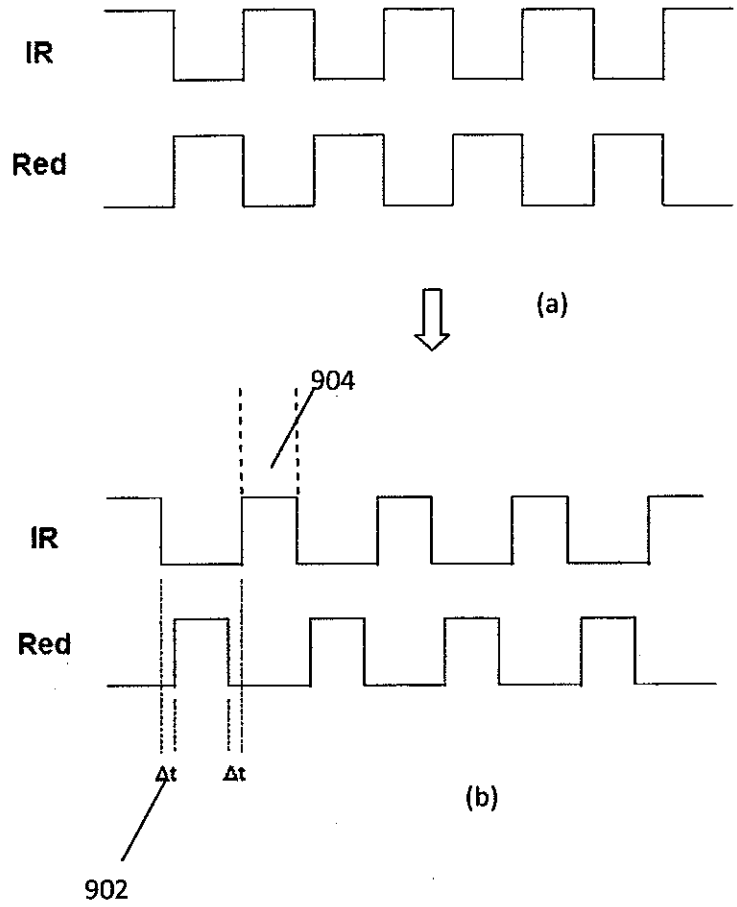


Figure 9

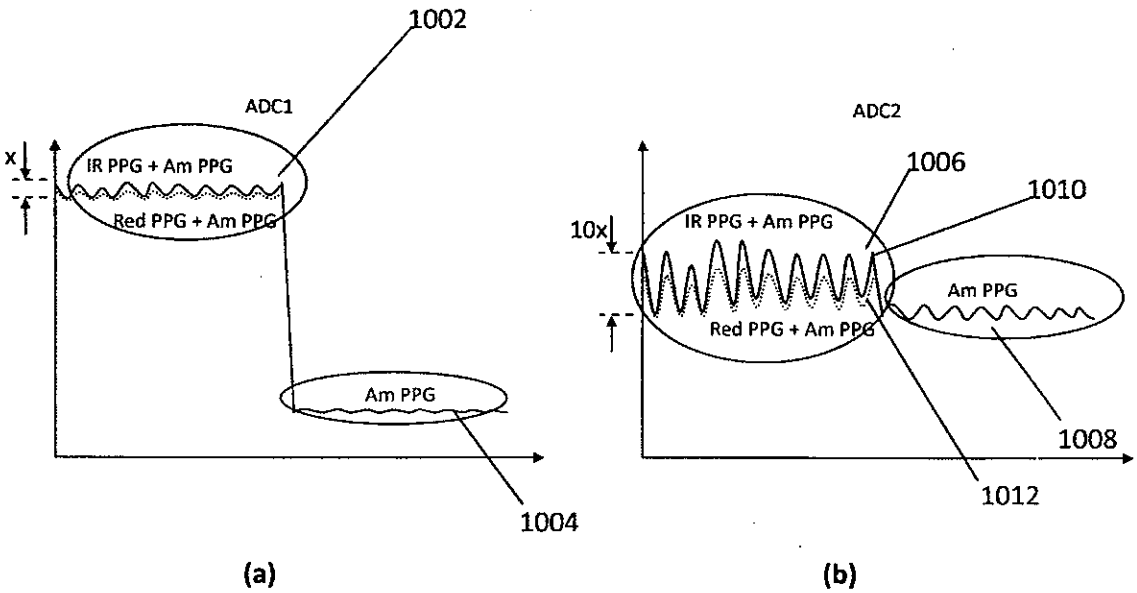

1002
ADC1
X
IR PPG + Am PPG
Red PPG + Am PPG
Am PPG
1004
(a)
ADC2
10x
1006
1010
IR PPG + Am PPG
Red PPG + Am PPG
Am PPG
1008
1012
(b)

Figure 10

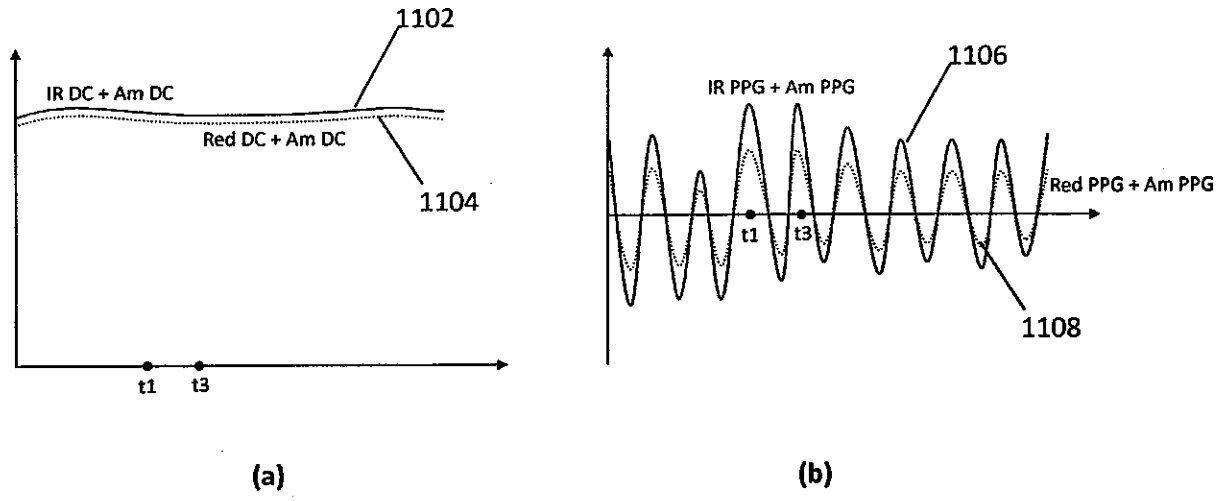

1102
IR DC + Am DC
Red DC + Am DC
1104
t1
t3
(a)
1106
IR PPG + Am PPG
Red PPG + Am PPG
t1
t3
1108
(b)

Figure 11

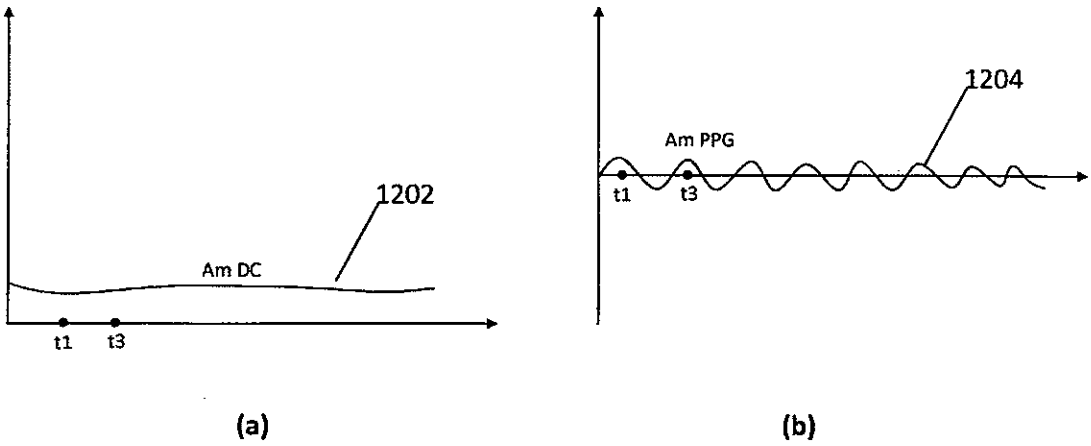


Figure 12

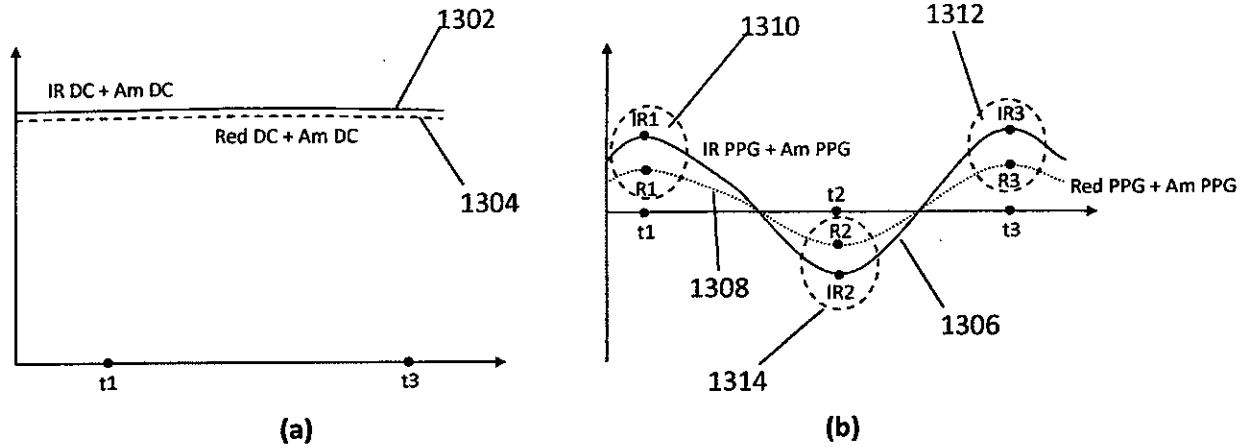

1302
IR DC + Am DC
Red DC + Am DC
1304
t1
t3
(a)
1310
1312
IR1
IR3
IR PPG + Am PPG
R1
R3
Red PPG + Am PPG
t2
t1
R2
t3
1308
IR2
1306
1314
(b)

Figure 13

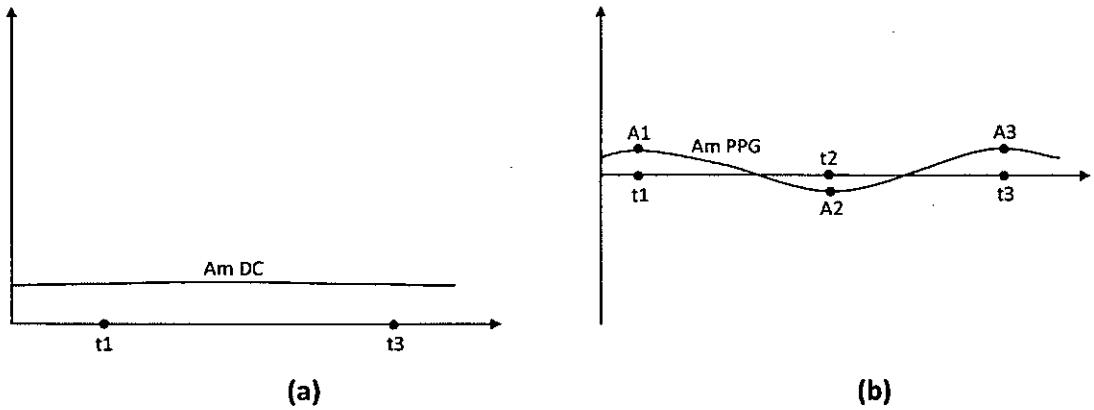


Figure 14

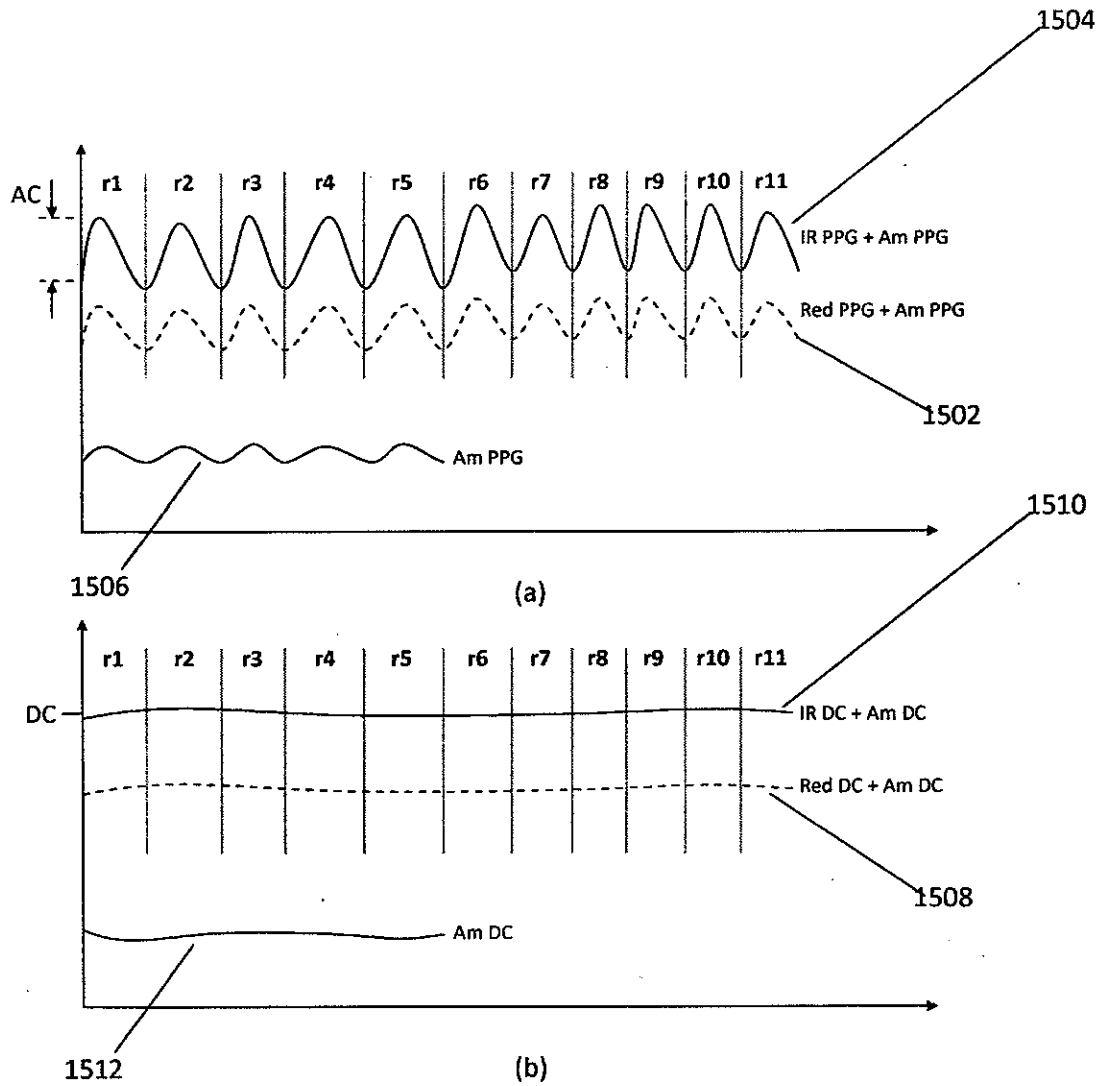

1504
AC
r1
r2
r3
r4
r5
r6
r7
r8
r9
r10
r11
IR PPG + Am PPG
Red PPG + Am PPG
1502
Am PPG
1506
(a)
1510
DC
IR DC + Am DC
Red DC + Am DC
1508
Am DC
1512
(b)

Figure 15

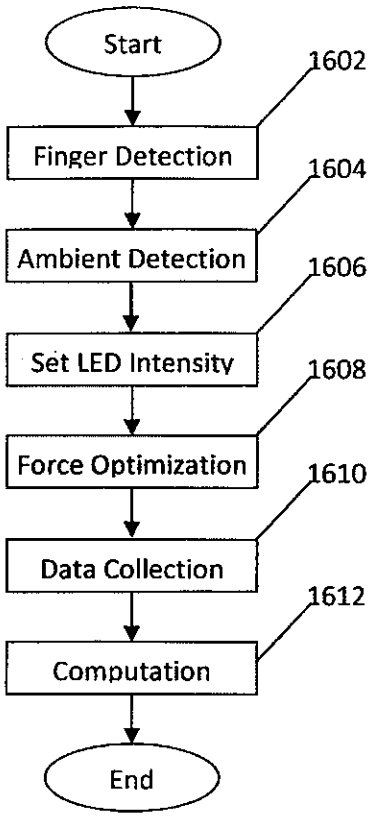
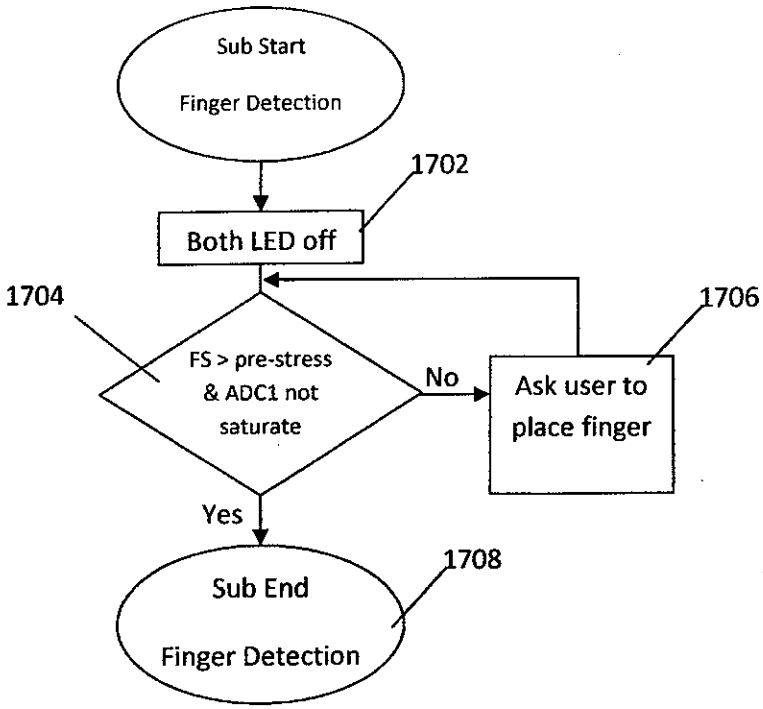
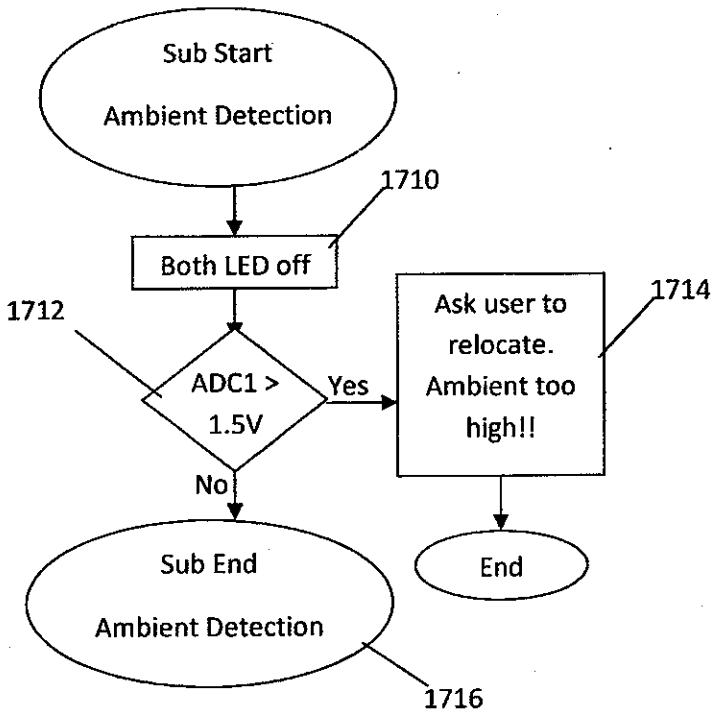

Start
1602
Finger Detection
1604
Ambient Detection
1606
Set LED Intensity
1608
Force Optimization
1610
Data Collection
1612
Computation
End

Figure 16


Sub Start
Finger Detection
1702
Both LED off
1704
FS > pre-stress
& ADC1 not
saturate
No
1706
Ask user to
place finger
Yes
Sub End
Finger Detection
1708

(a)


Sub Start
Ambient Detection
1710
Both LED off
1712
ADC1 >
1.5V
Yes
1714
Ask user to
relocate.
Ambient too
high!!
No
End
Sub End
Ambient Detection
1716

(b)

Figure 17

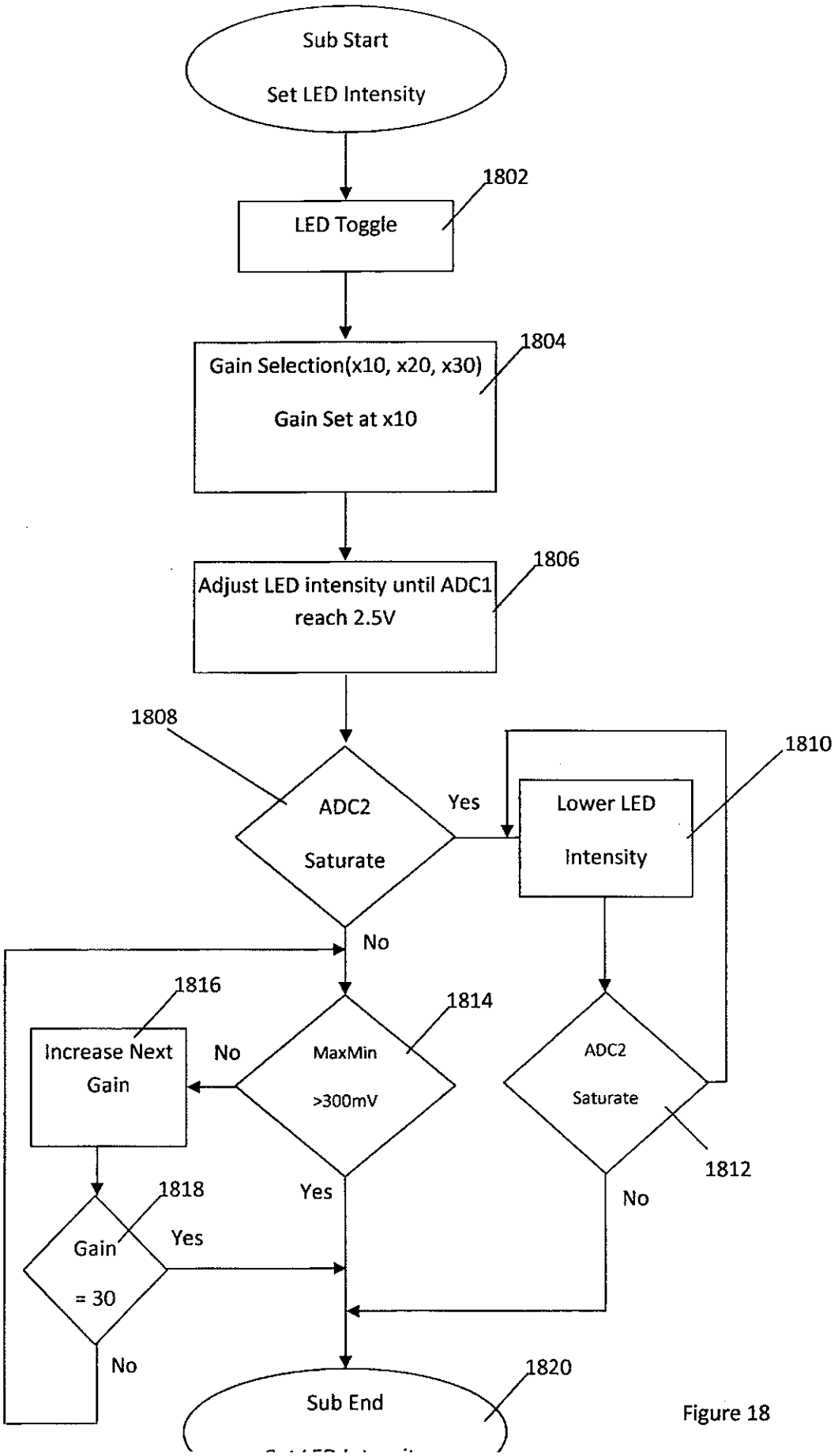

Sub Start
Set LED Intensity
1802
LED Toggle
1804
Gain Selection(x10, x20, x30)
Gain Set at x10
1806
Adjust LED intensity until ADC1 reach 2.5V
1808
ADC2 Saturate
Yes
1810
Lower LED Intensity
No
1816
Increase Next Gain
No
1814
MaxMin >300mV
ADC2 Saturate
1812
Yes
No
1818
Gain = 30
Yes
No
1820
Sub End

Figure 18

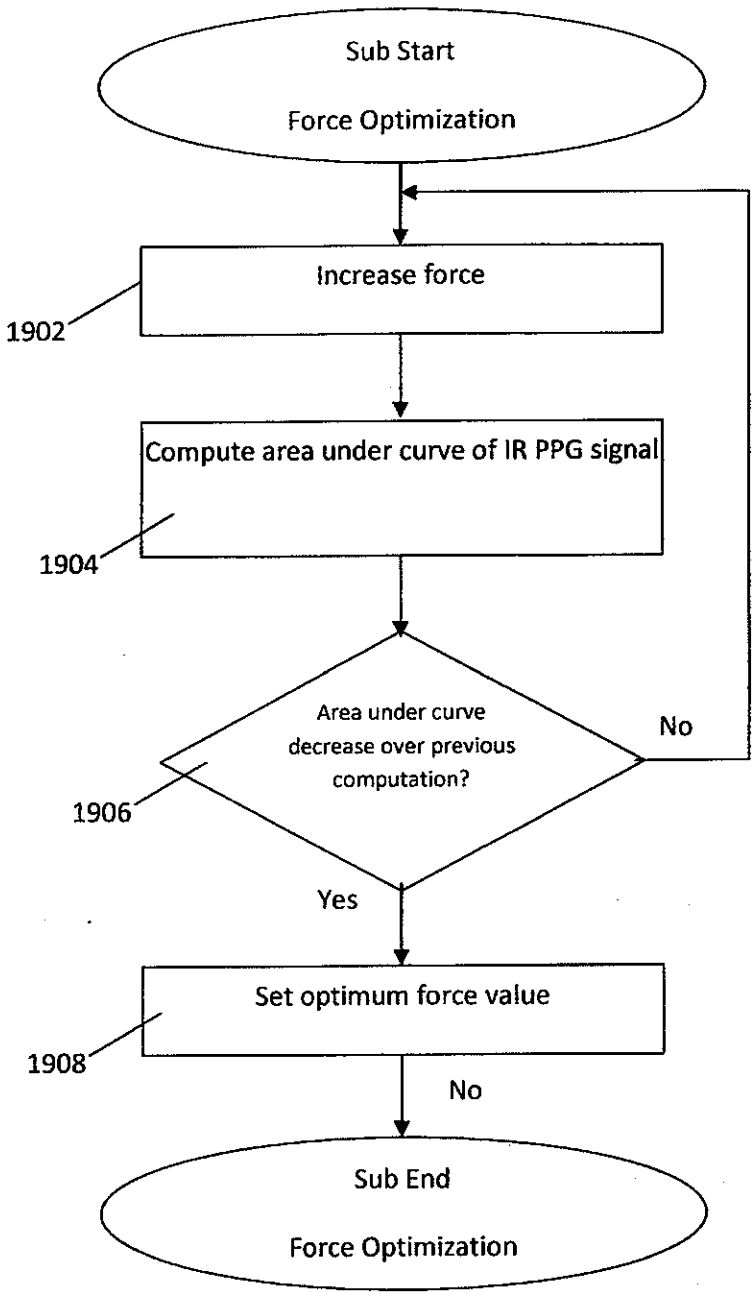

Sub Start
Force Optimization
Increase force
1902
Compute area under curve of IR PPG signal
1904
Area under curve decrease over previous computation?
1906
No
Yes
Set optimum force value
1908
No
Sub End
Force Optimization

Figure 19

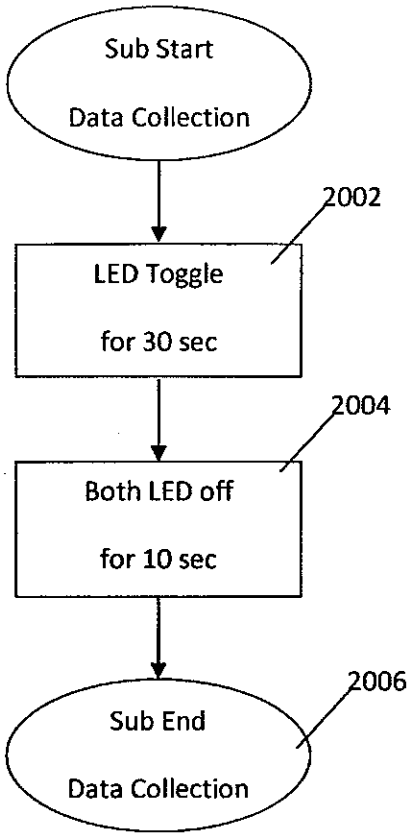

Sub Start
Data Collection
2002
LED Toggle
for 30 sec
2004
Both LED off
for 10 sec
2006
Sub End
Data Collection

Figure 20

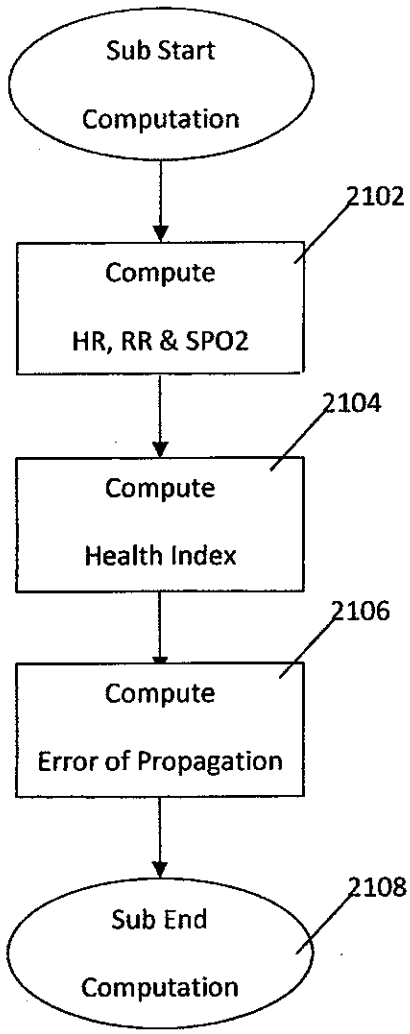

Sub Start
Computation
2102
Compute
HR, RR & SPO2
2104
Compute
Health Index
2106
Compute
Error of Propagation
2108
Sub End
Computation

Figure 21

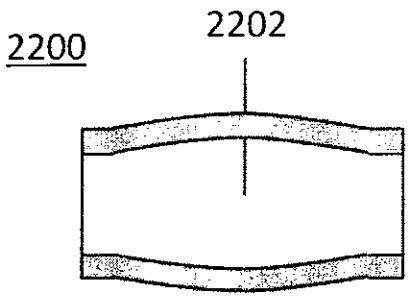


Figure 22

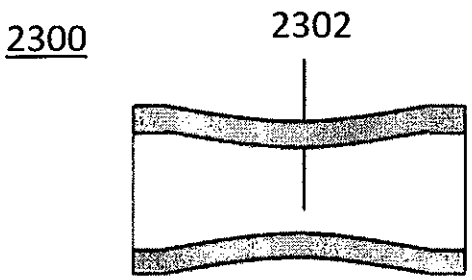


Figure 23

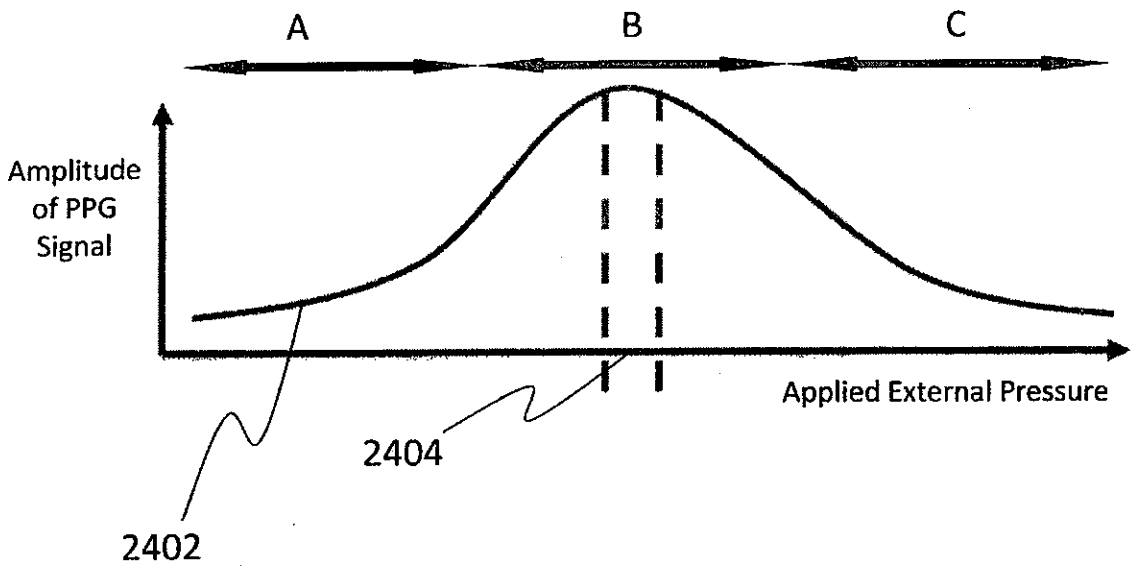

A
B
C
Amplitude of PPG Signal
Applied External Pressure
2404
2402

Figure 24

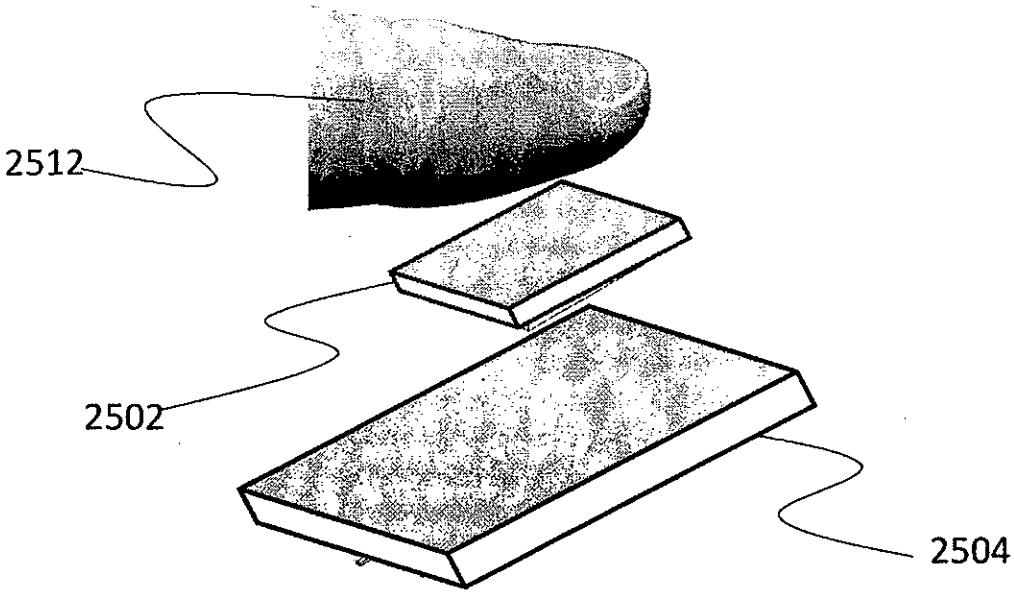


Figure 25(a)

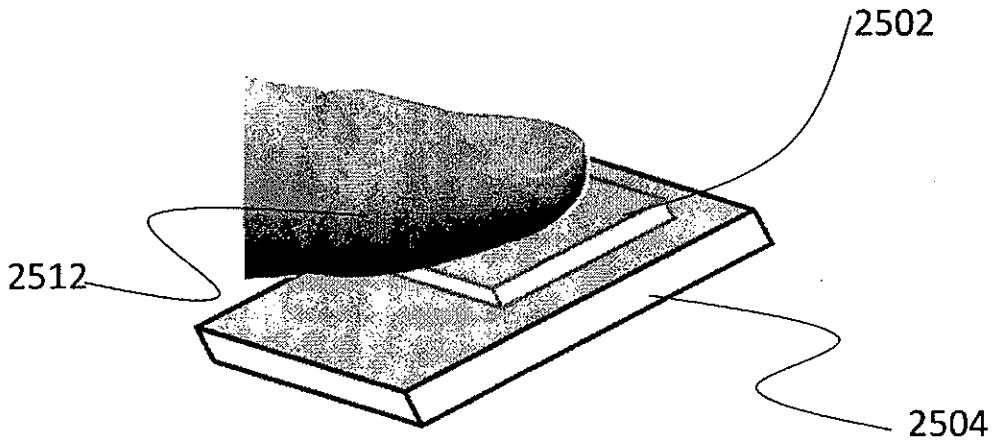


Figure 25(b)

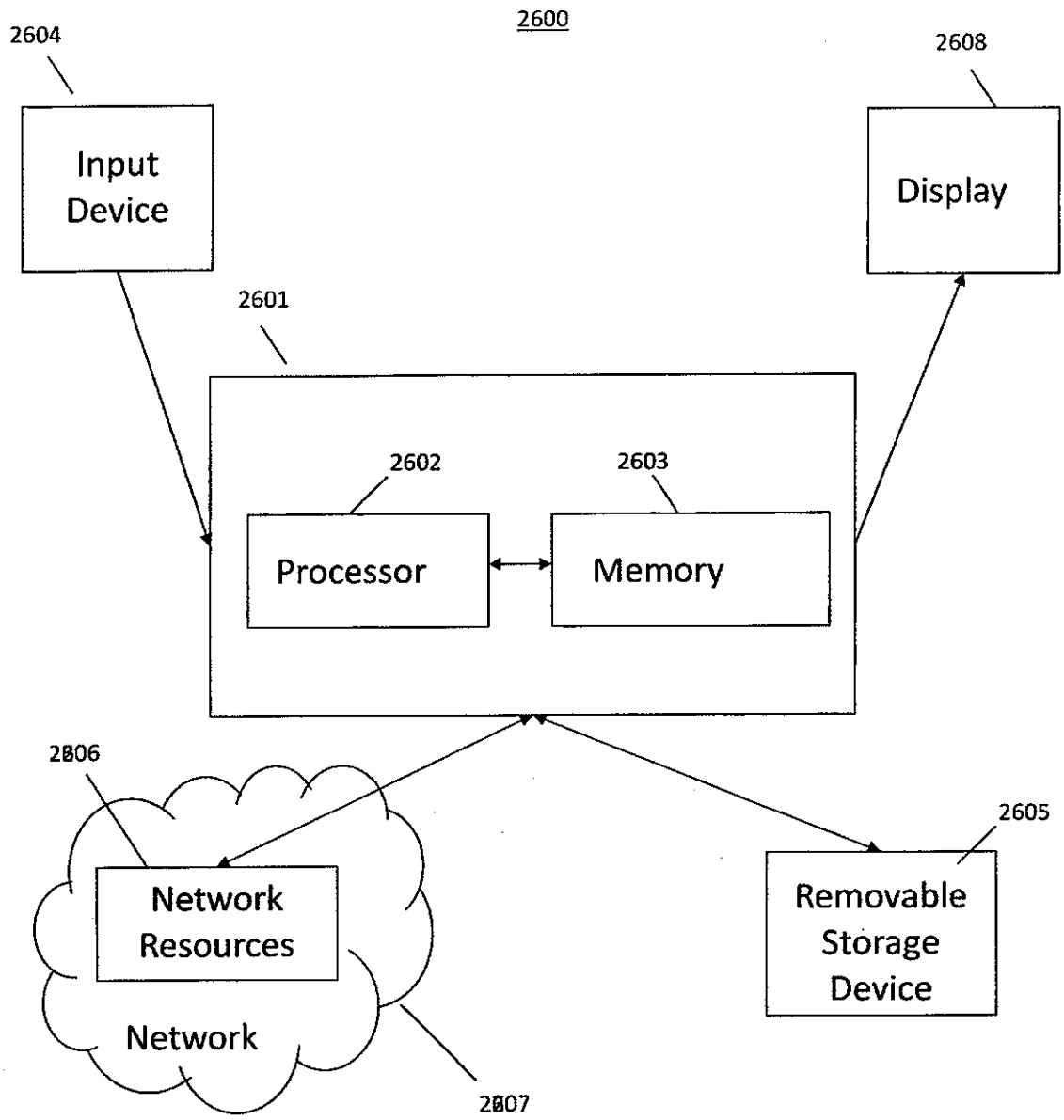

2600
2604
Input Device
2608
Display
2601
2602
Processor
2603
Memory
2606
Network Resources
Network
2607
2605
Removable Storage Device

Figure 26

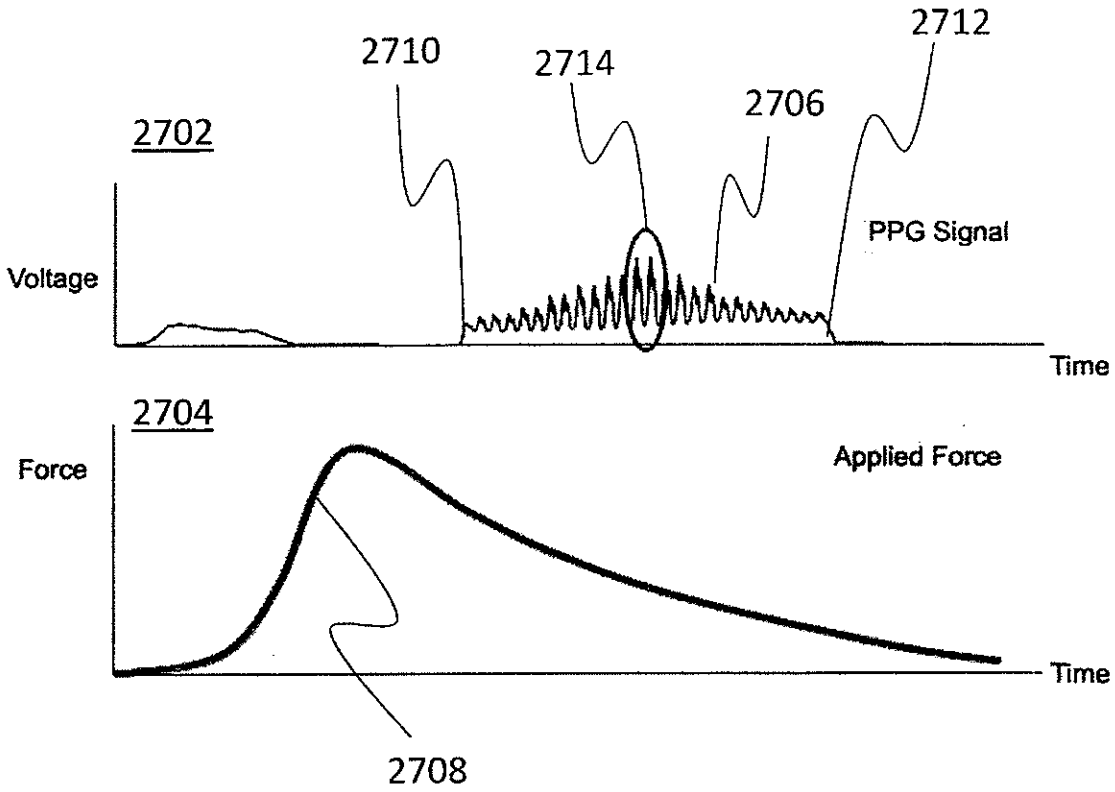

2712
2710
2714
2706
2702
PPG Signal
Voltage
Time
2704
Force
Applied Force
Time
2708

Figure 27

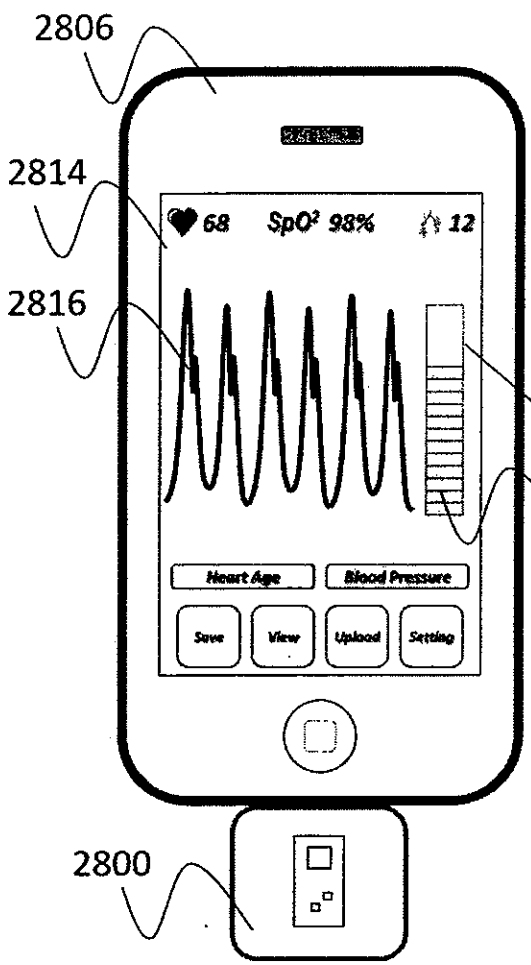


Figure 28(a)

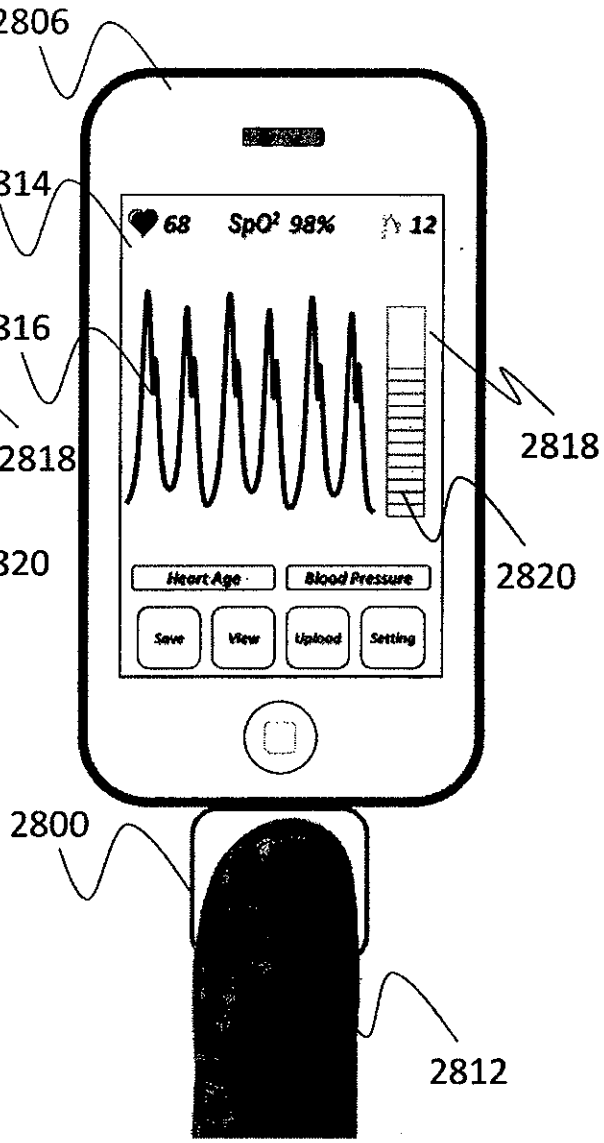


Figure 28(b)

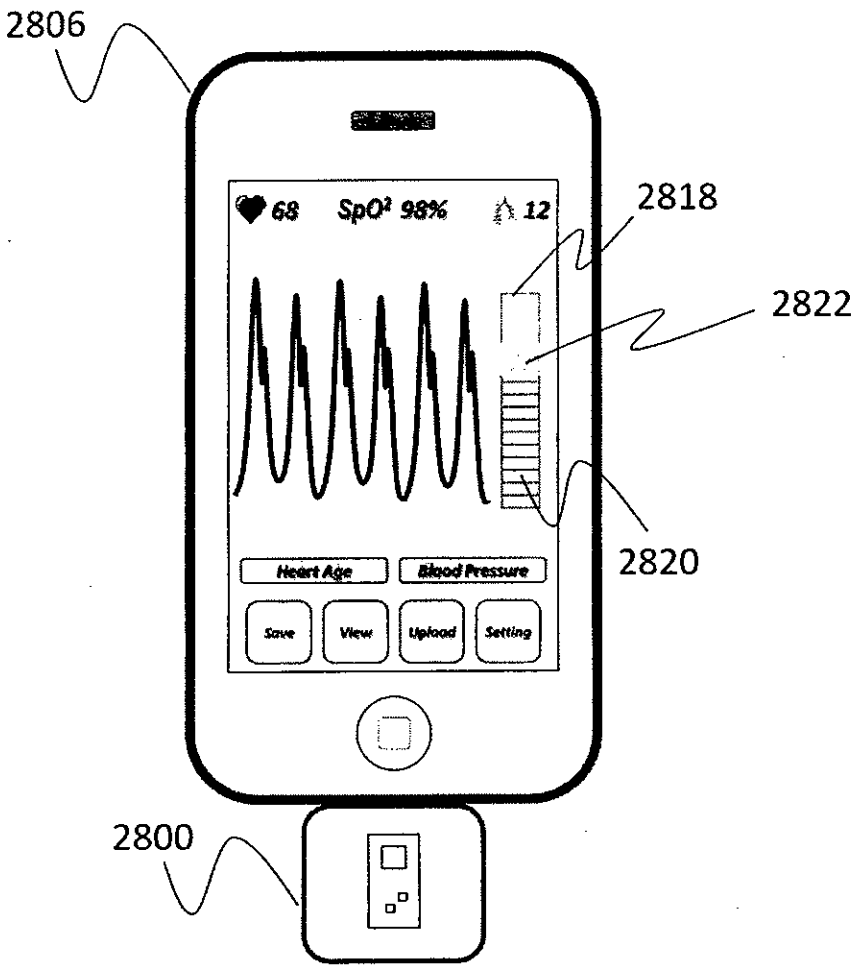
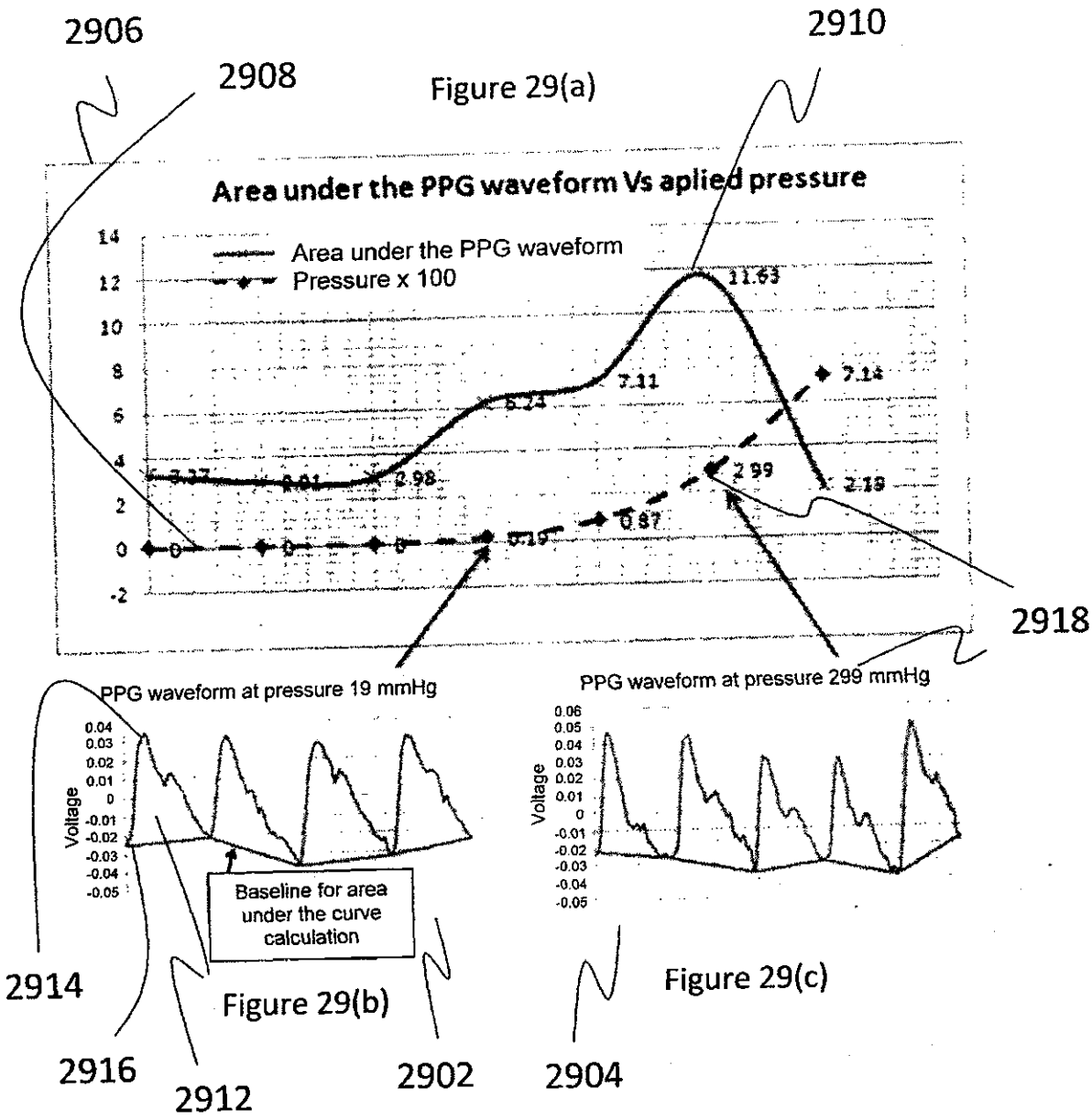

2806
68
SpO² 98%
12
2818
2822
2820
Heart Age
Blood Pressure
Save
View
Upload
Setting
2800

Figure 28(c)


2906
2908
2910
Figure 29(a)
Area under the PPG waveform Vs aplied pressure
Area under the PPG waveform
Pressure x 100
14
12
10
8
6
4
2
0
-2
11.63
7.11
5.24
7.14
2.98
2.99
2.19
0.87
2918
PPG waveform at pressure 19 mmHg
Voltage
0.04
0.03
0.02
0.01
0
-0.01
-0.02
-0.03
-0.04
-0.05
Baseline for area under the curve calculation
PPG waveform at pressure 299 mmHg
Voltage
0.06
0.05
0.04
0.03
0.02
0.01
0
-0.01
-0.02
-0.03
-0.04
-0.05
2914
Figure 29(b)
Figure 29(c)
2916
2912
2902
2904

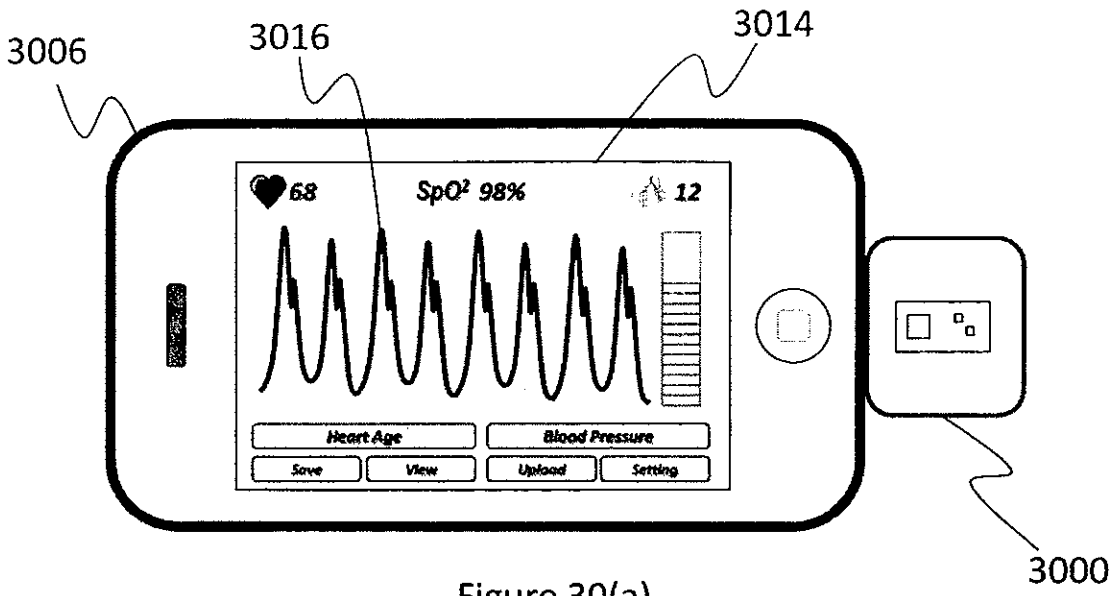


Figure 30(a)

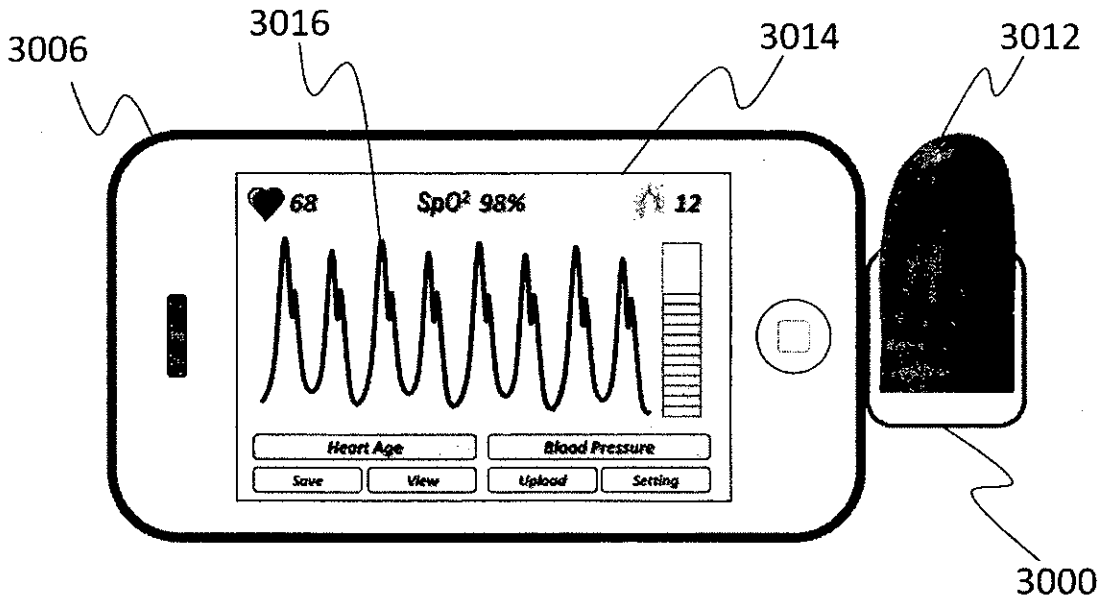


Figure 30(b)

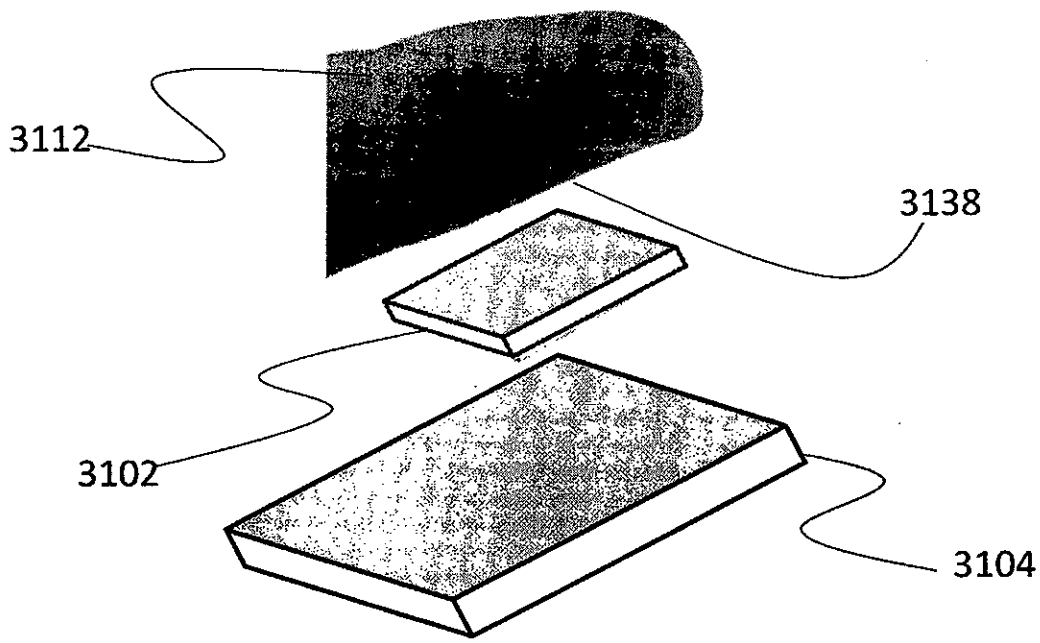


Figure 31(a)

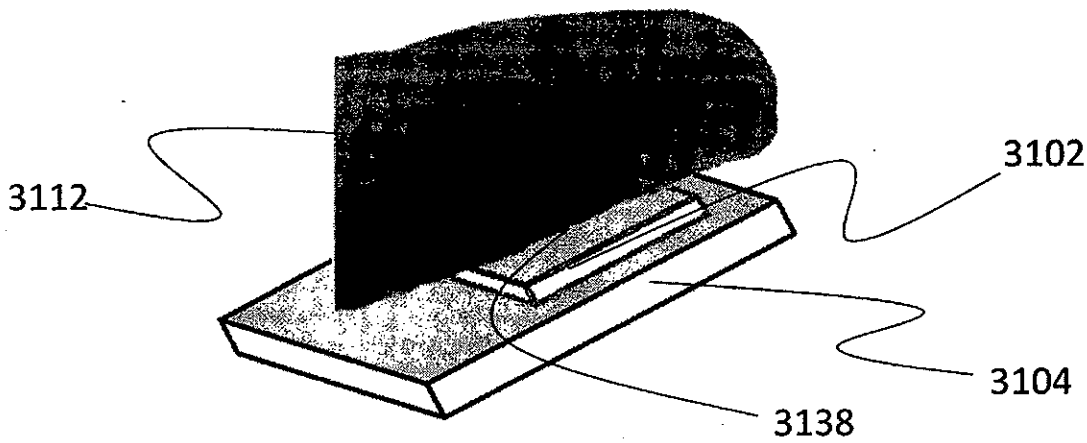


Figure 31(b)

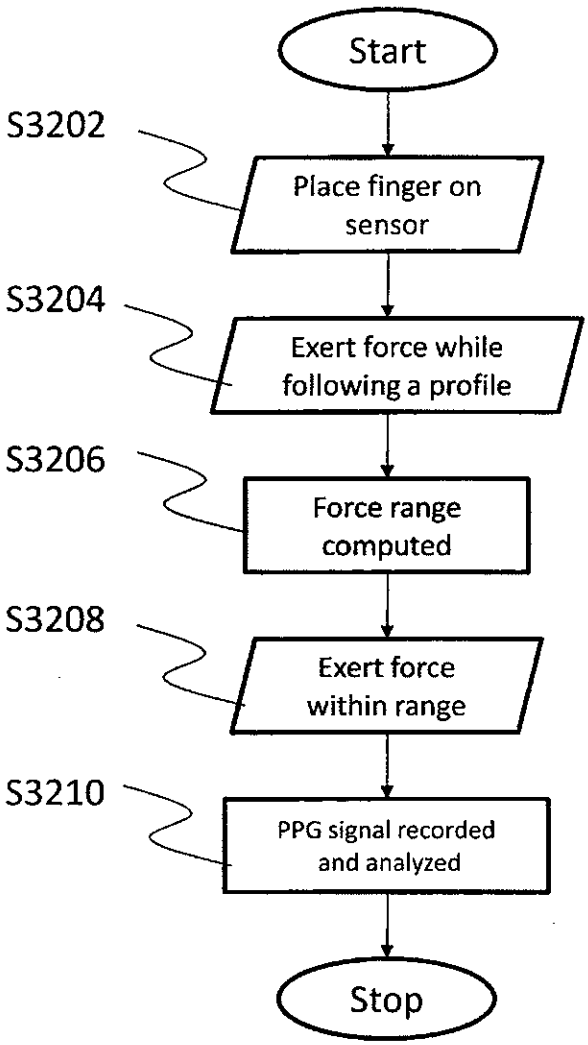

Start
S3202
Place finger on sensor
S3204
Exert force while following a profile
S3206
Force range computed
S3208
Exert force within range
S3210
PPG signal recorded and analyzed
Stop

Figure 32

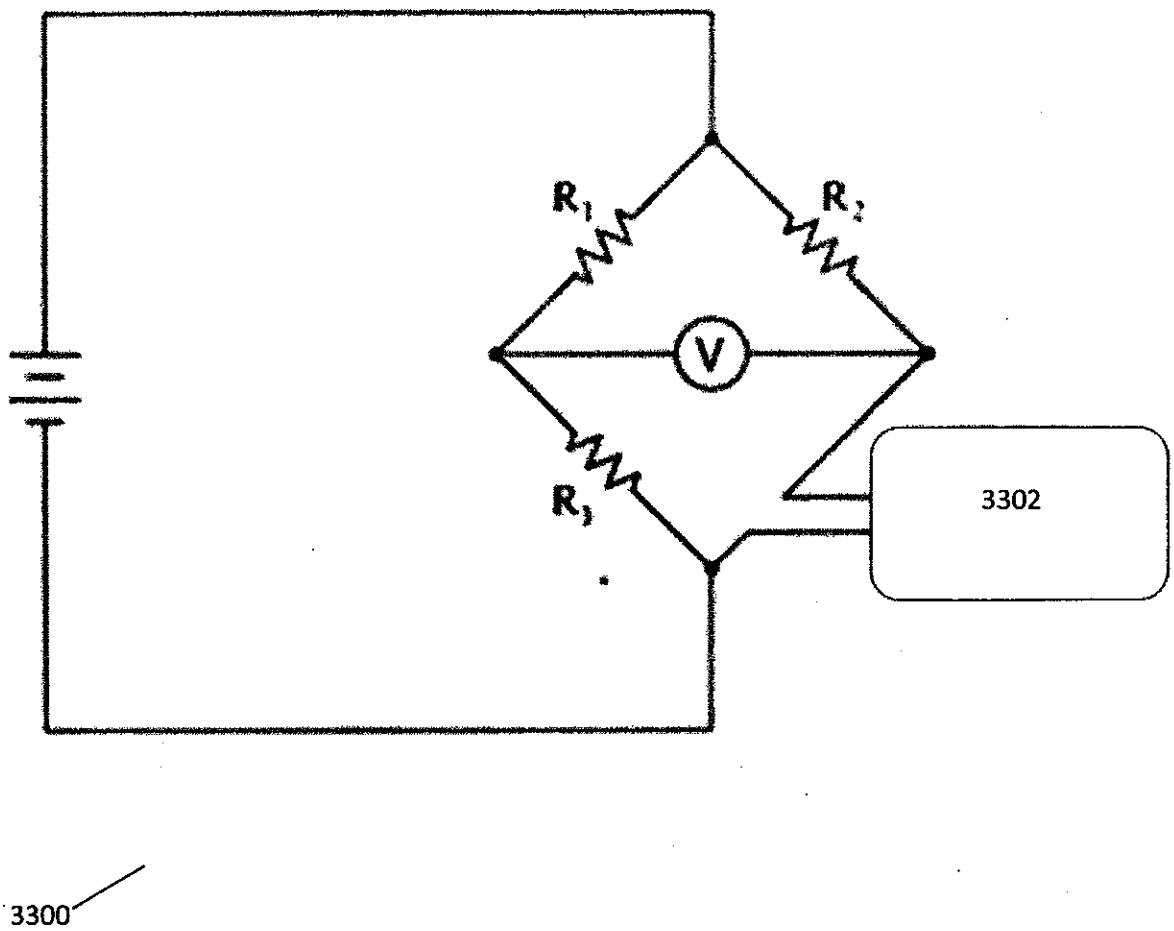


Figure 33

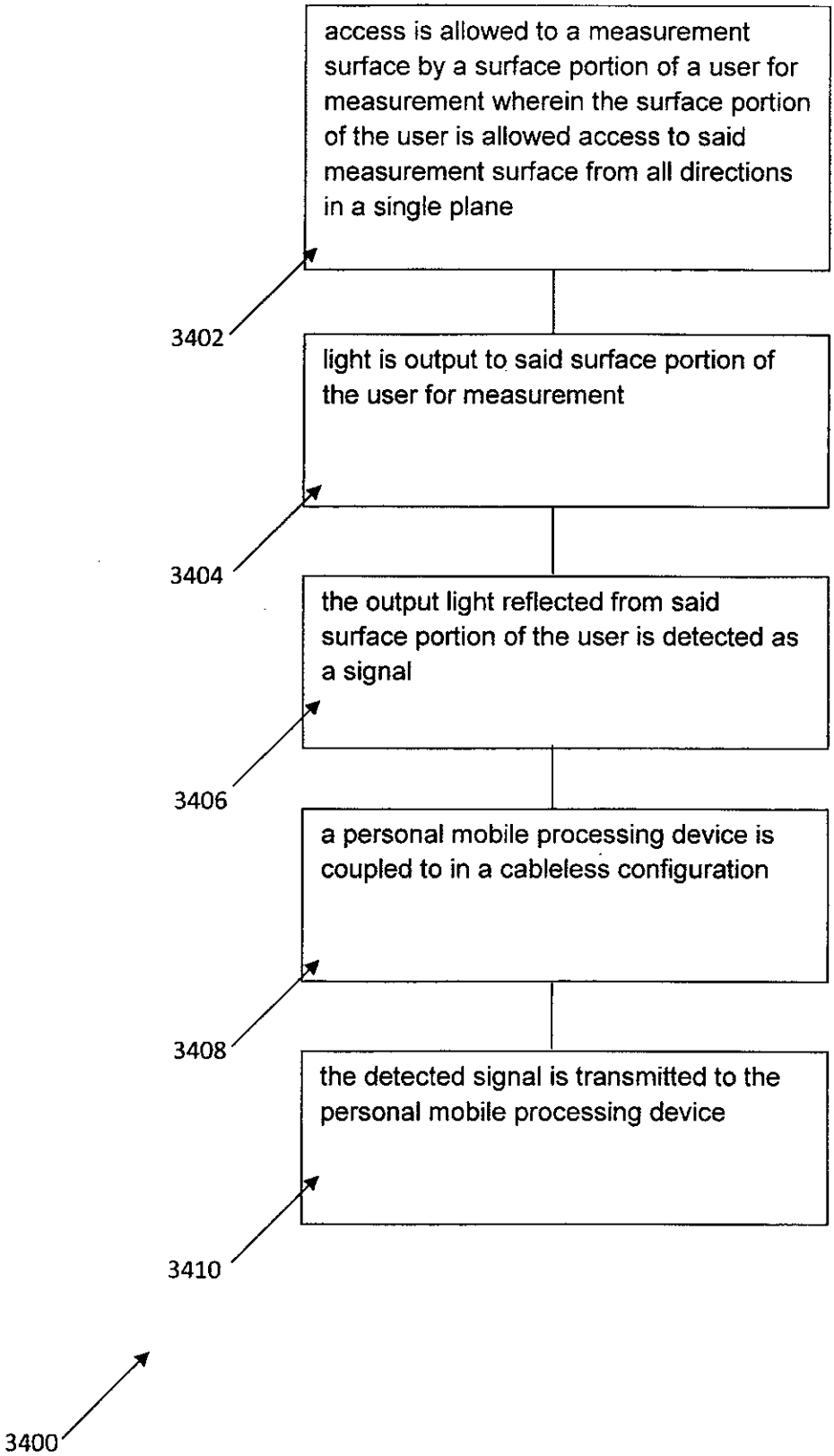

access is allowed to a measurement surface by a surface portion of a user for measurement wherein the surface portion of the user is allowed access to said measurement surface from all directions in a single plane
3402
light is output to said surface portion of the user for measurement
3404
the output light reflected from said surface portion of the user is detected as a signal
3406
a personal mobile processing device is coupled to in a cableless configuration
3408
the detected signal is transmitted to the personal mobile processing device
3410
3400

Figure 34

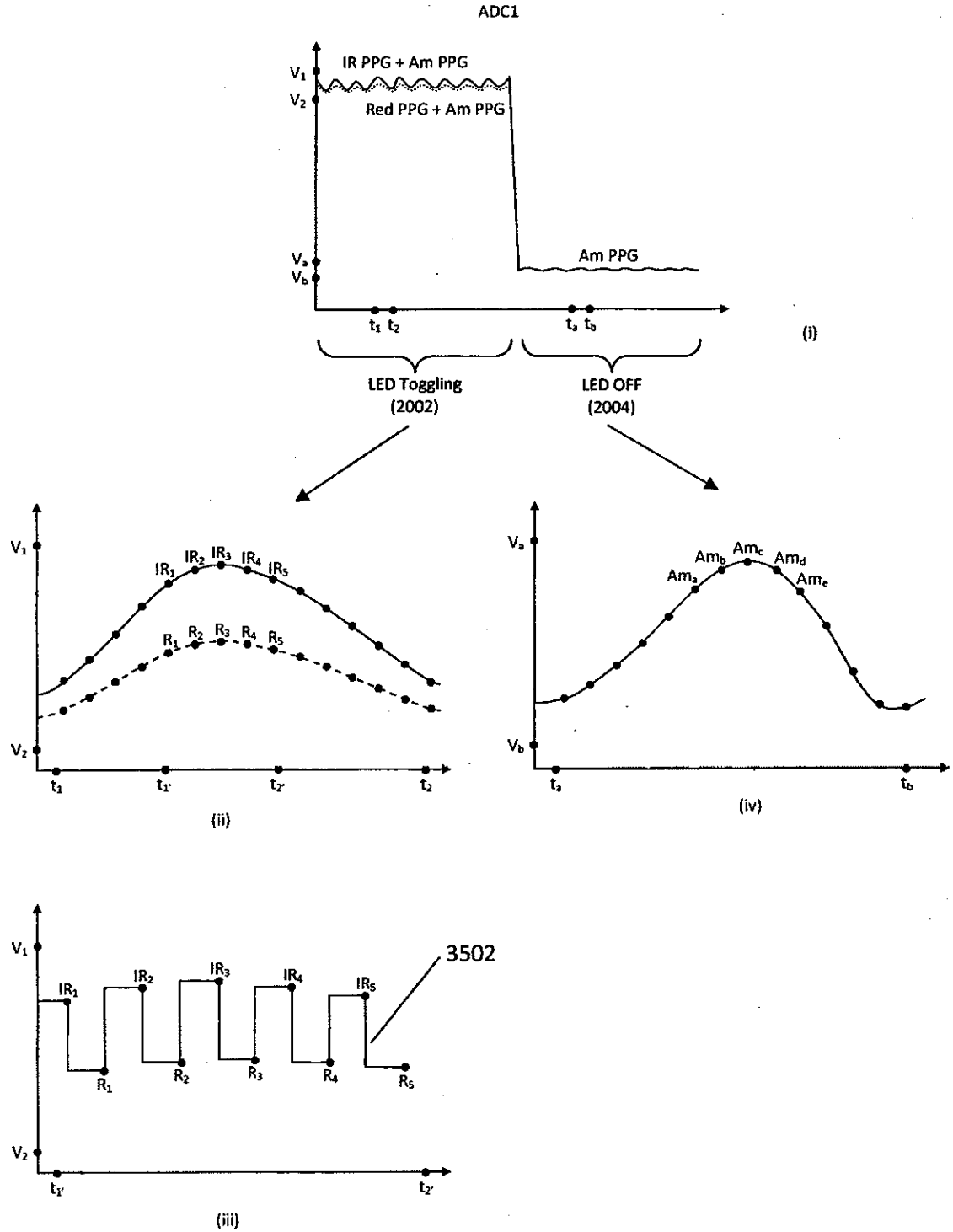

ADC1
IR PPG + Am PPG
Red PPG + Am PPG
Am PPG
LED Toggling
(2002)
LED OFF
(2004)
(i)
(ii)
(iii)
(iv)
3502

Figure 35