Transient Behavior of Synchronous machine using Matlab / Simulink

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Abstract: The requirement of electricity is increasing at an alarming rate but the running demand of power is ahead of its supply. More the demand more generation. Due to increase generation, synchronism between different parts of power system has become difficult. In this research paper firstly the behavioral study of synchronous machine with PID controller and discrete filter is carried out of transfer by aid transfer function and In the second step point-by-point method using simulink show the transient behavior of the synchronous machine. The prefault condition, during fault and after fault condition is presented in this paper.

Keyword: Synchronous Machine, PID Controller, Filter, Matlab , Simulink.

I. INTRODUCTION

Power System interconnection has widen to large extent and hence length of conductor increase as result reactance increases and hence condition of stability and its necessity increase. The generator, transformer, transmission lines, protective circuit breaker, relay forms an electrical power system. And Disturbances like lightning hit, short circuit, conductor clashing such faults frequently occur on power system. Faults are is like ''problem'' for power system which has to be cleared within few seconds. Fault other than short circuit faults like breaking of conduction path is also a fault. Smaller fault is not cleared on time can result into bigger disturbances. Such disturbances result into transient faults. Transient faults makes the power system run out of synchronism and hence lost in power system stability . It is essential to maintain synchronism between generator and system else voltage fluctuations and current fluctuation will disconnect the supply at the faulty sections.[4]. Power system stability is Define as "The power system is said to be stable if after large disturbances, the system comes to normal working condition''. Maximum power without causing any instability is supplied**.**

II. TYPES OF SYSTEM STABILITY

1. Steady state stability
2. Dynamic stability
3. Transient stability

Steady state stability :- Th**e** power system is said to be steady state stable if comes to its normal working condition after smaller disturbances like automatic voltage regulator action and load fluctuation. Steady state stability is limit at which maximum power can be transferred without stability loss.

Dynamic Stability: - If after smaller disturbances the system does not lose synchronism and attains natural oscillation, then the system is dynamically instable. Dynamic stability is the ability of the system which can makes the oscillation not to cross the more than certain value and not die out suddenly.

Transient Stability:-The system is said to be transient stable if after large disturbances it comes to its natural state of working.

III. TYPE OF TRANSIENT FAULT

1. Change of load suddenly
2. Break & make of any of the system element
3. Short circuit
4. Momentary tree contact.
5. conductor clashing

Since faults stays only for a second but then also can make the system to loss synchronism.[3]

IV. SWING EQUATION:-

The power system is stable or not with rotating synchronous machine is determined by swing equation. Swing equation is a non linear equation and point-by-point numerical solution can be used to solve it.[2]

$$M \frac{d^2\delta}{dt^2} = P_m - P_e \qquad\qquad -----(1)$$

$$M = \frac{GH}{\pi f} \qquad\qquad - (2)$$

Here
P_m = Mechanical power in MW
P_e = Electrical power output MW
δ = Rotor angular displacement
G = Machine rating in MVA
H = Inertia constant in MJ/MVA
The swing equation shows the behavior of rotor angle with respect to stator field.[1][5]

V. EQUAL AREA CRITERIA:-

If machine swings with respect to an infinite machine i.e
if $\frac{d\delta}{dt} = 0$; system is stable
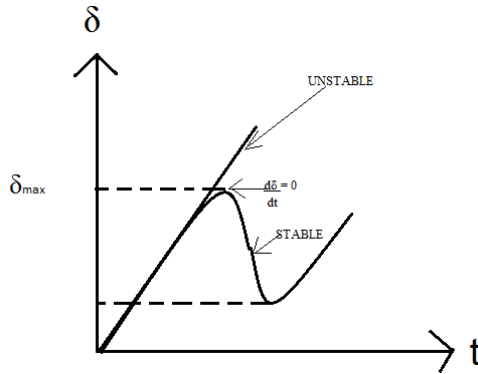
$\frac{d\delta}{dt} > 0$; system is unstable

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Fig. 1 Curve representing stable and unstable state

by equal area criteria

$$\int_{\delta_o}^{\delta} P_a \, d\delta = 0$$

The system is stable if
positive area under P_a - δ curve = negative area under P_a - δ curve

VI. PROPOSED METHODOLOGY

The paper uses MATLAB/ Simulink to illustrate the behavior of transient stability.The below is M-file proposed program for a machine connected to infinite bus through two parallel lines.

Example 1- A 50 MVA Synchronous generator with inertia constant H=2.7 KJ/MVA at a rated speed is studied with the help power angle curves . Following data is assumed M-File coding.

```
E = 50;
V =1;
Xd = 0.2; X1 =0.4; X2 = 0.4;H = 2.7;
del = 0:pi/10:pi;
del1 =del;
del2 = del;
M = 2.7/(180*50);
Peo = (1.05/0.4)*sin(del);
Po = 1 ;
delo = asind(0.4/1.05);
% During fault
Pe2 = 1.05*sin(del1);
%Post fault condition
Pe3 = (1.05/0.6)*sin(del2);
plot(del,Peo);
set(gca,'XTick',0:pi/10:pi);
set(gca,'XTickLabel',{'0','','','','','pi/2','','','','','pi'});
title('Power Curve');
xlabel('Load angle');
ylabel('Genpower');
text((2/3)*pi,(1.05/0.4)*sin((2/3)*pi),'prefault
curve','HorizontalAlignment','right');
text(pi/2,2.75,'2.625*sin\delta','HorizontalAlignment','center');
hold all
plot(del1,Pe2);
text((2/3)*pi,1.05*sin((2/3)*pi),' during fault
curve','HorizontalAlignment','right');
```

```
text(pi/2,1.80,'1.05*sin\delta','HorizontalAlignment','center');
plot(del2,Pe3);
text((2/3)*pi,(1.05/0.6)*sin((2/3)*pi),' after fault
curve','HorizontalAlignment','right');
text(pi/2,1.1,'1.75*sin\delta','HorizontalAlignment','center');
hold off
```
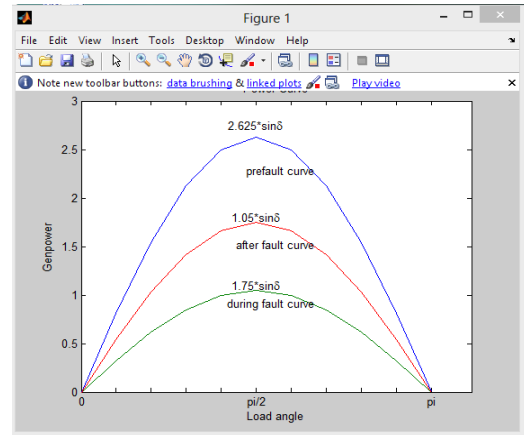

Fig. 2 Power angle curve showing the prefault, during fault and after faults conditions.

EXAMPLE 2- A 50 MVA Synchronous generator with inertia constant H=2.7 KJ/MVA at a rated speed is used to study the sustained fault by following data

```
E = 60; V =1; Xd = 0.2; X1 =0.4;
X2= 0.4;H = 2.7;
t = 0.05;
t1 = 0:t:0.5;
Pao = (1 - (1.05*sind(delo)))/2;
Pa(1) = Pao;
cdel(1) = 0;
d1 = t^2/M;
for i = 1:11
if i == 1
d2(i) = d1*Pa(i);
del(i) = delo;
else
cdel(i) = cdel(i-1)+d2(i-1);
del(i)  = del(i-1)+cdel(i);
Pe(i) = 1.05*sind(del(i));
Pa(i) = 1 - Pe(i);
d2(i) = d1*Pa(i);
end
end
figure (2);
plot(t1,del);
set(gca,'Xtick',0:0.05:0.5);
set(gca,'XtickLabel',{'0','0.02','0.04','0.06','0.08','0.10','0.12','0.14','0.16','0.18','0.20'});
title('Swing Curve');
xlabel('seconds');
ylabel('degrees');
text(0.30,150,'                    Sustained
fault','HorizontalAlignment','right');
text(0.001,130,' load angle increases with time -- Unstable
state','HorizontalAlignment','left');
```
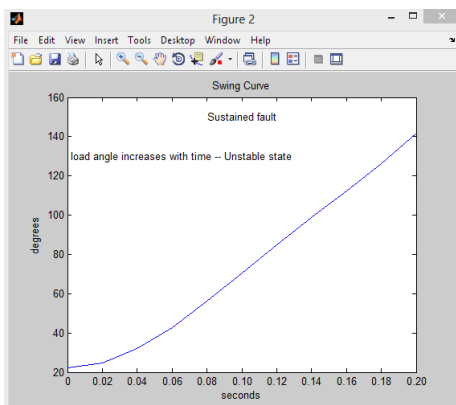
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```
Pafo = (1 - (1.05*sind(delo)))/2;
Paf(1) = Pao;
cdelf(1) = 0;
d1f = t^2/M;
for i = 1:2
if i == 1
d2f(i) = d1*Pa(i);
delf(i) = delo;
else
cdelf(i) = cdelf(i-1)+d2f(i-1);
delf(i)  = delf(i-1)+cdelf(i);
Pef(i) = 1.05*sind(delf(i));
Paf(i) = 1 - Pef(i);
d2f(i) = d1*Paf(i);
end
end
```


Fig. 3 Curve representing sustained fault

VII.   SYNCHRONOUS GENERATOR WITH PID AND DISCRETE FILTER
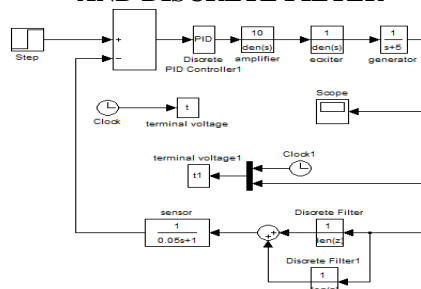
Fig. 5 Simulation block diagram of SG with PID Controller and Discrete Filter
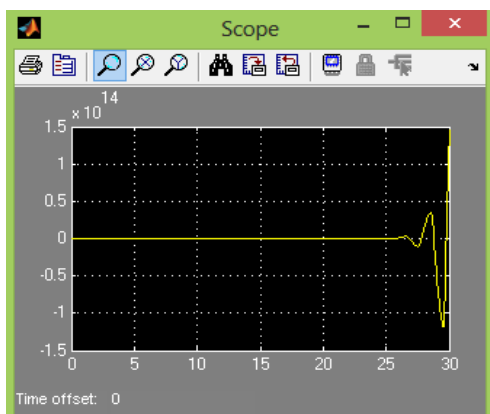

Fig. 6 Response of SG with PID Controller   and Discrete Filter

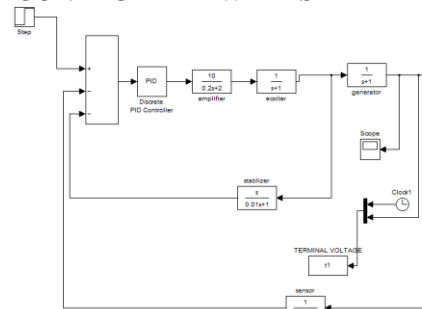## VIII.   BEHAVIOUR OF SG WITH PID CONTROLLER WITH STABILIZER

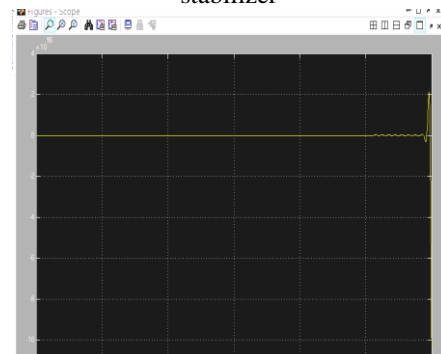Fig.7 Simulation block diagram of SG with PID Controller stabilizer

Fig8.Response of SG with PID controller and stablizer

IX.   CONCLUSION

The research emphasized on the behavior of transient stability by MATLAB / Simulink. A M-file is presented to show Numerical solution by Point-by-Point method. The response of Synchronous generator with PID and Discrete filter is also shown using MATLAB blocks.

X.   FUTURE WORK

A Non- linear method of power system stability, point-by-point and behavior synchronous generator with PID Controller and Discrete Filter with help of MATLAB/ Simulink is carried out here For future the behavior of synchronous generator with combination of PID and PI Controller can be investigated.

REFERENCES

[1]. J.B. Gupta, A Course in power system systems, S.K.Kataria and publications
[2]. D.P Kothari , I.J. Nagrath , Power System Engineering, Second edition, Mcgraw Hill Education Pvt Ltd
[3]. Badri Ram, DN Vishwakarma, Power System Protection and Switchgear, Second edition, Mcgraw Hill Education Pvt Ltd.
[4]. Naresh K. Tanwani , Aslam. P. Memon , Waqar A. Adil , Jamshid A. Ansari, Simulation Techniques of Electrical Power System Stability Studies Utilizing Matlab/Simulink.
[5]. H. Saadat, Power System Analysis, Tata McGraw-Hill
[6]. www.srmuniv.ac.in,, Power system stability,Swing equation.
[7]. MATLAB 7.6.0