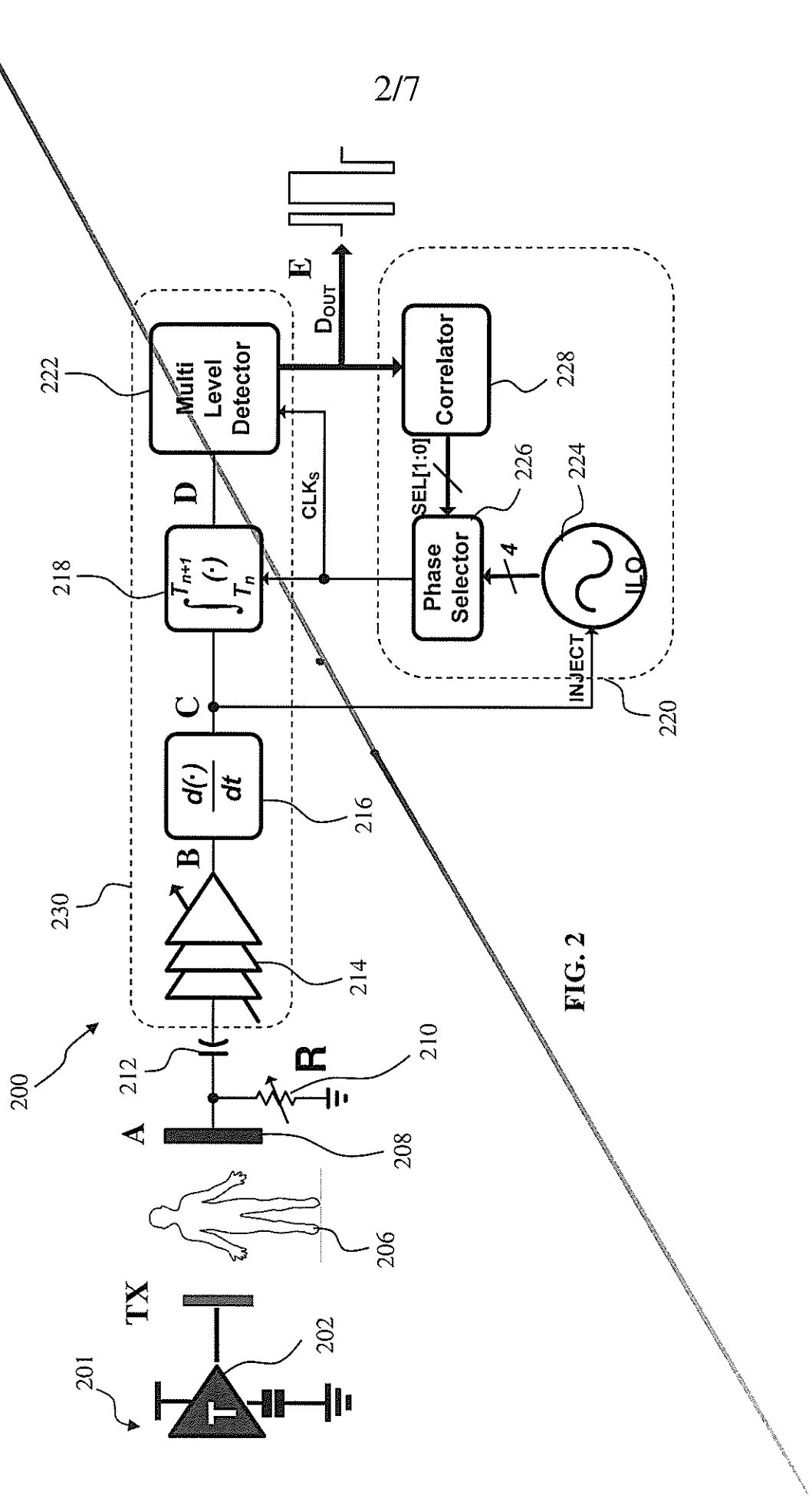

200
201
TX
T
202
206
208
A
212
R
210
214
230
B
216
d(·)/dt
C
218
∫ Tn+1 Tn (·)
D
222
Multi Level Detector
E
DOUT
CLKS
228
Correlator
SEL[1:0]
226
Phase Selector
4
224
ILO
INJECT
220

FIG. 2

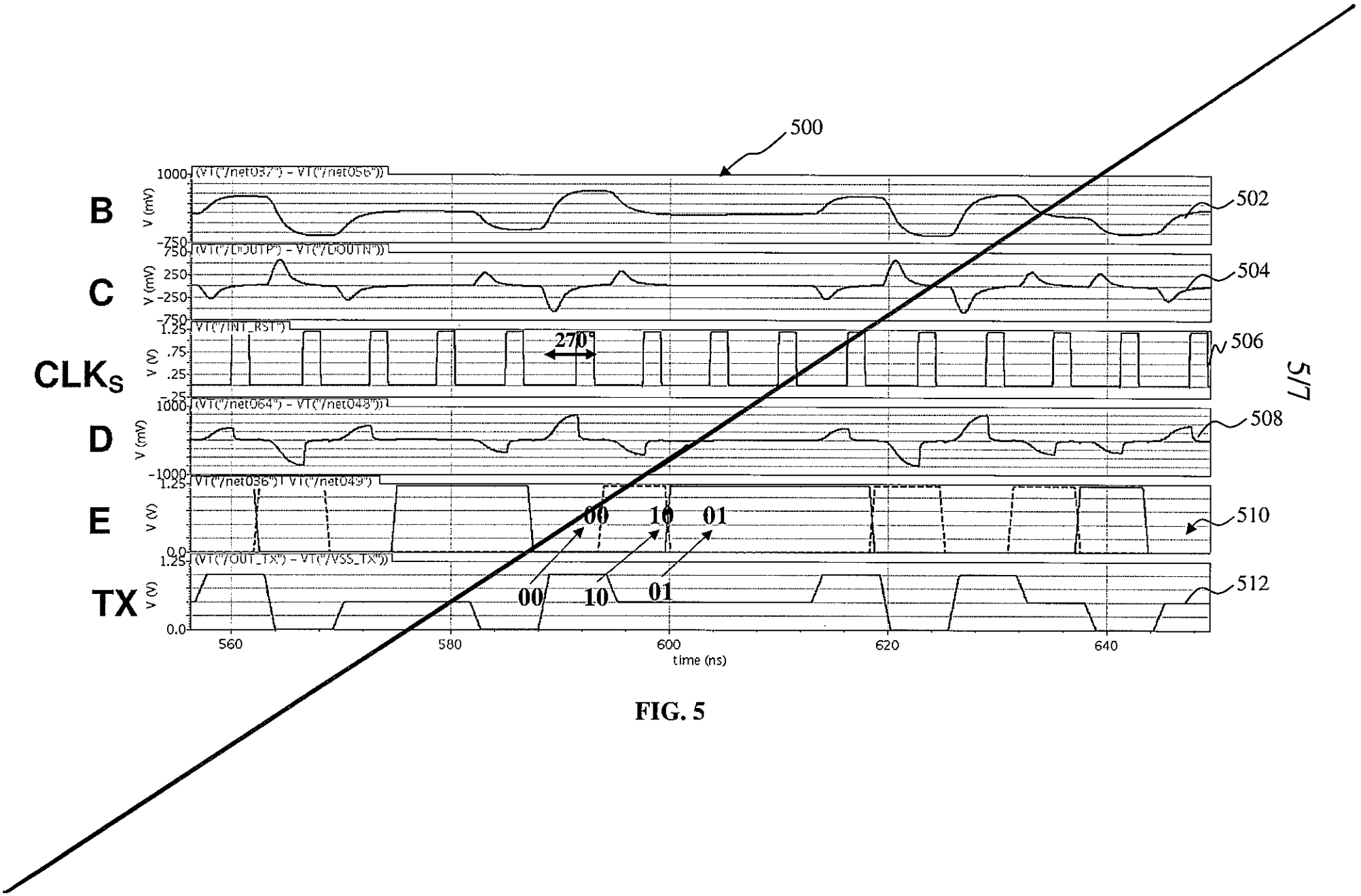
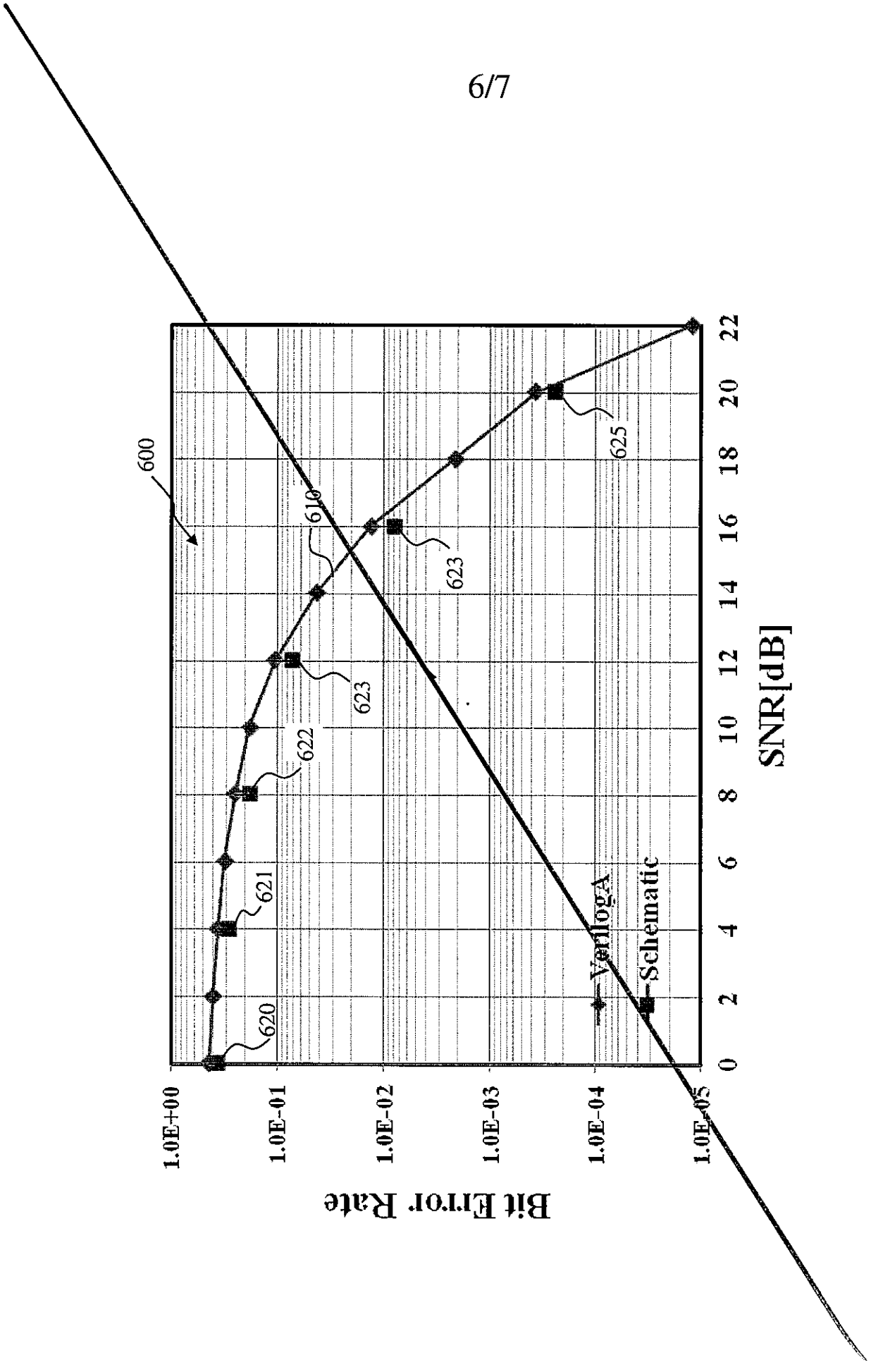

500
B
C
CLKs
D
E
TX
502
504
506
508
510
512
270°
00
10
01
00
10
01
time (ns)
560
580
600
620
640

FIG. 5


600
610
620
621
622
623
623
625
Bit Error Rate
1.0E+00
1.0E-01
1.0E-02
1.0E-03
1.0E-04
1.0E-05
0
2
4
6
8
10
12
14
16
18
20
22
SNR[dB]
VerilogA
Schematic

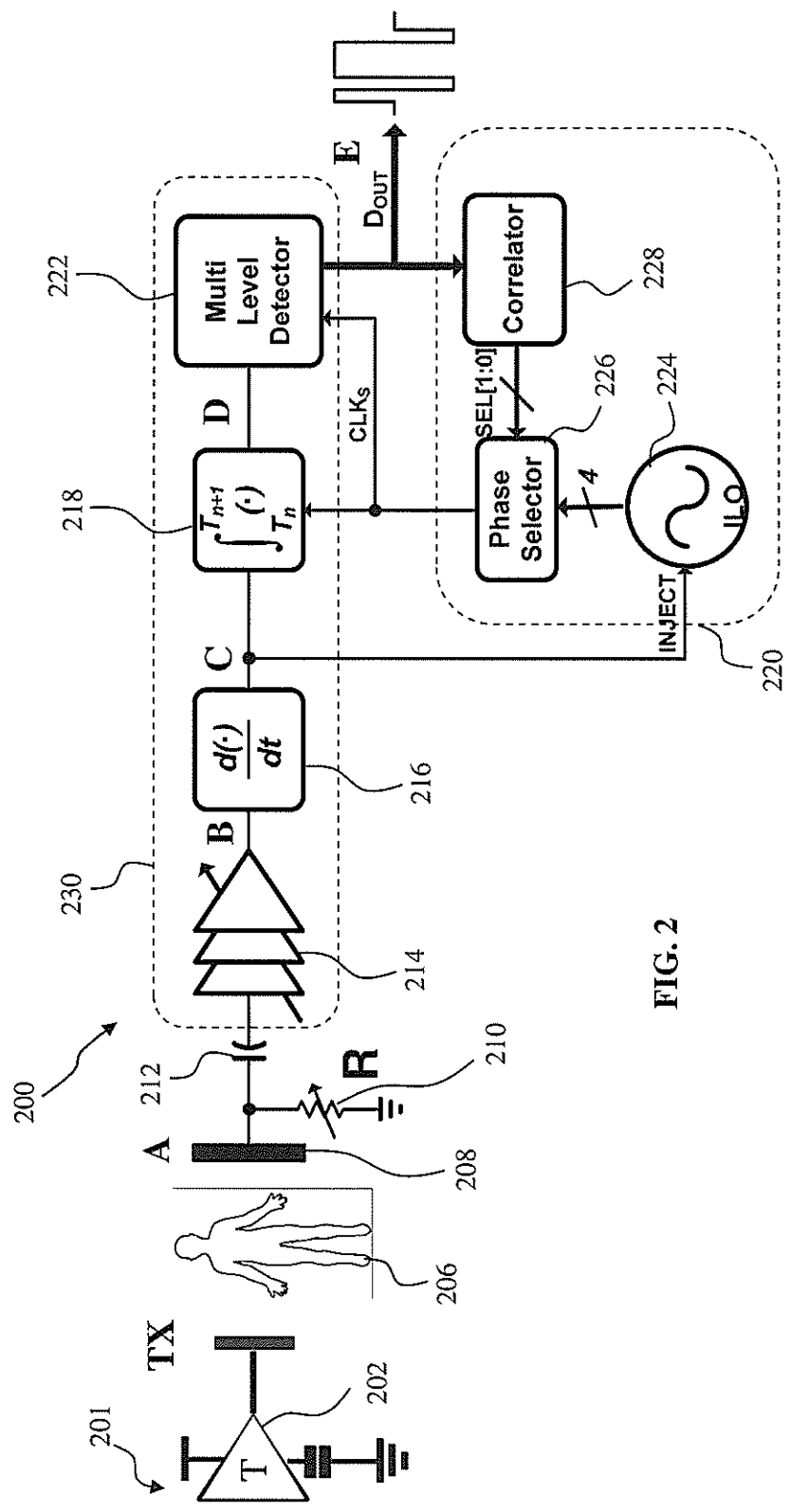

200
201
TX
T
202
206
208
A
212
R
210
214
230
B
216
C
218
D
222
Multi Level Detector
CLKs
E
DOUT
Correlator
228
SEL[1:0]
226
Phase Selector
4
224
LO
INJECT
220

FIG. 2

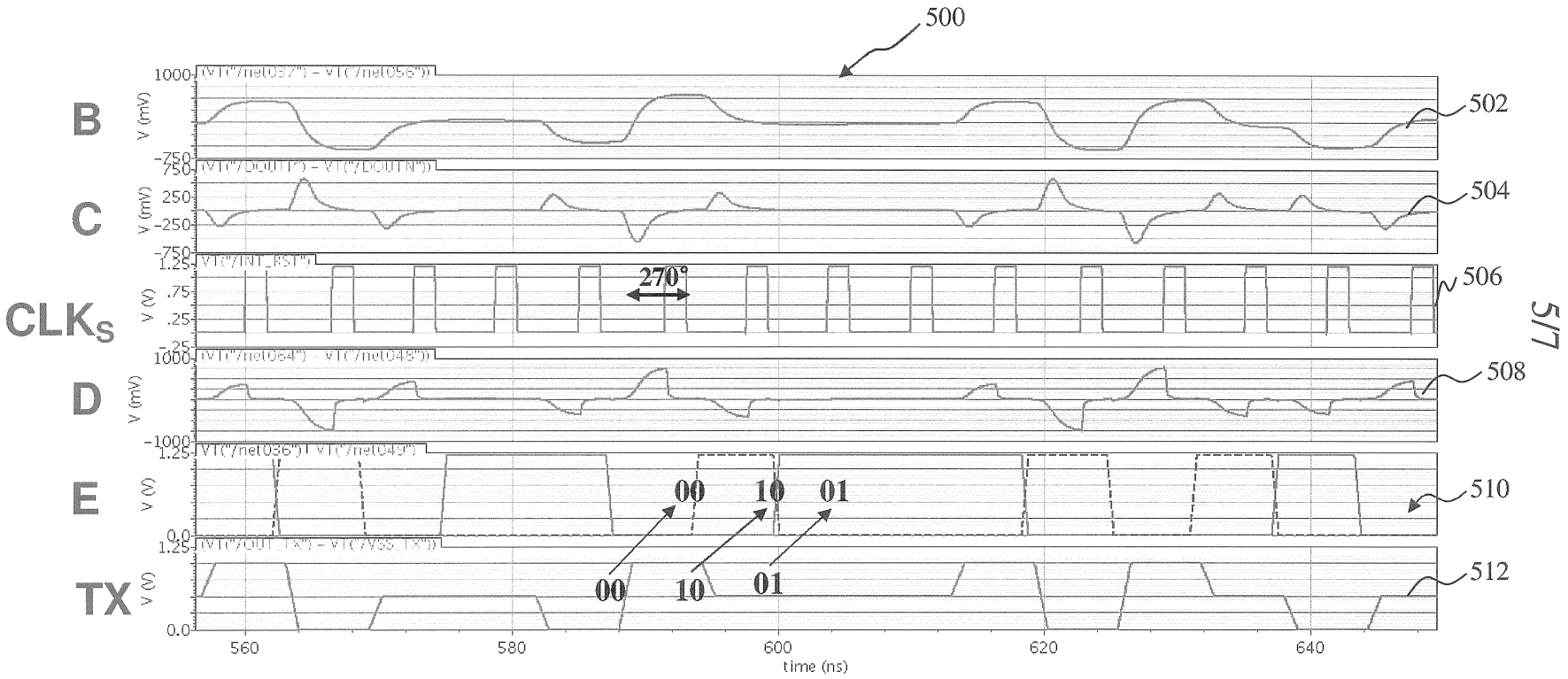

500
B
C
CLKS
D
E
TX
502
504
506
508
510
512
270°
00
10
01
00
10
01
V (mV)
V (V)
time (ns)
560
580
600
620
640

FIG. 5

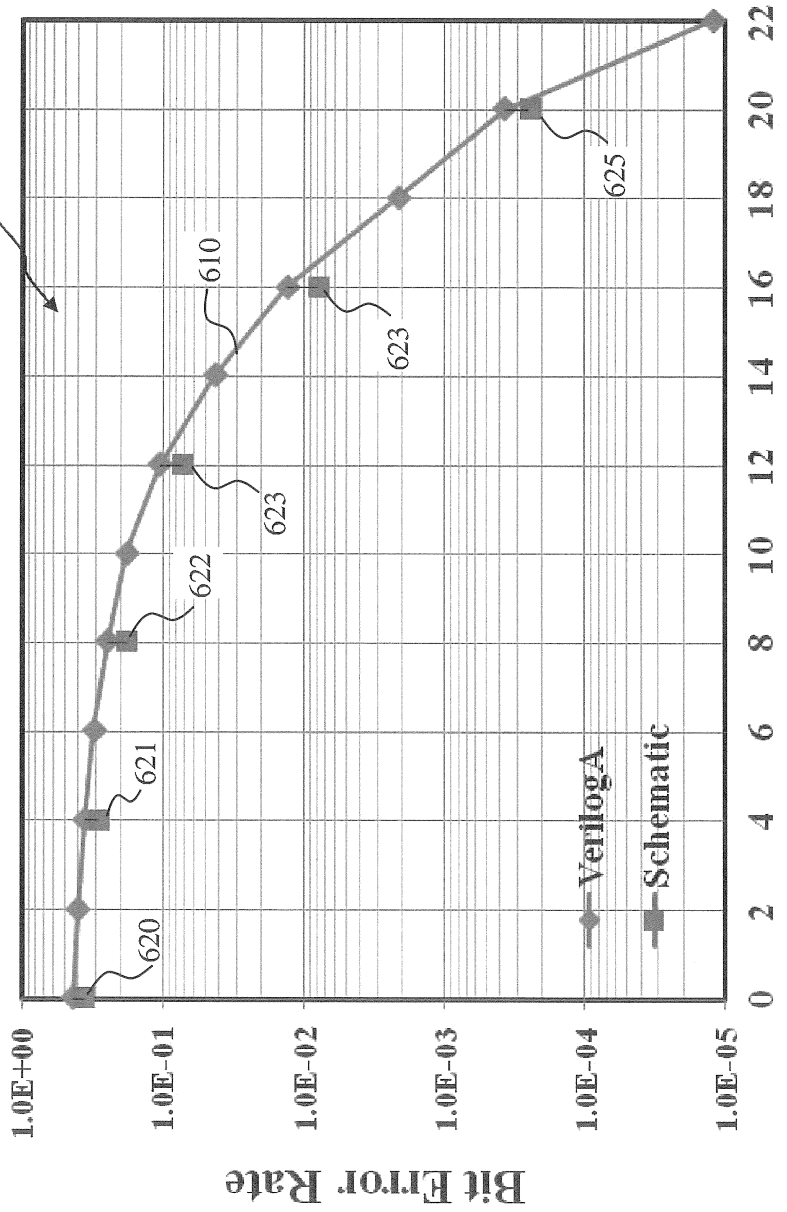

600
610
620
621
622
623
623
625
Bit Error Rate
1.0E+00
1.0E-01
1.0E-02
1.0E-03
1.0E-04
1.0E-05
0
2
4
6
8
10
12
14
16
18
20
22
SNR[dB]
VerilogA
Schematic

FIG. 6

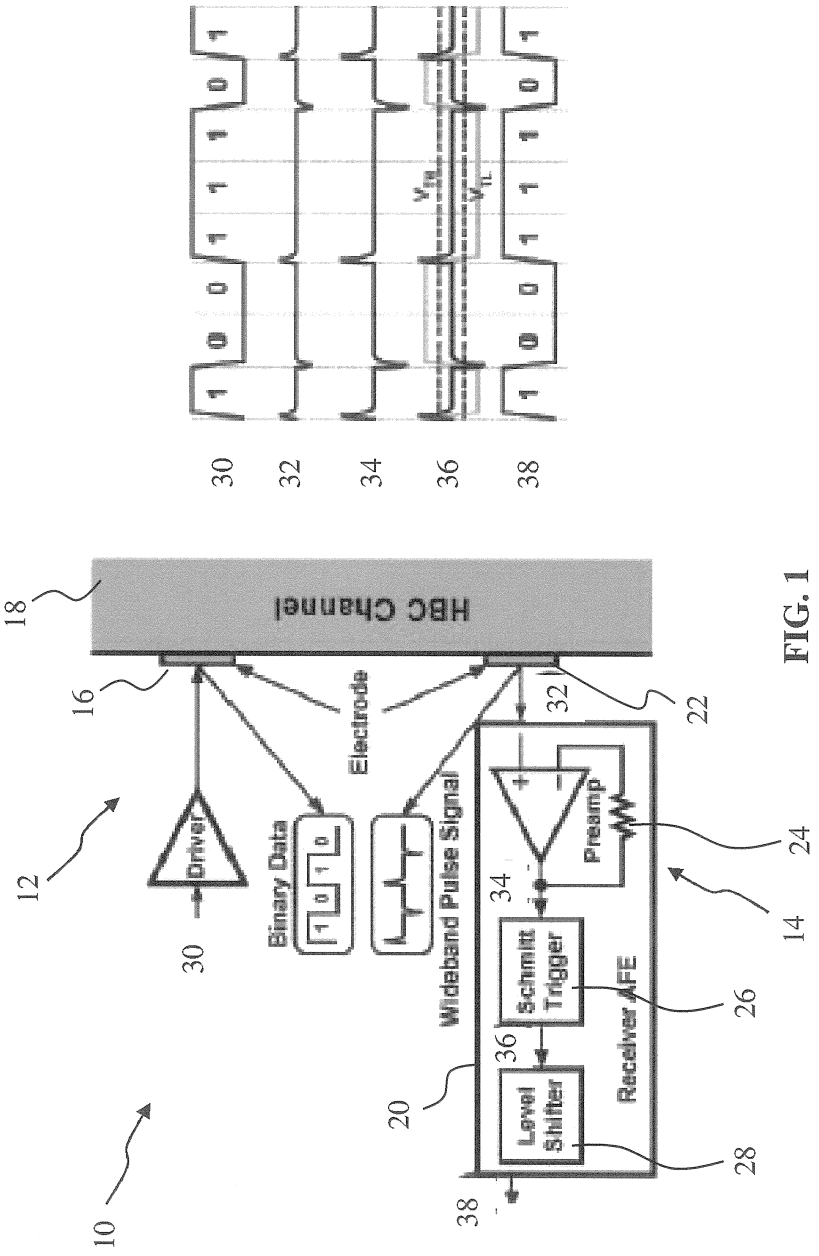

HBC Channel
18
16
Electrode
32
22
12
Driver
Binary Data
1 0 1 0
Wideband Pulse Signal
Preamp
24
34
30
Schmitt Trigger
26
14
Receiver AFE
36
20
Level Shifter
28
38
10
30
32
34
36
38

FIG. 1

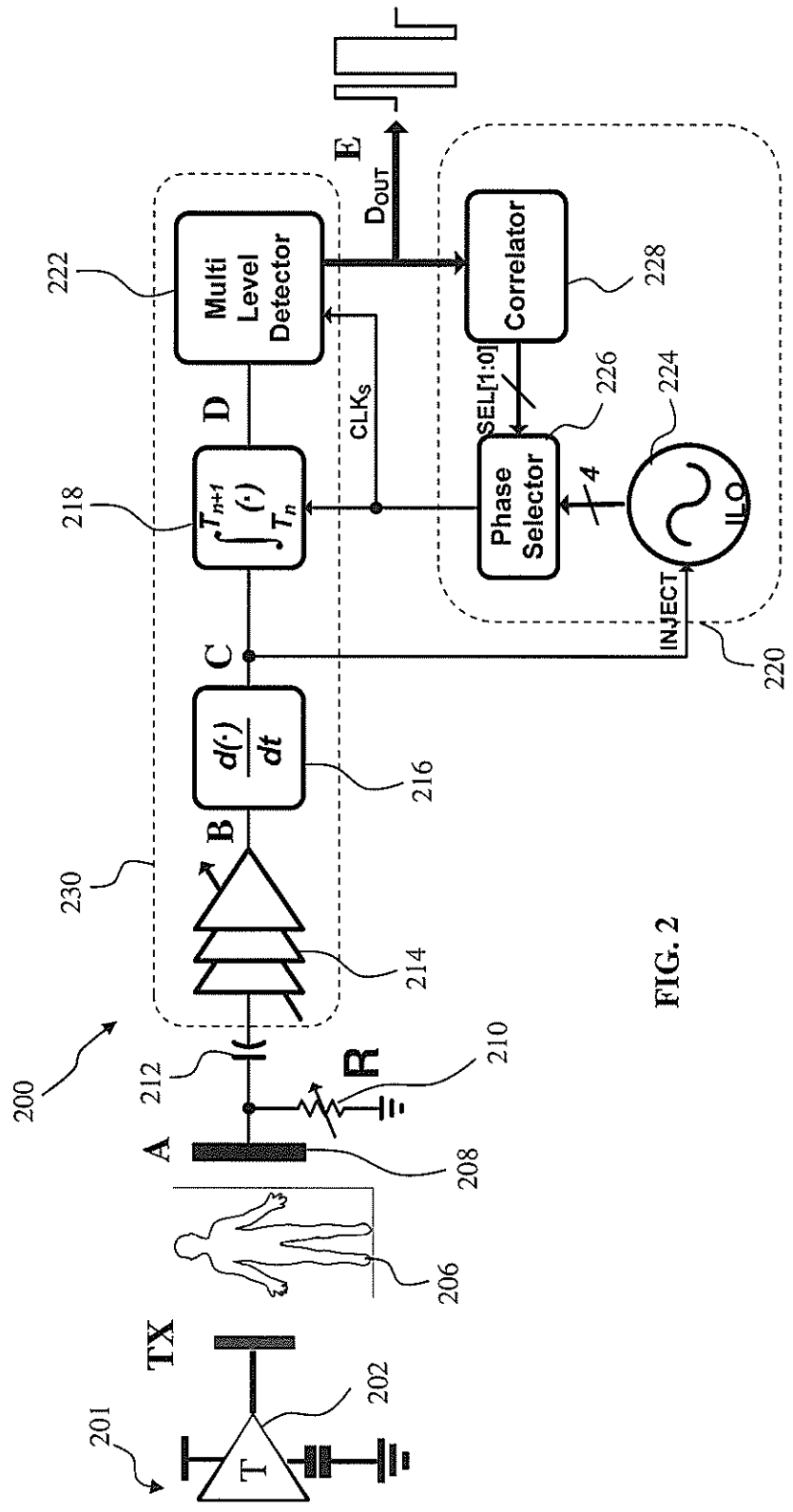

201
TX
T
202
206
208
A
210
R
212
200
214
B
230
216
d(·)/dt
C
218
∫ Tn+1 Tn (·)
D
222
Multi Level Detector
E
DOUT
CLKS
SEL[1:0]
226
Phase Selector
4
224
LO
228
Correlator
INJECT
220

FIG. 2

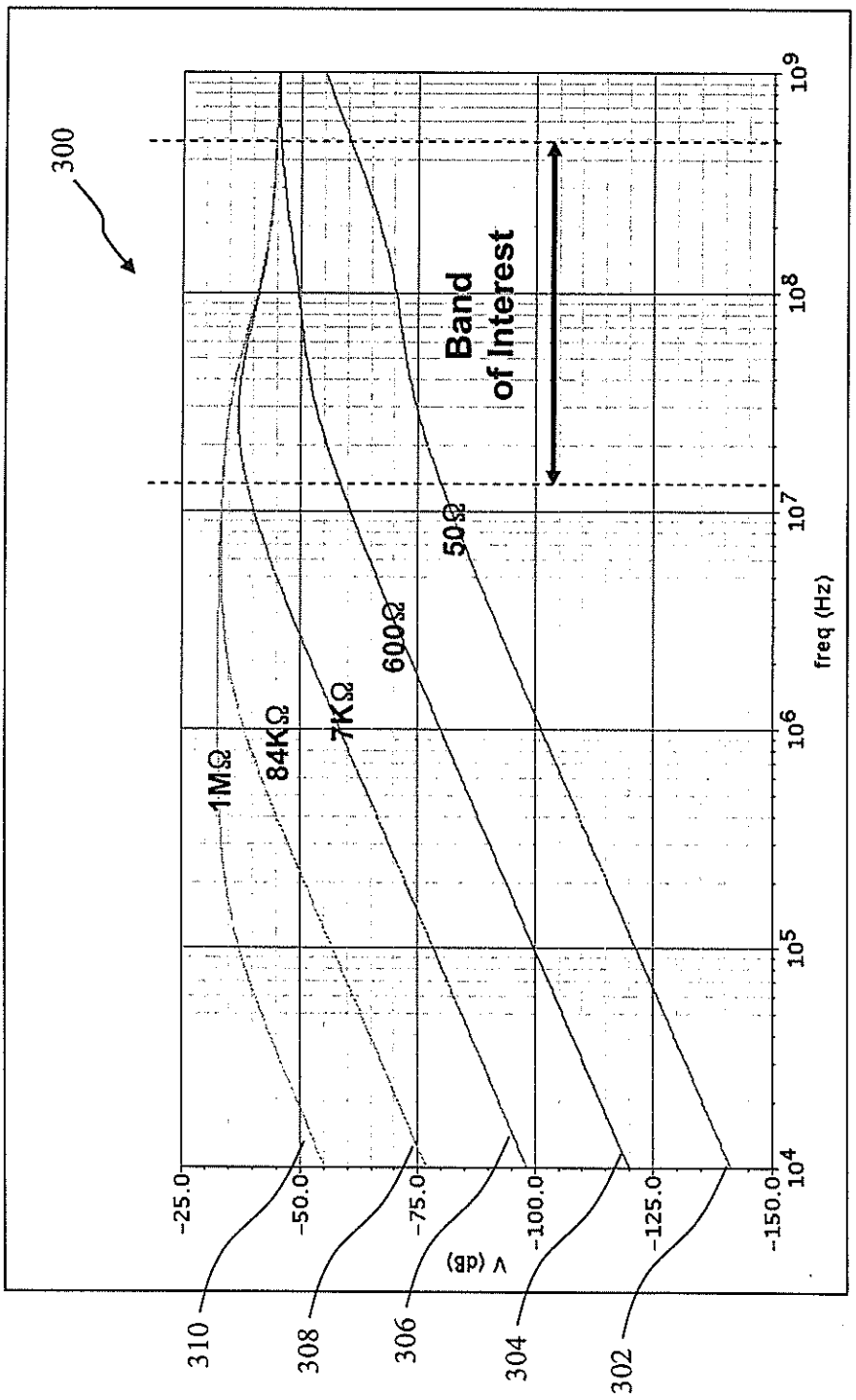

300
Band
of Interest
1MΩ
84KΩ
7KΩ
600Ω
50Ω
freq (Hz)
v (dB)
-25.0
-50.0
-75.0
-100.0
-125.0
-150.0
10^4
10^5
10^6
10^7
10^8
10^9
310
308
306
304
302

FIG. 3

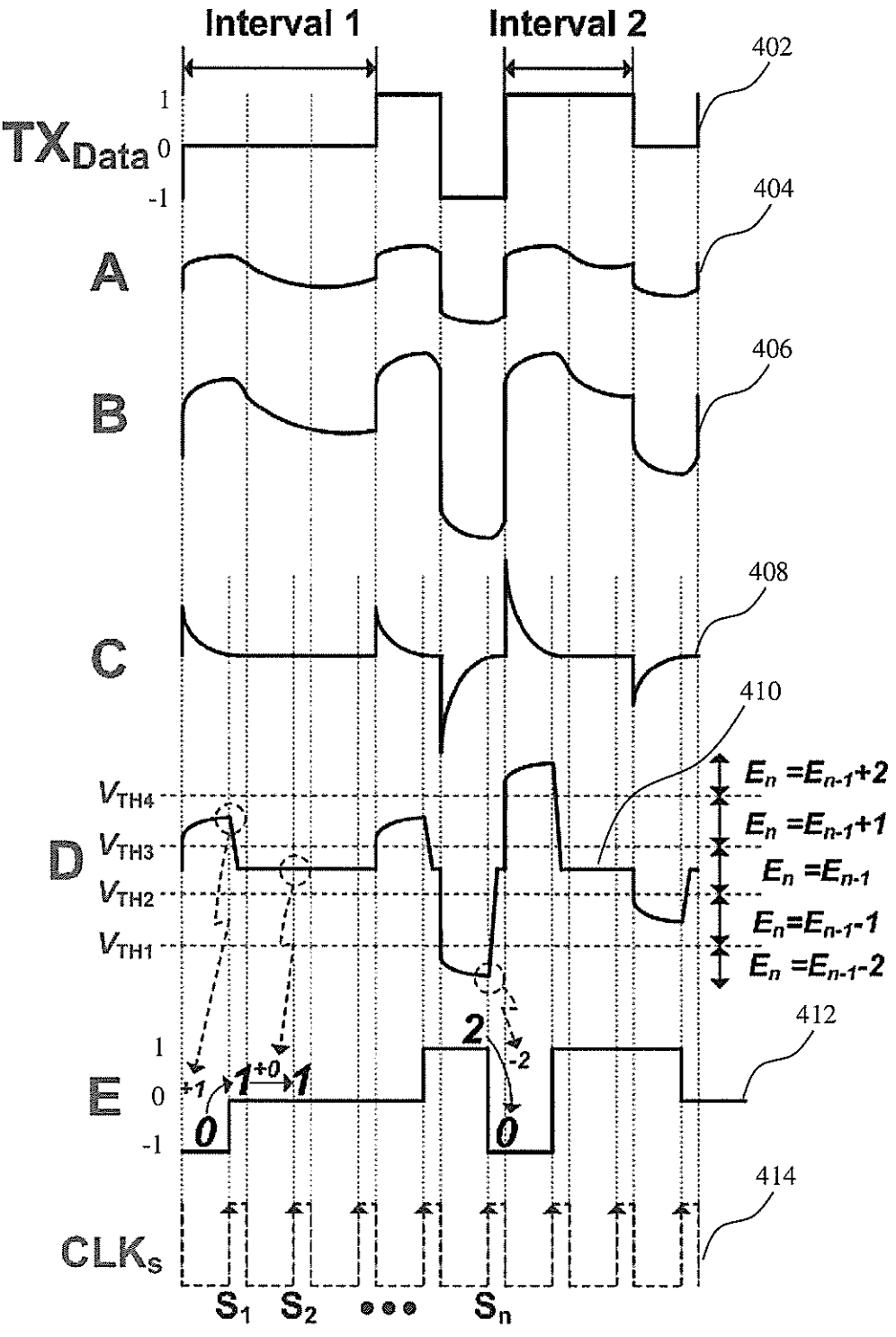

Interval 1
Interval 2
402
TXData
1
0
-1
404
A
406
B
408
C
410
D
VTH4
VTH3
VTH2
VTH1
En =En-1+2
En =En-1+1
En =En-1
En=En-1-1
En =En-1-2
412
E
1
0
-1
+1
+0
-2
414
CLKS
S1
S2
Sn

FIG. 4

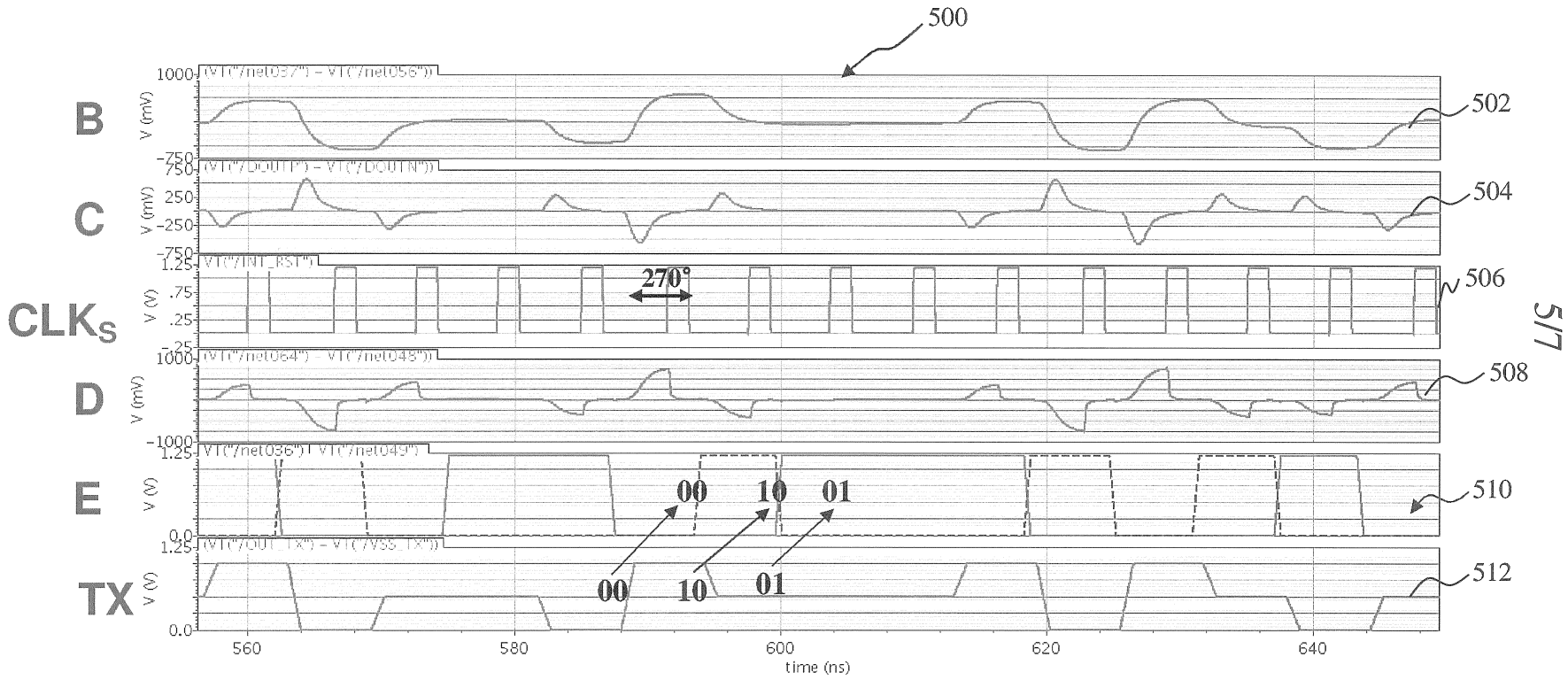

500
B
C
CLKS
D
E
TX
V (mV)
V (V)
1000
-750
750
250
-250
1.25
.75
.25
-1000
0.0
270°
00
10
01
502
504
506
508
510
512
560
580
600
620
640
time (ns)

FIG. 5

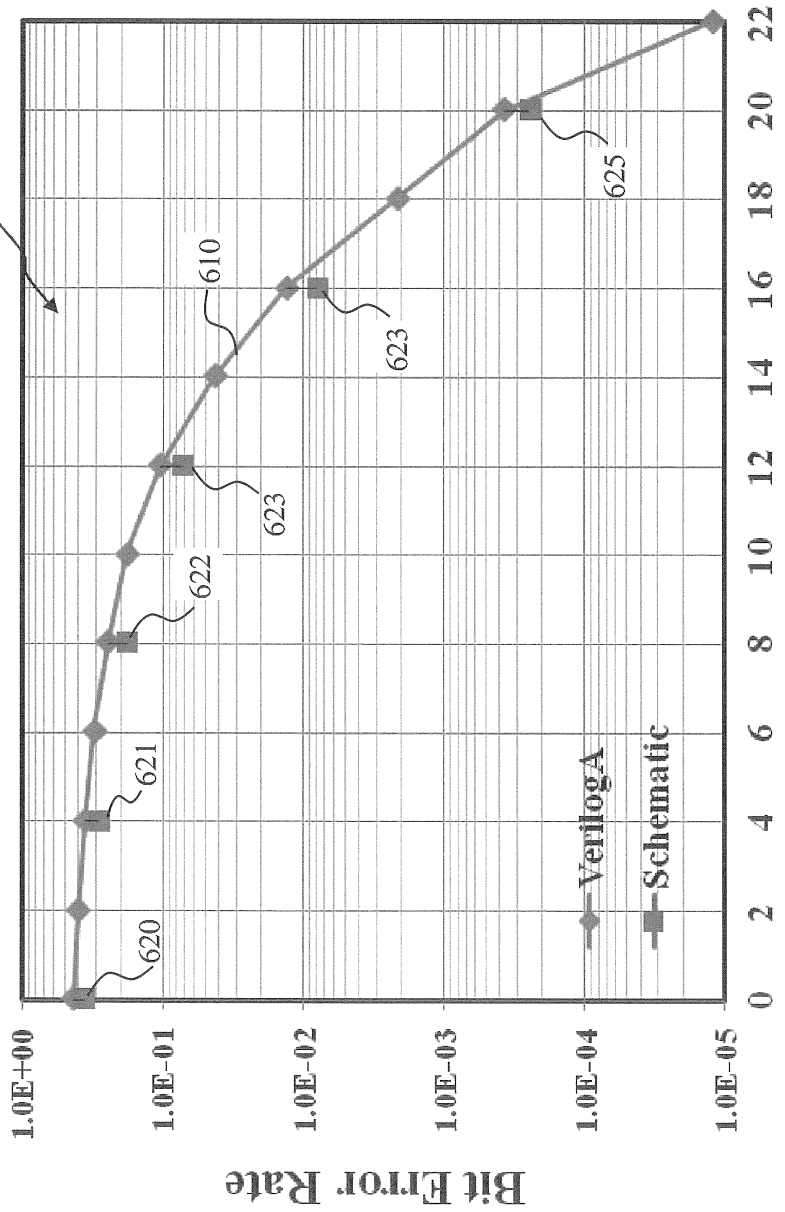

600
610
620
621
622
623
623
625
Bit Error Rate
1.0E+00
1.0E-01
1.0E-02
1.0E-03
1.0E-04
1.0E-05
0
2
4
6
8
10
12
14
16
18
20
22
SNR[dB]
VerilogA
Schematic

FIG. 6

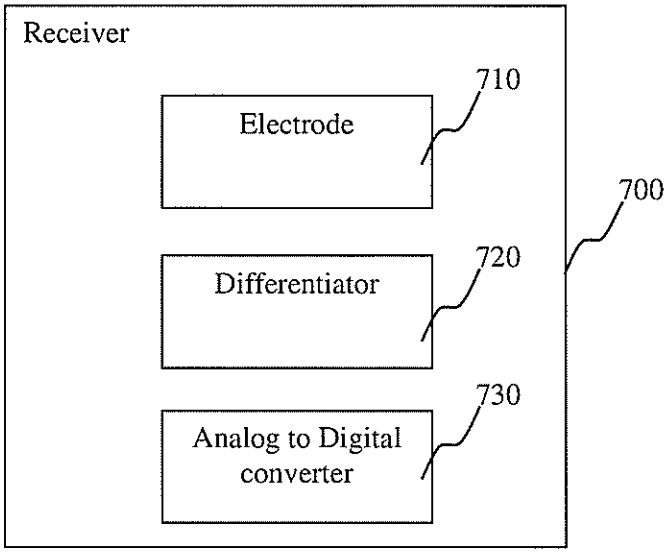

Receiver
Electrode
710
700
Differentiator
720
Analog to Digital converter
730

FIG. 7

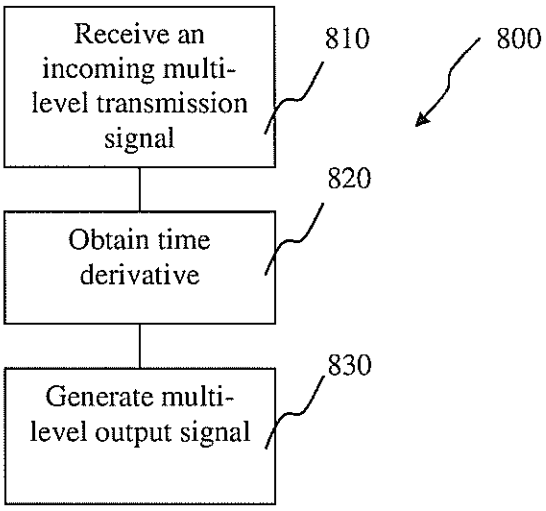

Receive an incoming multi-level transmission signal
810
800
Obtain time derivative
820
Generate multi-level output signal
830

FIG. 8