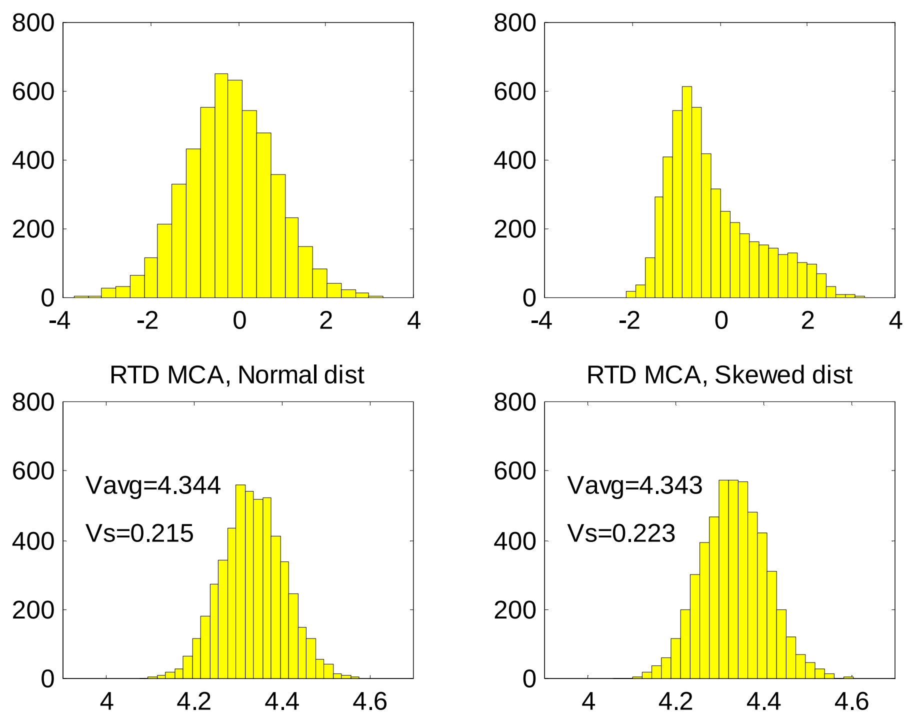
The Effect of Unusual Input Distributions in MCA

With any linear dc circuit with a normal distribution input, the output will always be normally distributed or Guassian. If the input is uniformly distributed, then most linear dc circuits will have a normally distributed output, with a 3σ that is $\sqrt{3}$ times larger. This is especially true for circuits with a relatively large component count.

However with unusual inputs such as pre-screened (values close to average screened out for a closer tolerance batch; the distribution then has two peaks and is known as bimodal.) and skewed distributions, the output will be Gaussian if the component count is relatively large. This is probably due to the Central Limit Theorem (CLT) from statistics which loosely stated, says that the sum of a large number of non-normal distributions will tend to be normally distributed. This assumes the random variables are approximately equally weighted.

This is illustrated with two examples; a skewed input and a bimodal input to the RTD circuit. As will be seen the output is very close to normal. The skewed input compared to normal inpu/output is shown in the plots below. The M-file rtd3mca.m is given after the plots.

Plots from rtd3mca.m:



Note that the response to the skewed input shown above it, appears normally distributed. The means (Vavg) are about 1mV apart. Vs is the 3σ value.

```
% File c:\M_files\bookupdate\rtdmca3.m
% MCA of RTD circuit;
% normal and uniform distribution
% uses MATLAB function G2a.m
%
% Note:  Inverter stage using R8 & R9 added;
%   E1 input to R8, output to E2 & R1 on
%   schematic on p.20
% Updated 11/08/06
%
clc;clear;tic;
R1=4.53;R2=34.8;R3=132;R4=9.09;R5=9.09;E1=5;
R6=4.53;R7=27.4;R8=20;R9=20;RT=1.915;
X=[R1 R2 R3 R4 R5 R6 R7 R8 R9 RT E1];
%
Vo=G2a(X);
Tinit=0.001;Tlife=0.002;ppm=1e-6;
TC1=50*ppm;TC2=25*ppm;
Thi=Tinit+Tlife+35*TC1;Tlo=-Tinit-Tlife-80*TC1;
Trhi=8.1*1e-4;Trlo=-Trhi;Trefhi=0.02+35*TC2;
Treflo=-0.02-80*TC2;
%
T=[ Tlo Tlo Tlo Tlo Tlo Tlo Tlo Tlo Tlo Trlo Treflo;
   Thi Thi Thi Thi Thi Thi Thi Thi Thi Trhi Trefhi];
Nc=size(T,2);
%
Nk=5000 % <<<<<<<<<<<<<<<<<<<<< Nk
%
nb=30; % Number of histogram bins
randn('state',sum(100*clock)); % Randomize seed
rand('state',sum(100*clock));
for mc=1:2
   Tn=zeros(Nk,Nc);Vm=zeros(Nk,1);
   for k=1:Nk
      for w=1:Nc
         if mc==1
            Rn(w,k)=X(w)*(((T(2,w)-T(1,w))/6)*(randn+3)+T(1,w)+1);
         else
            Rn(w,k)=X(w)*((T(2,w)-T(1,w))*rand+T(1,w)+1);
         end
      end
      Vm(k)=G2a(Rn(:,k));
   end
       if mc==1
      Vs1=3*std(Vm);Vavg1=mean(Vm);
      h1=hist(Vm,nb)/Nk;VL=min(Vm);VH=max(Vm);
      intv=(VH-VL)/nb;q=1:nb;
      bin1=VL+intv*(q-1);
      Vhi1=Vavg1+Vs1;Vlo1=Vavg1-Vs1;
      Vsr=sprintf('%2.3f\n',Vs1);
      Vavgr=sprintf('%2.3f\n',Vavg1);
   else
      Vs2=3*std(Vm);Vavg2=mean(Vm);
      h2=hist(Vm,nb)/Nk;VL=min(Vm);VH=max(Vm);
      intv=(VH-VL)/nb;q=1:nb;
      bin2=VL+intv*(q-1);
      Vhi2=Vavg2+Vs2;Vlo2=Vavg2-Vs2;
      Vsu=sprintf('%2.3f\n',Vs2);
      Vavgu=sprintf('%2.3f\n',Vavg2);
   end
end
subplot(2,1,1)
bar(bin1,h1,1,'y');

set(gca,'FontSize',8);
title('Fig 26. RTD MCA, Normal dist');
```

```
grid off
axis([3.9 4.7 0 0.15]);
text(3.95,0.1,['Vavg=',Vavgr],'FontSize',8);
text (3.95,0.12,['Vs=',Vsr],'FontSize',8);
%
subplot(2,1,2)
bar(bin2,h2,1,'y');
set(gca,'FontSize',8);
title('Fig 27. Uniform dist');
xlabel('Volts dc')
axis([3.9 4.7 0 0.15]);
text(3.95,0.1,['Vavg=',Vavgu],'FontSize',8);
text(3.95,0.12,['Vs=',Vsu],'FontSize',8);

figure(1)

ET=toc

function y = G2a(R1,R2,R3,R4,R5,R6,R7,R8,R9,RT,E1)
% mca for rtd function
% reduced order matrix - no opamps
A=[1/R1+1/R4+1/RT -1/RT -1/R4 0 -1/R1;
1/RT 1/R5+1/R6+1/RT -1/R5 0 0;
-1/R4 0 1/R2+1/R3+1/R4 -1/R3 0;
0 -1/R5 1/R5+1/R7 0 0;
0 0 0 0 -1/R9];
B=[0;E1/R6;E1/R2;0;E1/R8];
C=A\B;y=C(4);
```