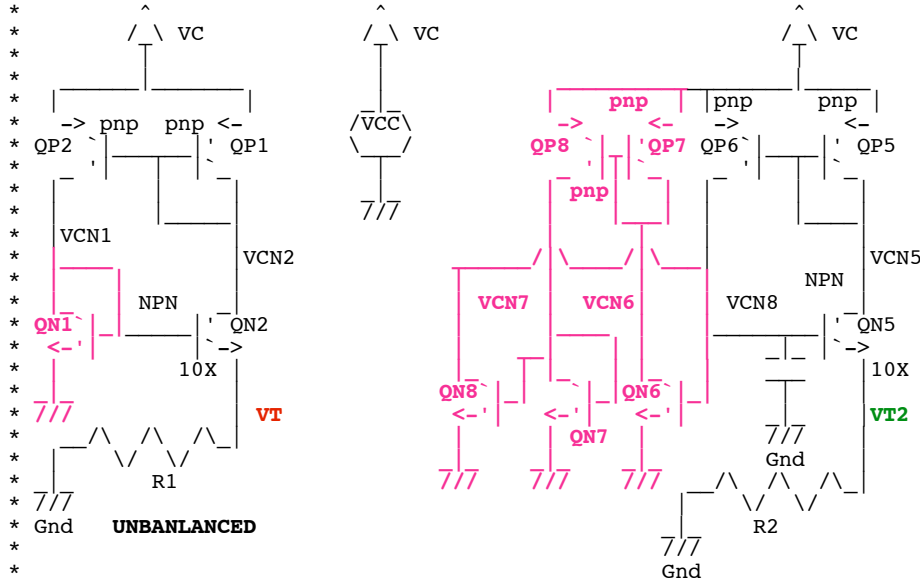


=====**Balanced_BandGap.cir**=====

HOW TO MAKE A PRECISE BANDGAP THAT HAS BEEN SHOWN TO WORK AT A 900MV (DEAD BATTERY VOLTAGE LEVEL), OVER -55C TO 155C, WITHOUT DRAINING THE BATTERY.

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* www.idea2ic.com



* **Patent No.: US 6,614,293 B1**

.OPTIONS gminsteps = 1

```

=====
VCC      VC      0          DC      5
*Q_NUMB  COL     BASE    EMIT   SUB    MODEL  AREA
QN1      VCN1   VCN1    0      SUB    NPN1   1
QN2      VCN2   VCN1    VT     SUB    NPN1  10
QP1      VCN2   VCN2    VC     SUB    PNP1   1
QP2      VCN1   VCN2    VC     SUB    PNP1   1
R1       VT     0       60K
QN5      VCN5   VCN8    VT2    SUB    NPN1  10
QN6      VCN6   VCN8    0      SUB    NPN1   1
QN7      VCN7   VCN7    0      SUB    NPN1   1
QN8      VCN8   VCN7    0      SUB    NPN1   1
QP5      VCN5   VCN5    VC     SUB    PNP1   1
QP6      VCN8   VCN5    VC     SUB    PNP1   1
QP7      VCN6   VCN6    VC     SUB    PNP1   1
QP8      VCN7   VCN6    VC     SUB    PNP1   1
R2       VT2    0       60K
C2       VCN8   0       1P
.dc      VCC      1.5      5      1

```

*#0====The_Balanced_BandGap_Balances_Out_Beta_And_VAF====

.control

*#1====Start_Off_With_Normal_Levels_Of_Beta_And_VAF====

```

run
plot          vt          vt2  title    BF_110_50_VAF_60_30

```

*#2====Test_The_Effects_Of_Cutting_NPN_Beta_BY_50%====

```

altermod  npn1      bf=50
run
plot          vt          vt2  title    BF_50_50_VAF_60_30

```

*#3====Test_The_Effects_Of_Cutting_PNP_Beta_BY_50%====

```

altermod  npn1      bf=110

```

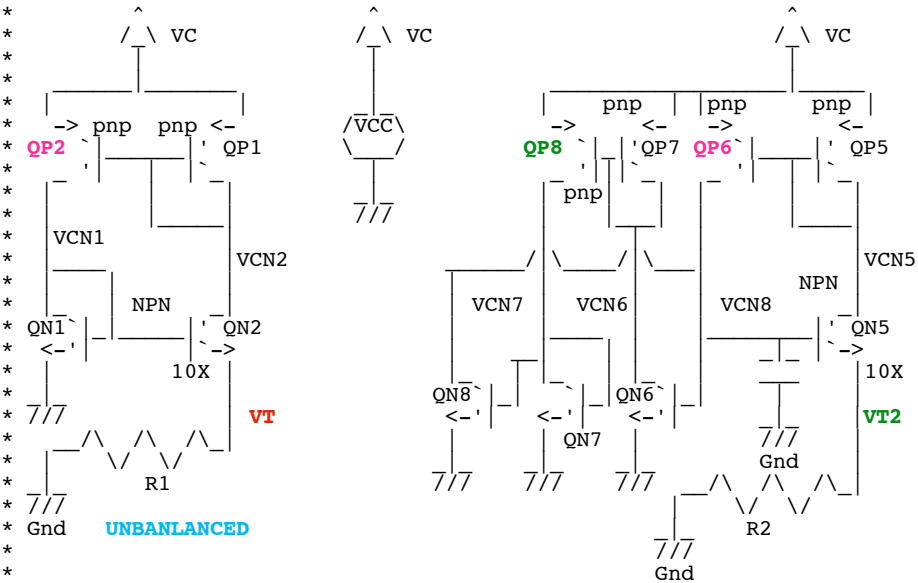
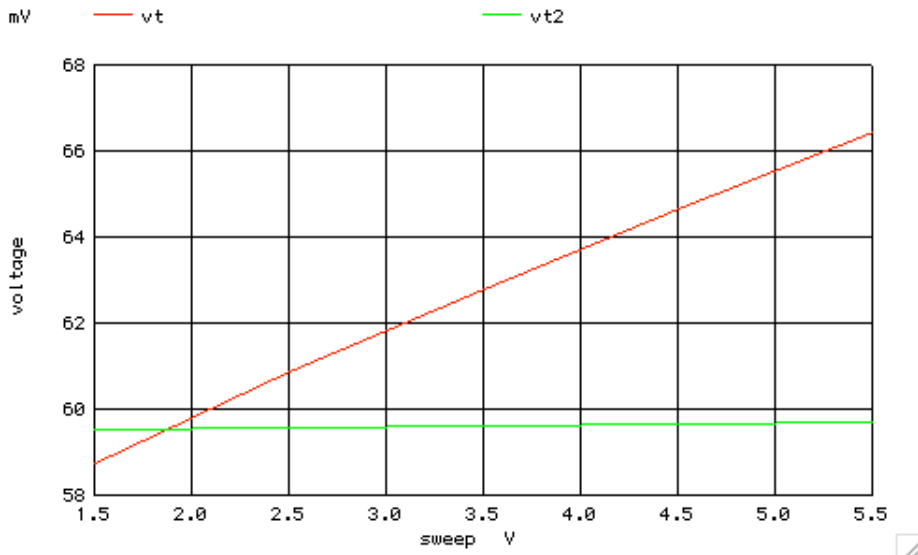
```

altermod  npn1      bf=25
run
plot      vt                vt2  title  BF_110_25_VAF_60_30
*#4====Test_The_Effects_Of_Cutting_NPN_VAF_BY_50%====
altermod  npn1      bf=50
altermod  npn1      vaf=30
run
plot      vt                vt2  title  BF_110_50_VAF_30_30
*#5====Test_The_Effects_Of_Cutting_PNP_VAF_BY_50%====
altermod  npn1      vaf=60
altermod  npn1      vaf=15
run
plot      vt                vt2  title  BF_110_50_VAF_60_15

.endc
*=====
.model  NPN1  NPN(  BF=110  VAF=60  )
.model  PNP1  PNP(  BF=50   VAF=30  )
.END

```


Graph 20 - dc30: BF_110_50_VAF_60_15

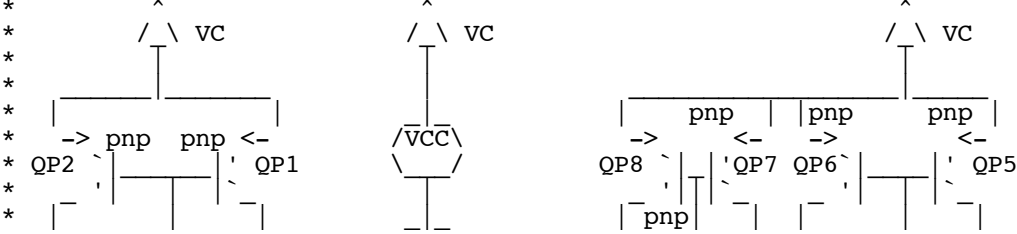


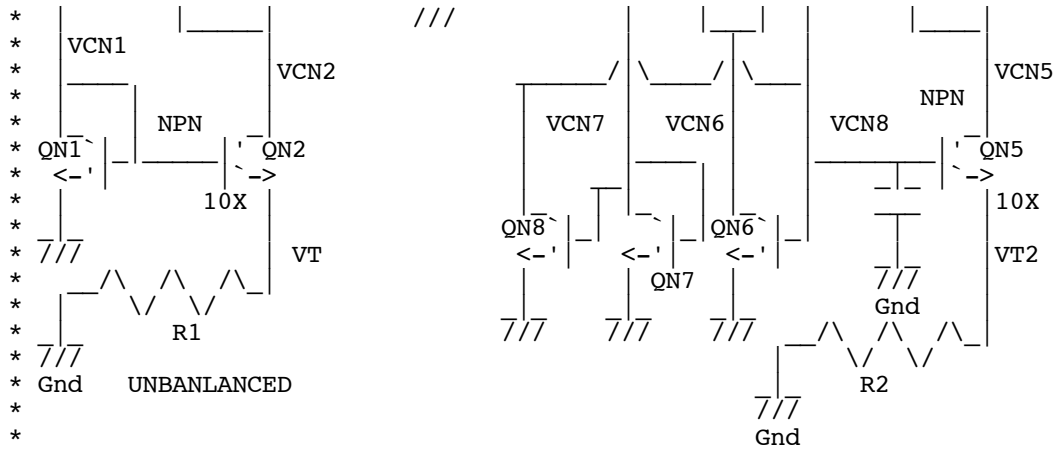
Transistors **QP8** balances out **QP6**

When the supply voltage is too low to add cascodes, the "old" balancing technique appears to work.

*#1=====WinSpiceVersion=====

Balanced_BandGap.cir
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* Patent No.: US 6,614,293 B1

.OPTIONS gminsteps = 1

```

=====
VCC      VC      0          DC      5
*Q_NUMB  COL     BASE     EMIT   SUB     MODEL  AREA
QN1      VCN1    VCN1     0      SUB     NPN1   1
QN2      VCN2    VCN1     VT     SUB     NPN1   10
QP1      VCN2    VCN2     VC     SUB     PNP1   1
QP2      VCN1    VCN2     VC     SUB     PNP1   1
R1       VT      0        60K
QN5      VCN5    VCN8     VT2    SUB     NPN1   10
QN6      VCN6    VCN8     0      SUB     NPN1   1
QN7      VCN7    VCN7     0      SUB     NPN1   1
QN8      VCN8    VCN7     0      SUB     NPN1   1
QP5      VCN5    VCN5     VC     SUB     PNP1   1
QP6      VCN8    VCN5     VC     SUB     PNP1   1
QP7      VCN6    VCN6     VC     SUB     PNP1   1
QP8      VCN7    VCN6     VC     SUB     PNP1   1
R2       VT2    0        60K
C2       VCN8    0        1P
.dc      VCC      1.5      5      1

```

*#0====The_Balanced_BandGap_Balances_Out_Beta_And_VAF====

.control

*#1====Start_Off_With_Normal_Levels_Of_Beta_And_VAF====

```

run
plot          vt          vt2 title  BF_110_50_VAF_60_30

```

*#2====Test_The_Effects_Of_Cutting_NPN_Beta_BY_50%====

```

alter npn1    bf=50
run
plot          vt          vt2 title  BF_50_50_VAF_60_30

```

*#3====Test_The_Effects_Of_Cutting_PNP_Beta_BY_50%====

```

alter npn1    bf=110
alter pnp1    bf=25
run
plot          vt          vt2 title  BF_110_25_VAF_60_30

```

*#4====Test_The_Effects_Of_Cutting_NPN_VAF_BY_50%====

```

alter pnp1    bf=50
alter npn1    vaf=30
run
plot          vt          vt2 title  BF_110_50_VAF_30_30

```

*#5====Test_The_Effects_Of_Cutting_PNP_VAF_BY_50%====

```

alter npn1    vaf=60
alter pnp1    vaf=15
run
plot          vt          vt2 title  BF_110_50_VAF_60_15

```

.endc

```

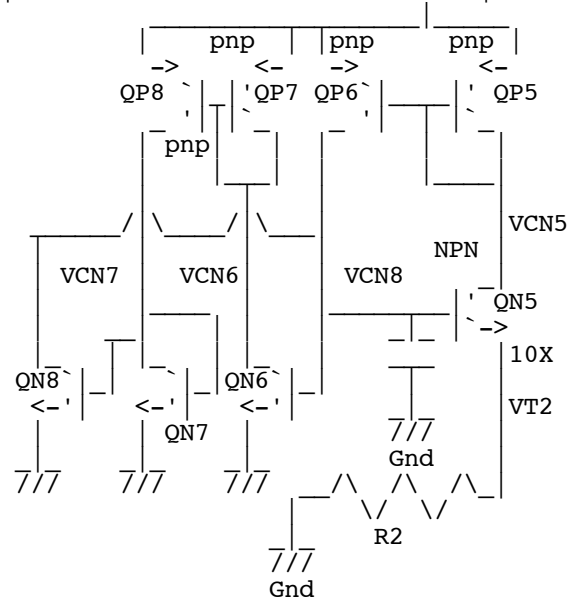
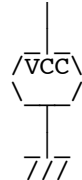
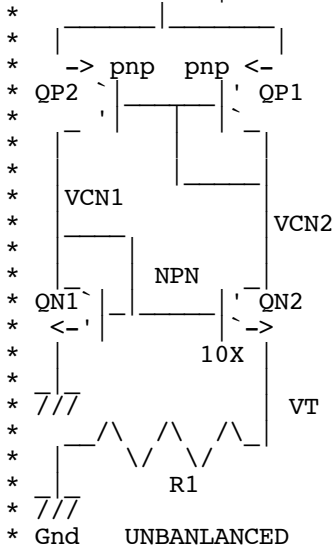
=====
.model  NPN1  NPN( BF=110 VAF=60 )

```



```
.model PNP1 PNP( BF=50 VAF=30 )
```

```
.END*
```



```
* Patent No.: US 6,614,293 B1
```

```
.OPTIONS gminsteps = 1
```

```
*****
```

VCC	VC	0	DC	5		
*Q_NUMB	COL	BASE	EMIT	SUB	MODEL	AREA
QN1	VCN1	VCN1	0		NPN1	1
QN2	VCN2	VCN1	VT		NPN1	10
QP1	VCN2	VCN2	VC		PNP1	1
QP2	VCN1	VCN2	VC		PNP1	1
R1	VT	0	60K			
QN5	VCN5	VCN8	VT2		NPN1	10
QN6	VCN6	VCN8	0		NPN1	1
QN7	VCN7	VCN7	0		NPN1	1
QN8	VCN8	VCN7	0		NPN1	1
QP5	VCN5	VCN5	VC		PNP1	1
QP6	VCN8	VCN5	VC		PNP1	1
QP7	VCN6	VCN6	VC		PNP1	1
QP8	VCN7	VCN6	VC		PNP1	1
R2	VT2	0	60K			
C2	VCN8	0	1P			

```
.dc VCC 1.5 5 1
```

```
*#0====The_Balanced_BandGap_Balances_Out_Beta_And_VAF====
```

```
.control
```

```
*#1====Start_Off_With_Normal_Levels_Of_Beta_And_VAF====
run
plot vt vt2 title BF_110_50_VAF_60_30

*#2====Test_The_Effects_Of_Cutting_NPN_Beta_BY_50%====
alter npn1 bf=50
run
plot vt vt2 title BF_50_50_VAF_60_30

*#3====Test_The_Effects_Of_Cutting_PNP_Beta_BY_50%====
alter npn1 bf=110
alter pnp1 bf=25
run
plot vt vt2 title BF_110_25_VAF_60_30

*#4====Test_The_Effects_Of_Cutting_NPN_VAF_BY_50%====
alter npn1 bf=50
alter npn1 vaf=30
run
plot vt vt2 title BF_110_50_VAF_30_30
```

```
*#5====Test_The_Effects_Of_Cutting_PNP_VAF_BY_50%====
alter npn1      vaf=60
alter pnp1      vaf=15
run
plot           vt                vt2  title  BF_110_50_VAF_60_15

.endc
*=====
.model NPN1     NPN(    BF=110 VAF=60 )
.model PNP1     PNP(    BF=50  VAF=30 )

.END
```