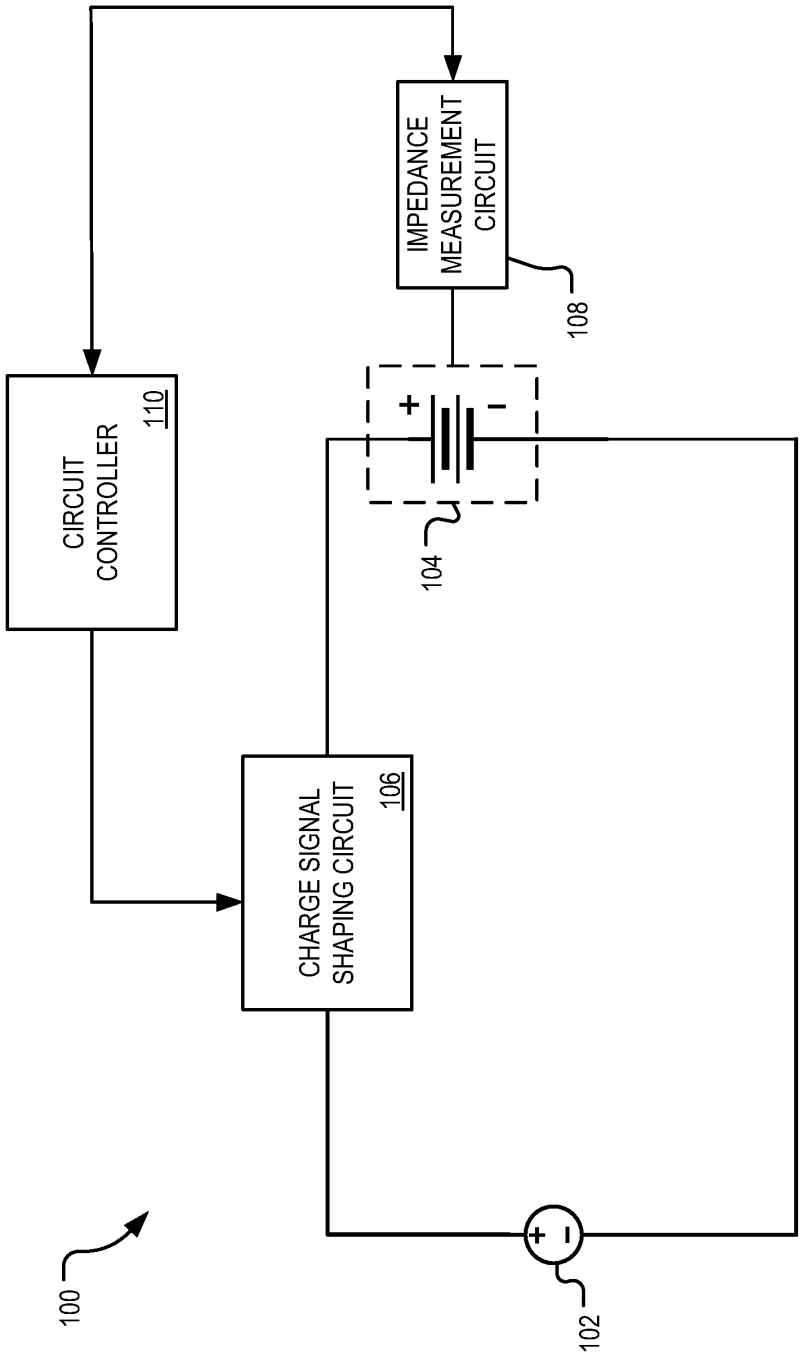

IMPEDANCE MEASUREMENT CIRCUIT
108
CIRCUIT CONTROLLER
110
+
-
104
CHARGE SIGNAL SHAPING CIRCUIT
106
+
-
102
100

FIG. 1A

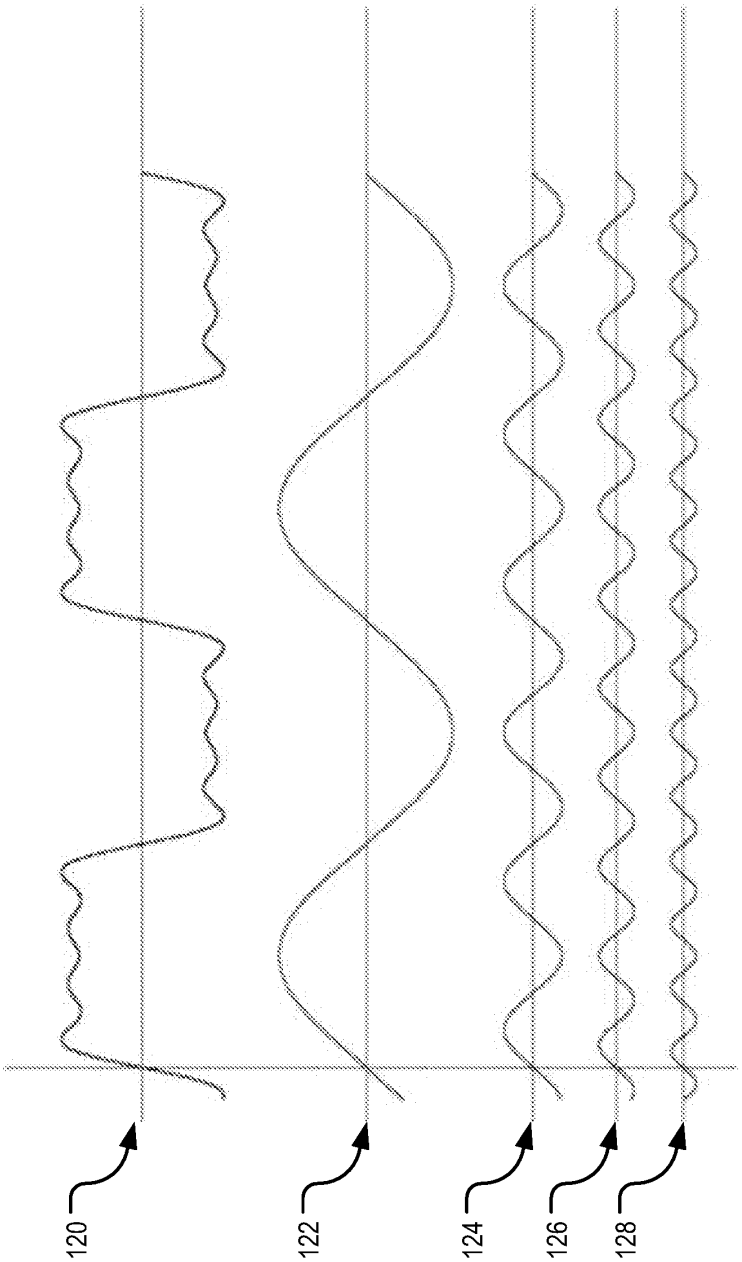


FIG. 1B

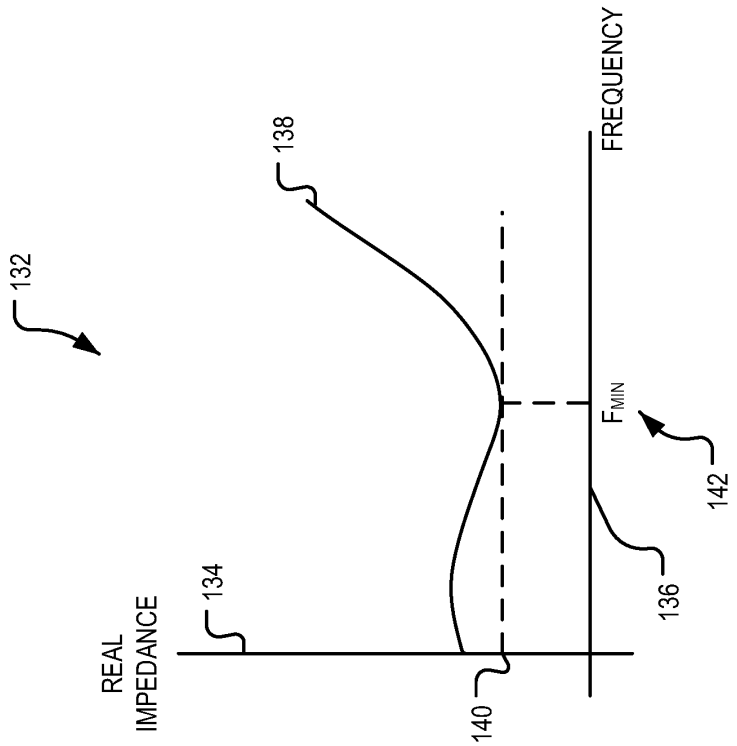


FIG. 1C

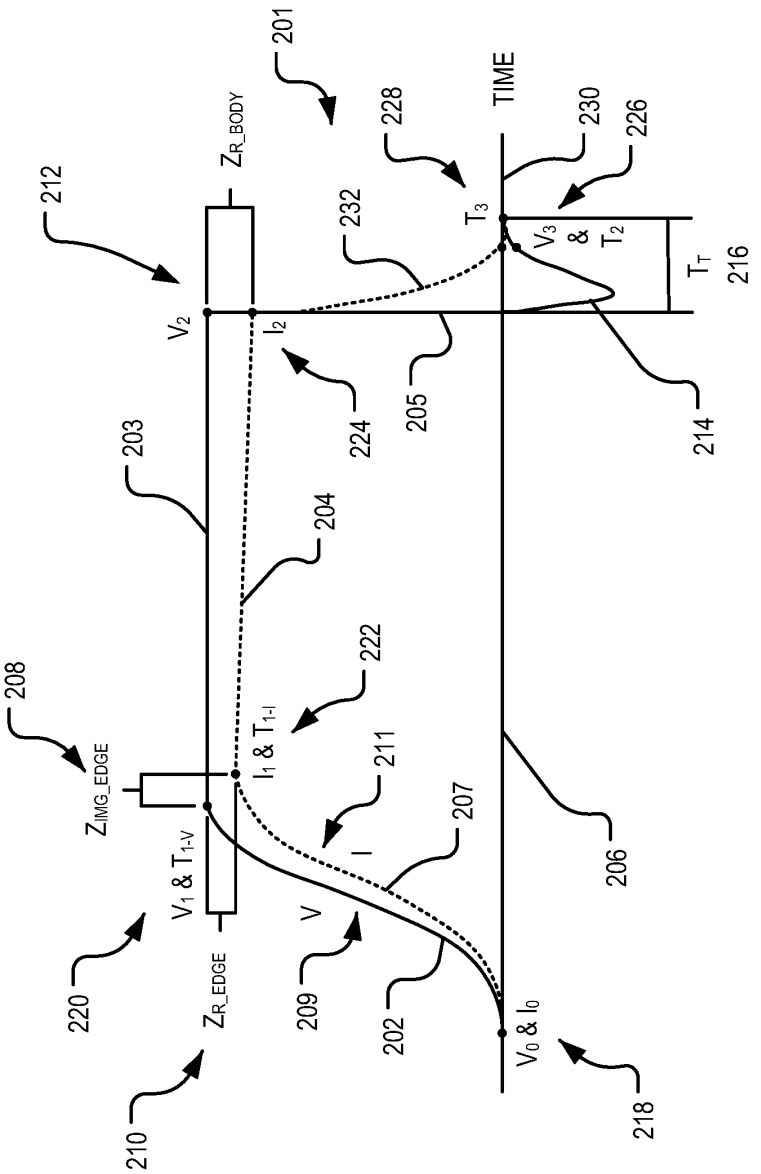

201
Z_{R_BODY}
212
228
TIME
230
226
232
T_3
V_3 & T_2
T_T
216
V_2
I_2
224
205
214
203
204
208
222
I_1 & $T_{1\text{-}I}$
Z_{IMG_EDGE}
211
207
V_1 & $T_{1\text{-}V}$
I
V
206
220
209
202
Z_{R_EDGE}
V_0 & I_0
210
218

FIG. 2

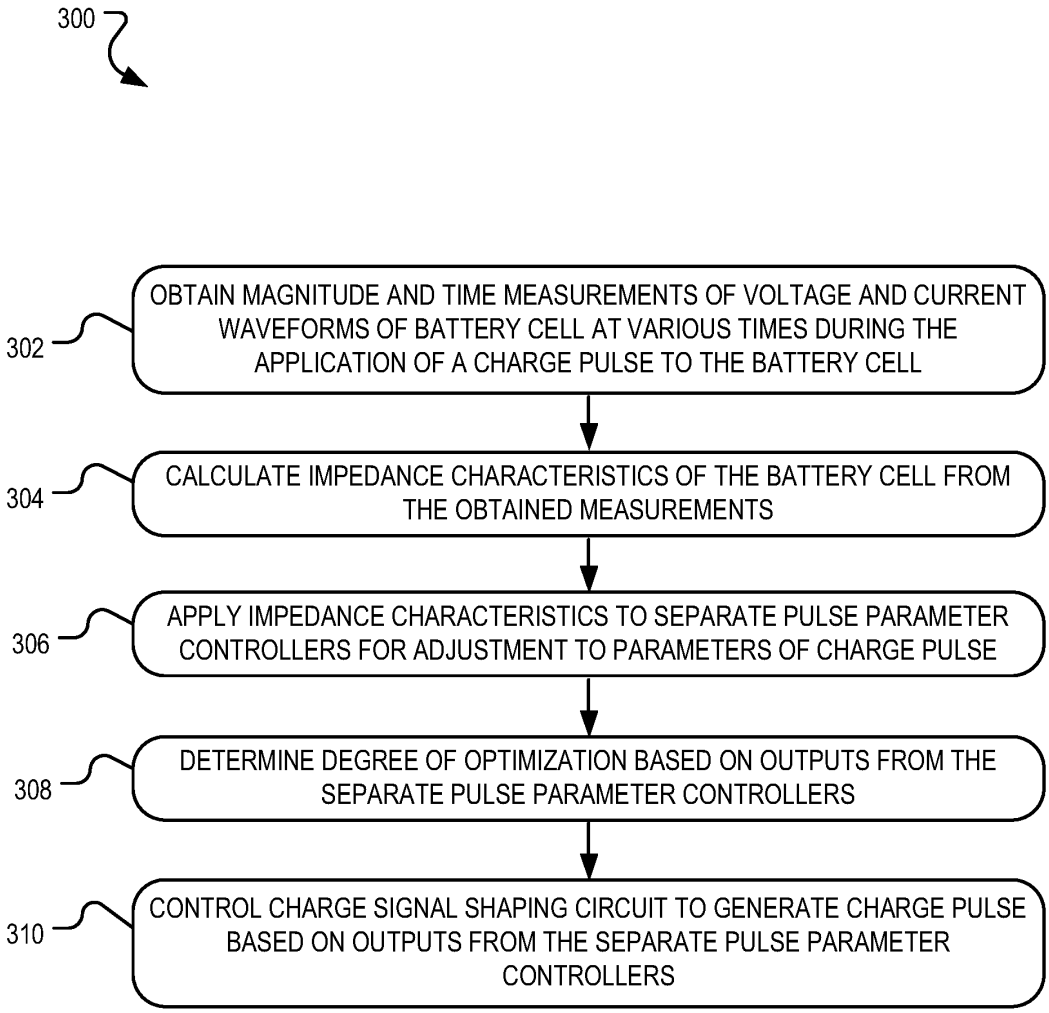

300
302
OBTAIN MAGNITUDE AND TIME MEASUREMENTS OF VOLTAGE AND CURRENT WAVEFORMS OF BATTERY CELL AT VARIOUS TIMES DURING THE APPLICATION OF A CHARGE PULSE TO THE BATTERY CELL
304
CALCULATE IMPEDANCE CHARACTERISTICS OF THE BATTERY CELL FROM THE OBTAINED MEASUREMENTS
306
APPLY IMPEDANCE CHARACTERISTICS TO SEPARATE PULSE PARAMETER CONTROLLERS FOR ADJUSTMENT TO PARAMETERS OF CHARGE PULSE
308
DETERMINE DEGREE OF OPTIMIZATION BASED ON OUTPUTS FROM THE SEPARATE PULSE PARAMETER CONTROLLERS
310
CONTROL CHARGE SIGNAL SHAPING CIRCUIT TO GENERATE CHARGE PULSE BASED ON OUTPUTS FROM THE SEPARATE PULSE PARAMETER CONTROLLERS

FIG. 3

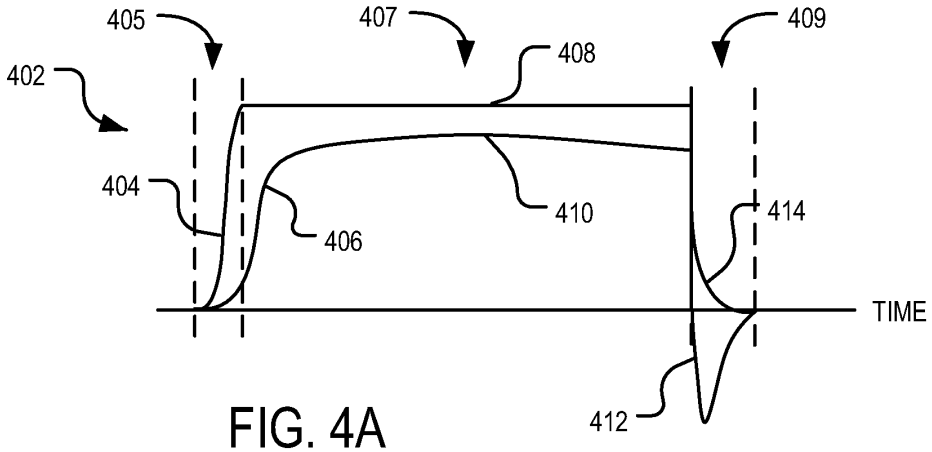


FIG. 4A

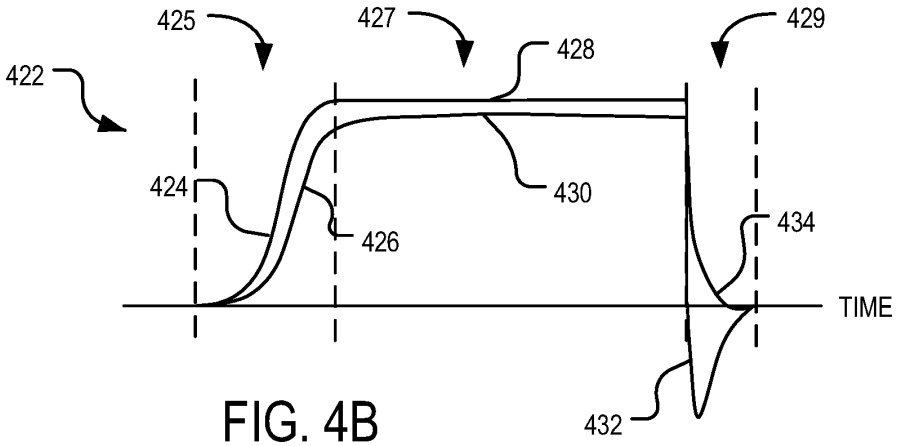


FIG. 4B

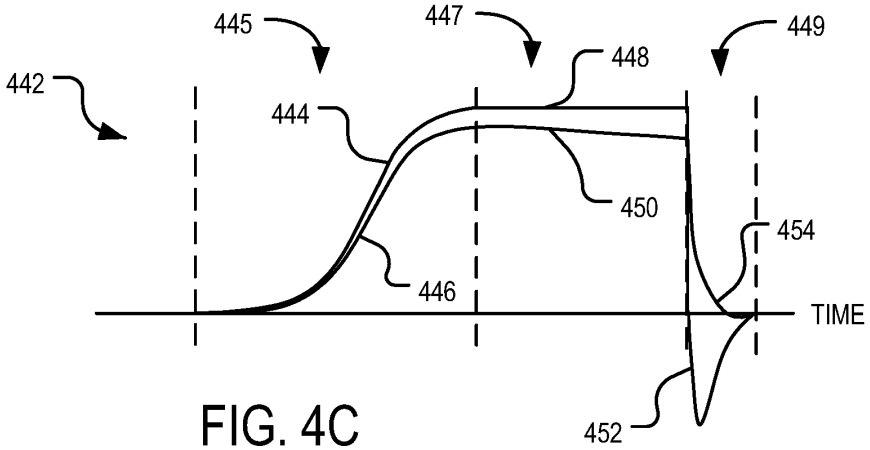


FIG. 4C

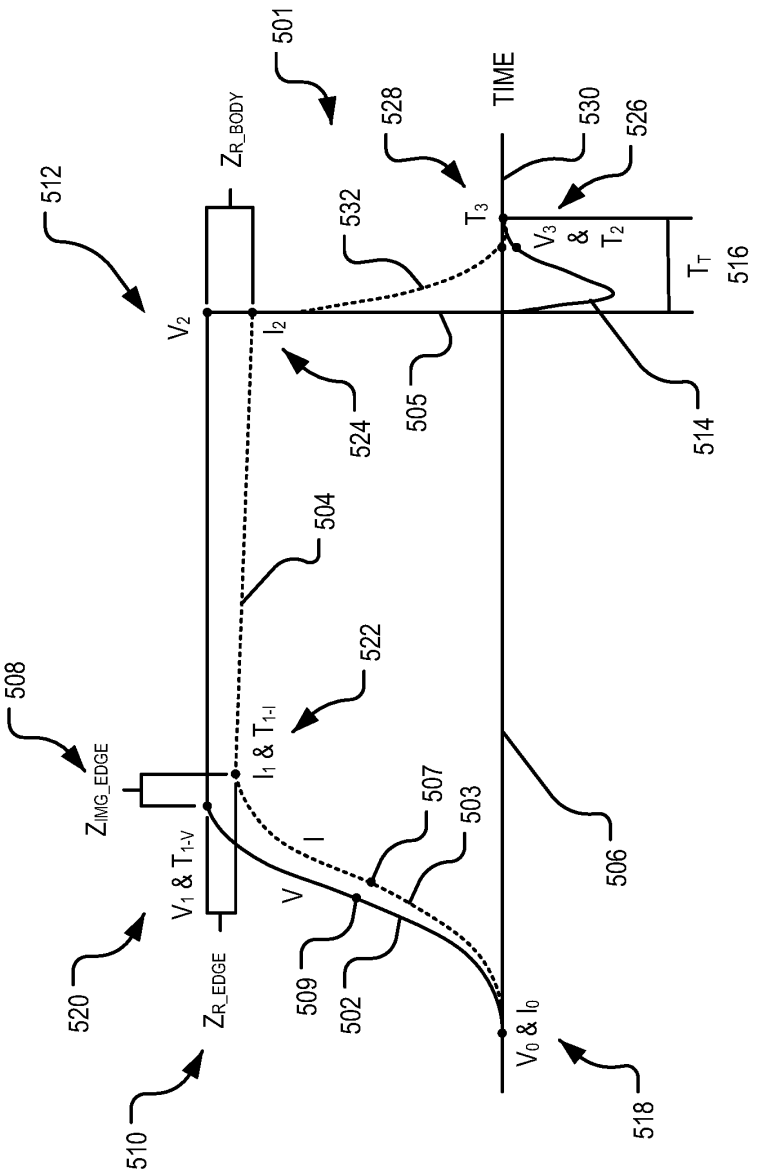

501
Z_{R_BODY}
512
528
TIME
530
526
532
T_3
V_3 & T_2
T_T
516
V_2
I_2
524
505
514
504
522
508
Z_{IMG_EDGE}
I_1 & T_{1-I}
507
503
I
V
V_1 & T_{1-V}
520
Z_{R_EDGE}
509
502
506
V_0 & I_0
510
518

FIG. 5

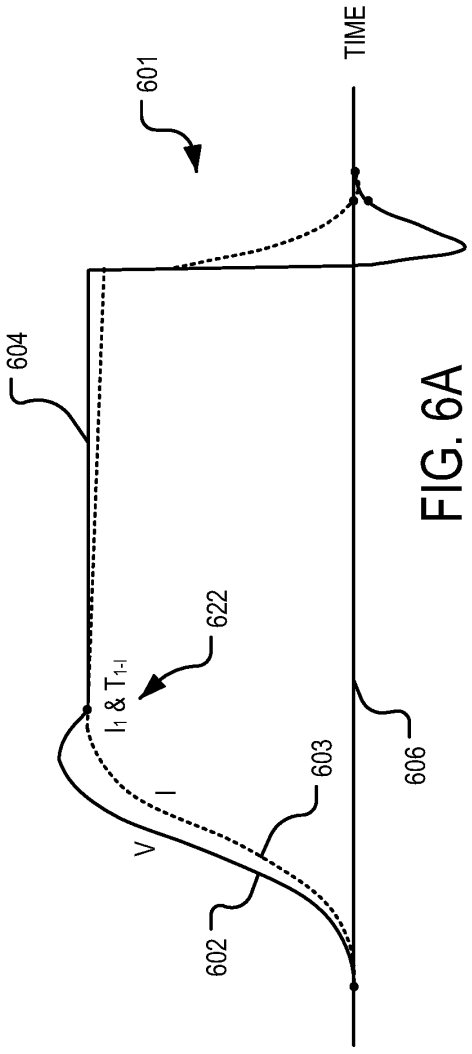

TIME
601
604
622
I_1 & T_{1-I}
I
V
603
602
606

FIG. 6A

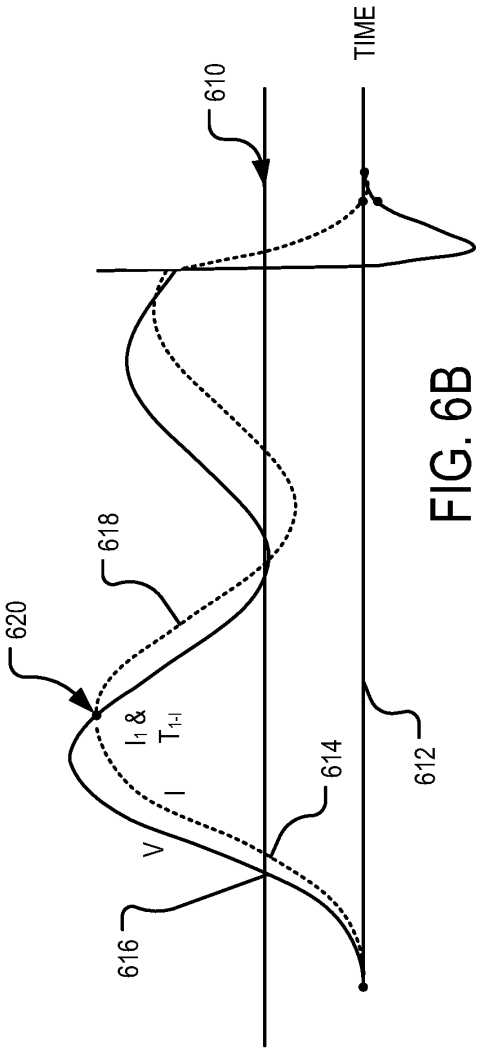

TIME
610
618
620
I_1 & T_{1-I}
I
V
614
616
612

FIG. 6B

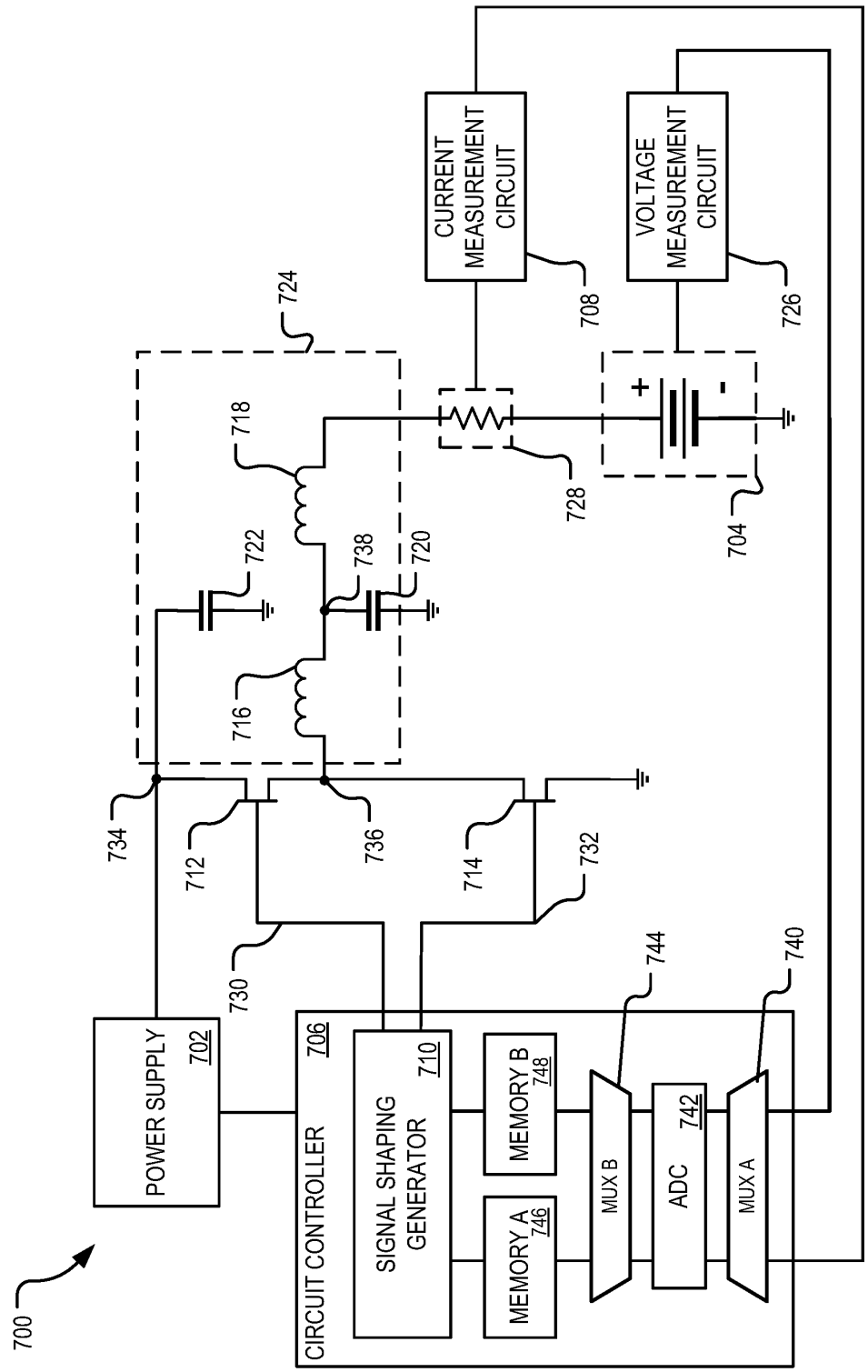

700
POWER SUPPLY 702
CIRCUIT CONTROLLER 706
SIGNAL SHAPING GENERATOR 710
MEMORY A 746
MEMORY B 748
MUX B
ADC 742
MUX A
744
740
730
732
734
712
736
714
716
718
722
738
720
724
728
704
CURRENT MEASUREMENT CIRCUIT
708
VOLTAGE MEASUREMENT CIRCUIT
726
+
-

FIG. 7

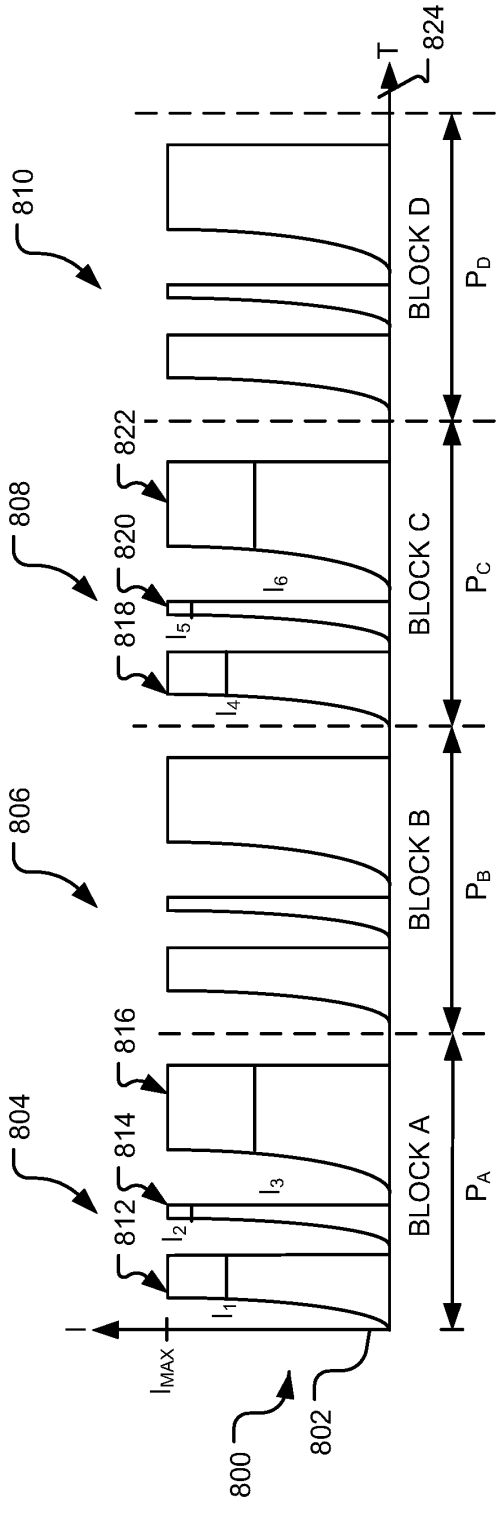

800
802
804
806
808
810
812
814
816
818
820
822
824
T
I_{MAX}
I_1
I_2
I_3
I_4
I_5
I_6
BLOCK A
BLOCK B
BLOCK C
BLOCK D
P_A
P_B
P_C
P_D

FIG. 8A

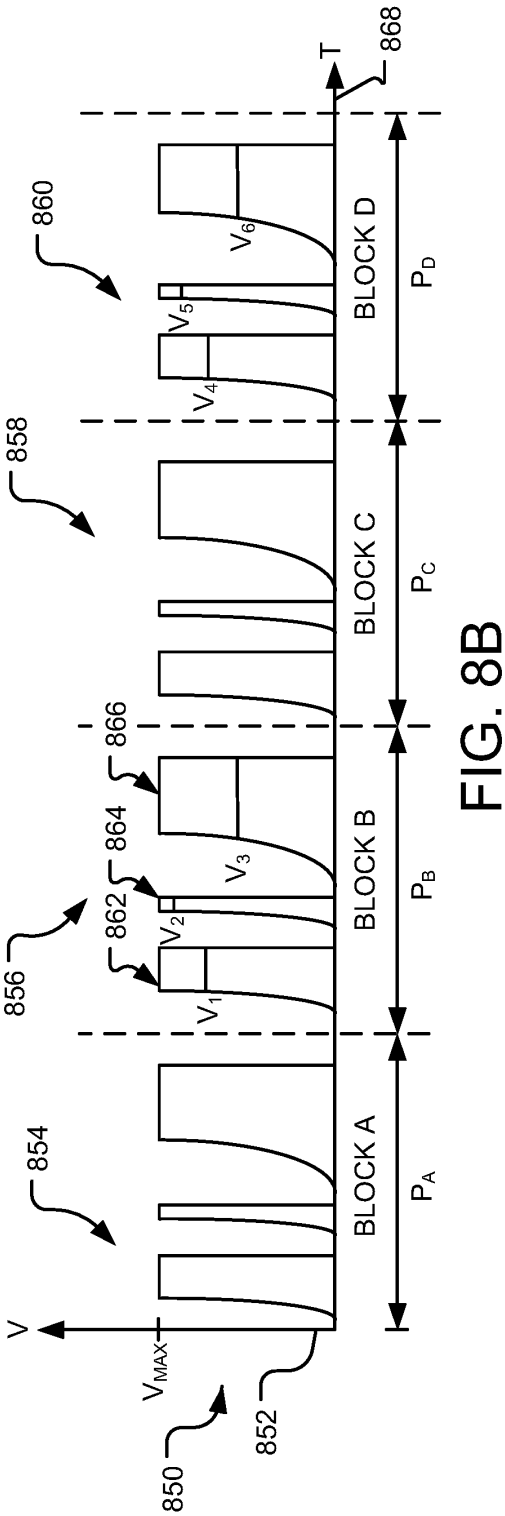

850
852
854
856
858
860
862
864
866
868
T
V
V_{MAX}
V_1
V_2
V_3
V_4
V_5
V_6
BLOCK A
BLOCK B
BLOCK C
BLOCK D
P_A
P_B
P_C
P_D

FIG. 8B

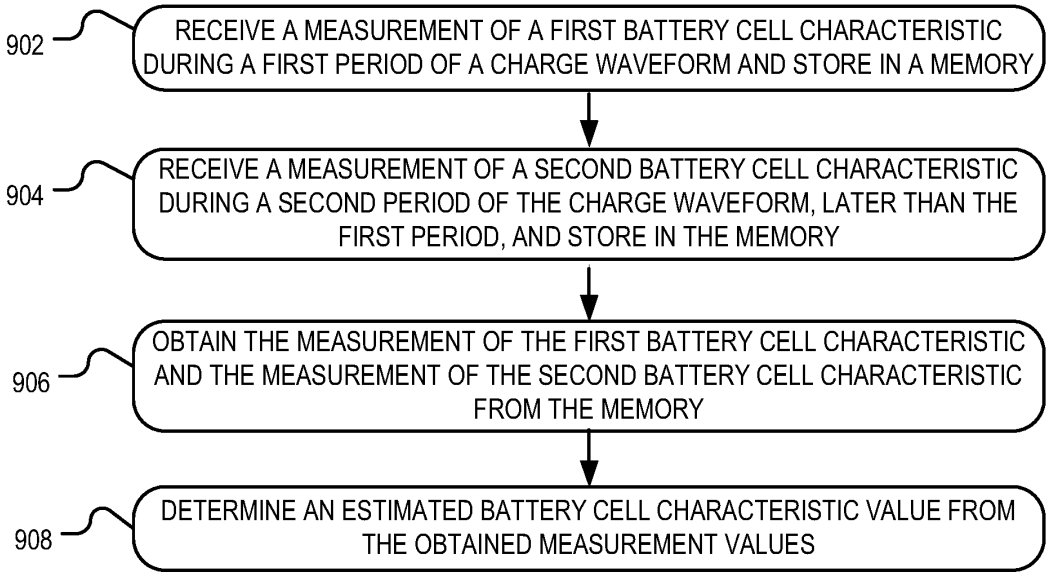

902
RECEIVE A MEASUREMENT OF A FIRST BATTERY CELL CHARACTERISTIC DURING A FIRST PERIOD OF A CHARGE WAVEFORM AND STORE IN A MEMORY
904
RECEIVE A MEASUREMENT OF A SECOND BATTERY CELL CHARACTERISTIC DURING A SECOND PERIOD OF THE CHARGE WAVEFORM, LATER THAN THE FIRST PERIOD, AND STORE IN THE MEMORY
906
OBTAIN THE MEASUREMENT OF THE FIRST BATTERY CELL CHARACTERISTIC AND THE MEASUREMENT OF THE SECOND BATTERY CELL CHARACTERISTIC FROM THE MEMORY
908
DETERMINE AN ESTIMATED BATTERY CELL CHARACTERISTIC VALUE FROM THE OBTAINED MEASUREMENT VALUES

FIG. 9

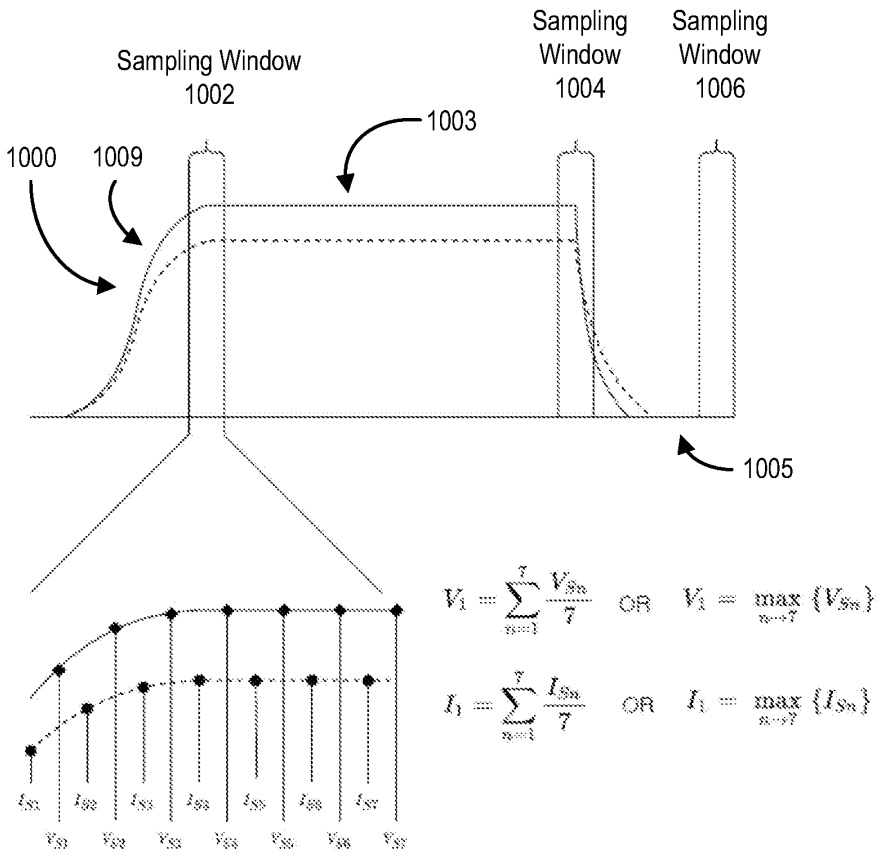

Sampling Window 1002
Sampling Window 1004
Sampling Window 1006
1003
1000
1009
1005
$V_1 = \sum_{n=1}^{7} \frac{V_{Sn}}{7}$ OR $V_1 = \max_{n=7} \{V_{Sn}\}$
$I_1 = \sum_{n=1}^{7} \frac{I_{Sn}}{7}$ OR $I_1 = \max_{n=7} \{I_{Sn}\}$

FIG. 10

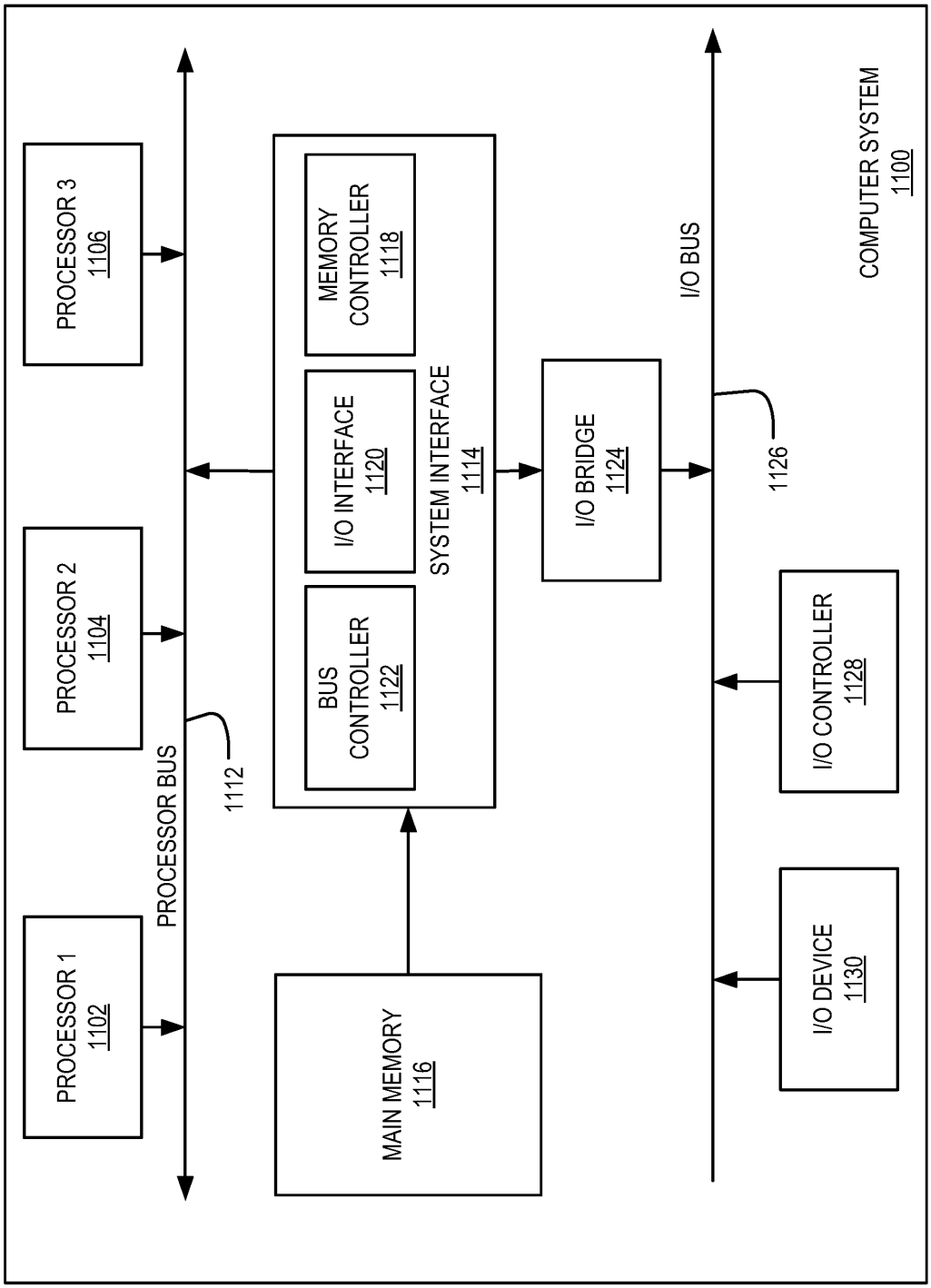

COMPUTER SYSTEM
1100
PROCESSOR 1
1102
PROCESSOR 2
1104
PROCESSOR 3
1106
PROCESSOR BUS
1112
SYSTEM INTERFACE
1114
BUS CONTROLLER
1122
I/O INTERFACE
1120
MEMORY CONTROLLER
1118
MAIN MEMORY
1116
I/O BRIDGE
1124
I/O BUS
1126
I/O CONTROLLER
1128
I/O DEVICE
1130

FIG. 11