

*ANALOG BANDGAP REFERENCE CIRCUIT

*TEMPERATURE_VARIATION_AND_COEFFICIENT

```
.options savecurrents
.lib "sky130_fd_pr/models/sky130.lib.spice" tt
.include "sky130_fd_pr/models/sky130_fd_pr__model__pnp.model.spice"
```

*BGR CIRCUIT

```
R4 VDD Net-_M24-Pad1_ 200k
xM24 Net-_M24-Pad1_ EN Net-_M20-Pad1_ GND sky130_fd_pr__nfet_g5v0d10v5 l=5 w=20
xM20 Net-_M20-Pad1_ Net-_M1-Pad1_ GND GND sky130_fd_pr__nfet_g5v0d10v5 l=5 w=20
xM21 Net-_M21-Pad1_ EN Net-_M21-Pad3_ GND sky130_fd_pr__nfet_g5v0d10v5 l=5 w=20
xM22 Net-_M22-Pad1_ EN Net-_M22-Pad3_ GND sky130_fd_pr__nfet_g5v0d10v5 l=5 w=20
R1 Net-_M22-Pad3_ Net-_Q2-Pad3_ 31k
xQ1 GND GND Net-_M21-Pad3_ GND sky130_fd_pr__pnp_05v5_W3p40L3p40 M=1
xQ2 GND GND Net-_Q2-Pad3_ GND sky130_fd_pr__pnp_05v5_W3p40L3p40 M=8
xQ3 GND GND V1 GND sky130_fd_pr__pnp_05v5_W3p40L3p40 M=1
R2 VREF V1 282.1k
R3 VREF GND 100MEG
xM9 Net-_M1-Pad2_ Net-_M20-Pad1_ GND GND sky130_fd_pr__nfet_g5v0d10v5 l=5 w=20
xM4 Net-_M1-Pad1_ Net-_M1-Pad1_ Net-_M21-Pad1_ GND sky130_fd_pr__nfet_g5v0d10v5 l=5 w=20
xM5 Net-_M1-Pad2_ Net-_M1-Pad1_ Net-_M22-Pad1_ GND sky130_fd_pr__nfet_g5v0d10v5 l=5 w=20
xM23 Net-_M23-Pad1_ EN VREF GND sky130_fd_pr__nfet_g5v0d10v5 l=5 w=20
xM1 Net-_M1-Pad1_ Net-_M1-Pad2_ VDD VDD sky130_fd_pr__pfet_g5v0d10v5 l=5 w=20
xM2 Net-_M1-Pad2_ Net-_M1-Pad2_ VDD VDD sky130_fd_pr__pfet_g5v0d10v5 l=5 w=20
xM3 Net-_M23-Pad1_ Net-_M1-Pad2_ VDD VDD sky130_fd_pr__pfet_g5v0d10v5 l=5 w=20
```

Vdd VDD GND dc 3.3V

VD EN GND dc 3.3V

```
.dc temp -40 140 0.1
```

```
.control
```

```
run
plot V(VREF)
*CTAT
plot V(V1)
*PTAT
plot V(VREF,V1)
*Temp_coefficient
plot deriv(v(VREF))/1.20
*combined
plot v(VREF) v(V1) v(VREF,V1)
.endc
```

```
.end
```

*ANALOG BANDGAP REFERENCE CIRCUIT

*SUPPLY_VARIATION_AND_COEFFICIENT

```
.options savecurrents
.lib "sky130_fd_pr/models/sky130.lib.spice" tt
.include "sky130_fd_pr/models/sky130_fd_pr__model__pnp.model.spice"
```

*BGR CIRCUIT

```
R4 VDD V3 200k
xM24 Net-_M24-Pad1_ EN Net-_M20-Pad1_ GND sky130_fd_pr__nfet_g5v0d10v5 l=5 w=20
xM20 Net-_M20-Pad1_ Net-_M1-Pad1_ GND GND sky130_fd_pr__nfet_g5v0d10v5 l=5 w=20
xM21 Net-_M21-Pad1_ EN V4 GND sky130_fd_pr__nfet_g5v0d10v5 l=5 w=20
xM22 Net-_M22-Pad1_ EN V5 GND sky130_fd_pr__nfet_g5v0d10v5 l=5 w=20
R1 Net-_M22-Pad3_ Net-_Q2-Pad3_ 31k
xQ1 GND GND Net-_M21-Pad3_ GND sky130_fd_pr__pnp_05v5_W3p40L3p40 M=1
xQ2 GND GND Net-_Q2-Pad3_ GND sky130_fd_pr__pnp_05v5_W3p40L3p40 M=8
xQ3 GND GND V1 GND sky130_fd_pr__pnp_05v5_W3p40L3p40 M=1
R2 VREF V1 282.1k
R3 VREF GND 100MEG
xM9 Net-_M1-Pad2_ Net-_M20-Pad1_ GND GND sky130_fd_pr__nfet_g5v0d10v5 l=5 w=20
xM4 Net-_M1-Pad1_ Net-_M1-Pad1_ Net-_M21-Pad1_ GND sky130_fd_pr__nfet_g5v0d10v5 l=5 w=20
xM5 Net-_M1-Pad2_ Net-_M1-Pad1_ Net-_M22-Pad1_ GND sky130_fd_pr__nfet_g5v0d10v5 l=5 w=20
xM23 Net-_M23-Pad1_ EN V6 GND sky130_fd_pr__nfet_g5v0d10v5 l=5 w=20
xM1 Net-_M1-Pad1_ Net-_M1-Pad2_ VDD VDD sky130_fd_pr__pfet_g5v0d10v5 l=5 w=20
xM2 Net-_M1-Pad2_ Net-_M1-Pad2_ VDD VDD sky130_fd_pr__pfet_g5v0d10v5 l=5 w=20
xM3 Net-_M23-Pad1_ Net-_M1-Pad2_ VDD VDD sky130_fd_pr__pfet_g5v0d10v5 l=5 w=20
```

```
VS1 V3 Net-_M24-Pad1_ DC 0V
VS2 V4 Net-_M21-Pad3_ DC 0V
VS3 V5 Net-_M22-Pad3_ DC 0V
VS4 V6 VREF DC 0V
```

```
Vdd VDD GND dc 3.3V
VD EN GND dc 3.3V
```

```
.dc Vdd 2 4 0.1
```

```
.control
```

```
run
```

```
plot V(VREF)
plot deriv(V(VREF))
```

```
.endc
```

```
.end
```

*ANALOG BANDGAP REFERENCE CIRCUIT

*EN_IN

```
.options savecurrents
.lib "sky130_fd_pr/models/sky130.lib.spice" tt
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```

*BGR CIRCUIT

```
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xM20 Net-_M20-Pad1_ Net-_M1-Pad1_ GND GND sky130_fd_pr__nfet_g5v0d10v5 l=5 w=20
xM21 Net-_M21-Pad1_ EN V4 GND sky130_fd_pr__nfet_g5v0d10v5 l=5 w=20
xM22 Net-_M22-Pad1_ EN V5 GND sky130_fd_pr__nfet_g5v0d10v5 l=5 w=20
R1  Net-_M22-Pad3_ Net-_Q2-Pad3_ 31k
xQ1  GND GND Net-_M21-Pad3_ GND sky130_fd_pr__pnp_05v5_W3p40L3p40 M=1
xQ2  GND GND Net-_Q2-Pad3_ GND sky130_fd_pr__pnp_05v5_W3p40L3p40 M=8
xQ3  GND GND V1 GND sky130_fd_pr__pnp_05v5_W3p40L3p40 M=1
R2  VREF V1 282.1k
R3  VREF GND 100MEG
xM9  Net-_M1-Pad2_ Net-_M20-Pad1_ GND GND sky130_fd_pr__nfet_g5v0d10v5 l=5 w=20
xM4  Net-_M1-Pad1_ Net-_M1-Pad1_ Net-_M21-Pad1_ GND sky130_fd_pr__nfet_g5v0d10v5 l=5 w=20
xM5  Net-_M1-Pad2_ Net-_M1-Pad1_ Net-_M22-Pad1_ GND sky130_fd_pr__nfet_g5v0d10v5 l=5 w=20
xM23 Net-_M23-Pad1_ EN V6 GND sky130_fd_pr__nfet_g5v0d10v5 l=5 w=20
xM1  Net-_M1-Pad1_ Net-_M1-Pad2_ VDD VDD sky130_fd_pr__pfet_g5v0d10v5 l=5 w=20
xM2  Net-_M1-Pad2_ Net-_M1-Pad2_ VDD VDD sky130_fd_pr__pfet_g5v0d10v5 l=5 w=20
xM3  Net-_M23-Pad1_ Net-_M1-Pad2_ VDD VDD sky130_fd_pr__pfet_g5v0d10v5 l=5 w=20

VS1 V3 Net-_M24-Pad1_ DC 0V
VS2 V4 Net-_M21-Pad3_ DC 0V
VS3 V5 Net-_M22-Pad3_ DC 0V
VS4 V6 VREF DC 0V

Vdd VDD GND dc 3.3V
VD EN GND pulse(0V 3.3V 100u 0 0 0.5 1)

.tran 1u 500u

.control

run

plot V(EN)
plot -I(Vdd)

.endc

.end
```

*ANALOG BANDGAP REFERENCE CIRCUIT

*STARTUP_CHECK

```
.options savecurrents
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.include "sky130_fd_pr/models/sky130_fd_pr__model__pnp.model.spice"
```

*BGR CIRCUIT

```
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xM20 Net-_M20-Pad1_ Net-_M1-Pad1_ GND GND sky130_fd_pr__nfet_g5v0d10v5 l=5 w=20
xM21 Net-_M21-Pad1_ EN V4 GND sky130_fd_pr__nfet_g5v0d10v5 l=5 w=20
xM22 Net-_M22-Pad1_ EN V5 GND sky130_fd_pr__nfet_g5v0d10v5 l=5 w=20
R1 Net-_M22-Pad3_ Net-_Q2-Pad3_ 31k
xQ1 GND GND Net-_M21-Pad3_ GND sky130_fd_pr__pnp_05v5_W3p40L3p40 M=1
xQ2 GND GND Net-_Q2-Pad3_ GND sky130_fd_pr__pnp_05v5_W3p40L3p40 M=8
xQ3 GND GND V1 GND sky130_fd_pr__pnp_05v5_W3p40L3p40 M=1
R2 VREF V1 282.1k
R3 VREF GND 100MEG
xM9 Net-_M1-Pad2_ Net-_M20-Pad1_ GND GND sky130_fd_pr__nfet_g5v0d10v5 l=5 w=20
xM4 Net-_M1-Pad1_ Net-_M1-Pad1_ Net-_M21-Pad1_ GND sky130_fd_pr__nfet_g5v0d10v5 l=5 w=20
xM5 Net-_M1-Pad2_ Net-_M1-Pad1_ Net-_M22-Pad1_ GND sky130_fd_pr__nfet_g5v0d10v5 l=5 w=20
xM23 Net-_M23-Pad1_ EN V6 GND sky130_fd_pr__nfet_g5v0d10v5 l=5 w=20
xM1 Net-_M1-Pad1_ Net-_M1-Pad2_ VDD VDD sky130_fd_pr__pfet_g5v0d10v5 l=5 w=20
xM2 Net-_M1-Pad2_ Net-_M1-Pad2_ VDD VDD sky130_fd_pr__pfet_g5v0d10v5 l=5 w=20
xM3 Net-_M23-Pad1_ Net-_M1-Pad2_ VDD VDD sky130_fd_pr__pfet_g5v0d10v5 l=5 w=20
```

```
VS1 V3 Net-_M24-Pad1_ DC 0V
VS2 V4 Net-_M21-Pad3_ DC 0V
VS3 V5 Net-_M22-Pad3_ DC 0V
VS4 V6 VREF DC 0V
```

```
Vdd VDD GND dc 3.3V pulse(0V 3.3V 100u 100u 0 0.5 1 0)
VD EN GND dc 3.3V
```

```
.tran 1u 800u
```

```
.control
```

```
run
```

```
plot V(VREF) V(VDD)
```

```
.endc
```

```
.end
```