## SAS Macro for the generation of minimally changed run sequence for Central Composite Designs with Fractional Factorial (Halfreplicate) Points

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Second Order Response Surface Designs (SORDs) are used to explore relationship between the response variable and the input variables and to find out the optimum input combinations to achieve a desired response. Experiments where changing of input factor levels are very difficult/ costly, instead of using the standard form of run sequences, response surface design with less factor level changes in run sequences should be used. The following SAS macro has been developed to generate minimally changed run sequence for Central Composite Designs with Fractional Factorial (Half-replicate) Points. Here, user needs to enter the number of factors as 'k'. If the user executes the program after entering the value of k, then the SAS Macro will produce minimally changed run sequence for central composite design with Fractional Factorial (Half-replicate) Points along with the number of factor-wise level changes, total changes and the number of runs.

```
*Program to generate Central Composite Designs with fractional
factorial points*/
/*small composite designs are not rotatable*/
%let k=5; /*Enter the number of input factors*/
ods rtf file= 'output.rtf' startpage=no;
proc iml;
if &k<4 then do;
print 'Enter a number >=4';/*Half fraction below four factor
will not ensure the estimation
of all the two factor interactions*/
end;
else do;
n0=round((4*(sqrt(2**(&k-1)))))+4-(2*&k));/*For fractional
factorial*/
n=(2**(&k-1))+(2*&k)+n0; /*For fractional factorial*/
alpha=((2**(&k-1))**(1/4));/* (alpha=(factorial points)^1/4)*/
*print n0 n alpha;
centre=j(n0,&k,0);
ax=alpha//(-alpha);
axial= i(&k)@ax;
axial1=j(nrow(axial)-2,ncol(axial),0);
do i=1 to nrow(axial1);
axial1[i, ]=axial[i, ];
end;
*print axial1;
```

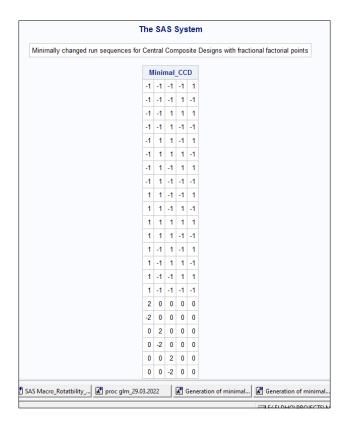
```
axial_last=j(2,&k-1,0);
axial_last=axial_last||ax;
*print axial last;
*print axial centre axial_last;
sss=j(&k,1,2);
s=j(nrow(sss)-1,1,0);/* 2 level for fractional factorial*/
do i=1 to nrow(s);
s[i,]=sss[i,];
end;
a=j(max(s),nrow(s),0);
do kk=1 to nrow(s);
m=mod(s[kk, ],2);
do i=1 to s[kk, ];
do j=i to s[kk, ];
if m=1 then
          do;
          a[j,kk]=-((s[kk, ]-1)/2)+(i-1);
          end;
          else
          do;
          if -(s[kk, ]/2)+(i-1)<0 then do;
          a[j,kk]=-(s[kk, ]/2)+(i-1);
          end;
          else do;
          a[j,kk]=-(s[kk, ]/2)+i;
          end;
          end;
end;
end;
end;
*print a;
aa=j(s[1, ],1,0);
do i=1 to s[1, ];
aa[i,]=a[i,1];
end;
*print aa;
sum=1;
do j=1 to nrow(s)-1;
do i=1 to nrow(aa);
kk=repeat(aa[i,],s[j+1,],1);
if i=1 then do;
aaa=kk;
end;else do;
aaa=aaa//kk;
end;
end;
*print aaa;
```

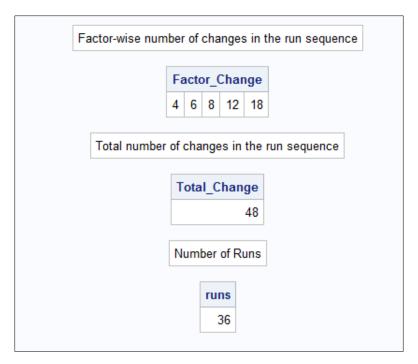
```
sum=sum*s[j, ];
if mod(sum, 2) = 0 then do;
qqq=j(s[j+1, ], 1, 0);
do i=1 to s[j+1, ];
ggg[i,]=a[i,j+1];
end;
ggg1=ggg*-1;
ggg2=ggg//ggg1;
hh=repeat(ggg2,sum/2,1);
aa=aaa||hh;
end;
else do;
ggg=j(s[j+1, ],1,0);
do i=1 to s[j+1, ];
ggg[i,]=a[i,j+1];
end;
ggg1=ggg*-1;
qqq2=qqq//qqq1;
hh1=repeat(ggg2,(sum-1)/2,1);
hh=hh1//qqq;
aa=aaa||hh;
end;
end;
aa1=j(nrow(aa),1,0);/* Generator by multiplying the columns of
aa*/
do k=1 to nrow(aa);
s=1;
do ii=1 to ncol(aa);
aa1[k,]=s*aa[k,ii];
s=aa1[k,];
end;
end;
*print aal;
aa=aa||aa1;
Minimal CCD=aa//axial1//centre//axial last;
runs=nrow(Minimal CCD);
print 'Minimally changed run sequences for Central Composite
Designs with fractional factorial points';
print Minimal CCD;
Factor_Change=j(1,ncol(Minimal_CCD),0);
do k=1 to ncol(Minimal_CCD);
do l=2 to nrow(Minimal_CCD);
if Minimal_CCD[l-1,k]^=Minimal_CCD[l,k] then do;
Factor_Change[1,k]=Factor_Change[1,k]+1;
end;
end;
end;
```

SAS Macro for the generation of minimally changed run sequence for Central Composite designs with fractional factorial points

```
Total_Change=sum(Factor_Change);
print 'Factor-wise number of changes in the run sequence';
print Factor_Change;
print 'Total number of changes in the run sequence';
print Total_Change;
print 'Number of Runs';
print runs;
end;
ods rtf close;
quit;
```

## **SAS Output**





## Research Paper:

- Eldho Varghese, Arpan Bhowmik, Seema Jaggi, Cini Varghese and Shwetank Lall, (2019). On the Construction of Response Surface Designs with Minimum Level Changes. *Utilitas Mathematica*, 110, 293-303.
- Eldho Varghese\*, Arpan Bhowmik, Seema Jaggi, Cini Varghese, Charanjit Kaur (2017). On the generation of cost effective response surface designs, *Computers and Electronics in Agriculture*, 133, 37-45.
- Eldho Varghese\*, Arpan Bhowmik, Seema Jaggi, Cini Varghese, Charanjit Kaur (2020). Corrigendum to "On the generation of cost effective response surface designs" [Comput. Electron. Agric. 133 (2017) 37–45], *Computers and Electronics in Agriculture*, 170, 105272.