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# IMPROVEMENT FIELD SYSTEM OF AUTONOMOUS ASYNCHRONOUS GENERATORS WITH WOUND-PHASE ROTOR ON MICROPROCESSOR BASE FOR MICRO HYDROPOWER

**Abstract**

The field system (FS) was improved by microprocessor controller like: dsPIC33F for autonomous asynchronous generator (AAG) with wound-phase rotor. An implementation of FS for AAG is carried out using an asynchronous generator with wound-phase rotor, PI controllers, RMS board and inventor. The main advancement with the AAG with wound-phase rotor is the rotor windings that allow a supplemental current to be injected directly to the rotor which affects the stator voltage and current. This concept is the basis of this project. The AAG with improved FS on microprocessor base provides a viable and cost-effective solution to achieve power quality improvement, voltage and frequency control on variable rotations of generator's rotor, harmonic elimination and load balancing for feeding nonlinear loads. Experimental results are presented to validate the effectiveness of the FS on microprocessor controllers for AAG with wound-phase rotor for micro hydroelectric power station [1-4].

**Keywords:** Autonomous asynchronous generator, field system, micro hydropower station, voltage control, frequency control.

## INTRODUCTION

Now a plenty of the small rural farmers in Kazakhstan removed from large settlements, remain not connected to the centralized sources of electro supply as it in most cases economically and is technically inexpedient.

At the same time the small rivers allow to solve a problem of electro supply of low-power consumers with a necessary stock of hydro resources economically enough. Advantages of using of hydraulic power, in comparison with others, little change of speed of current of water within a year, absence of the periods of calm is frequently rather.

The electricity produced on micro hydroelectric power station and small hydroelectric power stations has the lowest cost price in comparison with the electricity from other renewed and traditional energy sources.

One of the major units of micro hydroelectric power station is the generator. Besides simple generating the electric power, the generator should provide stabilization of parameters of the electricity which means controllability of generator.

This paper deals with a simple algorithm based on a synchronous reference frame (SRF) theory [5]. The FS on microprocessor base is used for controlling the voltage and its frequency.

## SYSTEM CONFIGURATION AND PRINCIPLE OF OPERATION

The autonomous system consists of a 1.4 kWt, 50 Hz asynchronous generator (AG) with wound-phase rotor, FS on microprocessor base, storage battery, non-linear and linear consumer loads as shown in Figure 1.

The proposed FS on microprocessor base is the combination of linear amplifiers OP-7 and IL300 optocoupler like isolation amplifier, isolated regulator dc/dc converters, microprocessor controller dsPIC33F, power controller IRAMX20UP60A for creating the output signal to the rotor of the AAG, LCD backpack for displaying current data. Microprocessor controller dsPIC33F get a signal from the output of generator then compare it with the constant data after that send signal which we need to the power controller IRAMX20UP60A for creating the output signal to the rotor of the AAG as shown in Figure 2.

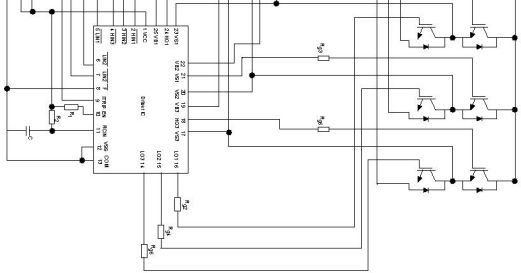
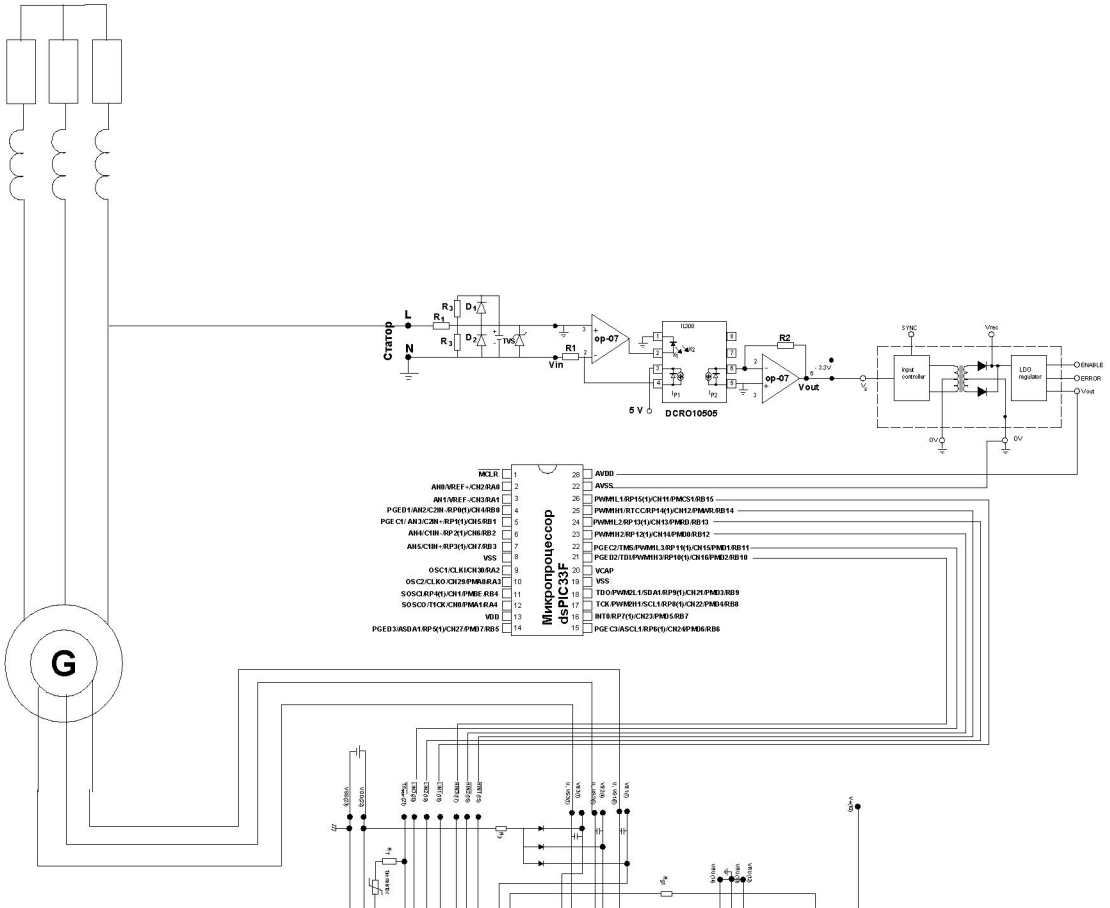
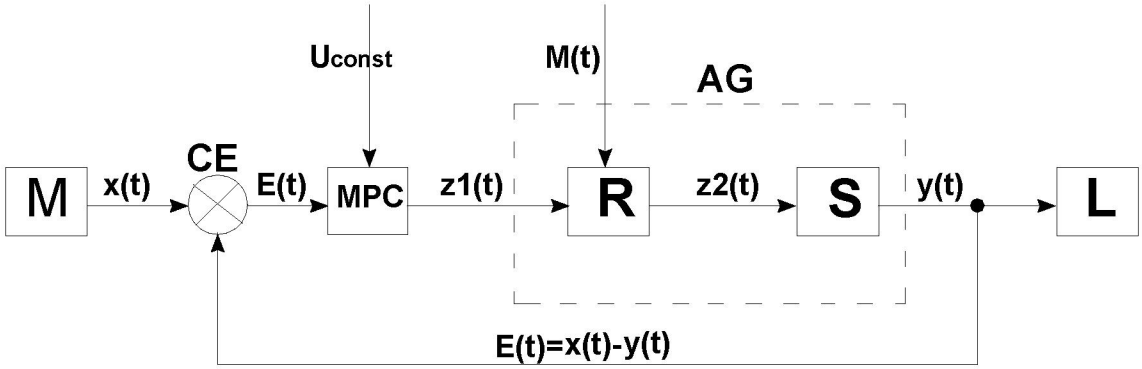


**figure 2 - control**

The FS on microprocessor base is used for controlling constant power output and regulating voltage and frequency along with power quality improvement. The control strategy for producing the signal for FS on microprocessor base is based on the generation of reference source currents and gating pulses for the chopper switch for constant power operation.


Статор
L
N
R3
R1
D1
D2
TVS
op-07
Vin
R1
5 V
DCRO10505
R2
op-07
Vout
SYNC
Vreg
Input controller
LDO regulator
ENABLE
ERROR
Vout
0V
0V
G
Микропроцессор dsPIC33F
MCLR
AN0/VREF+/CN2/RA0
AN1/VREF-/CN3/RA1
PGED1/AN2/C2IN-/RP0(1)/CN4/RB0
PGEC1/ AN3/C2IN+/RP1(1)/CN5/RB1
AN4/C1IN-/RP2(1)/CN6/RB2
AN5/C1IN+/RP3(1)/CN7/RB3
VSS
OSC1/CLKI/CN30/RA2
OSC2/CLKO/CN29/PMA0/RA3
SOSCI/RP4(1)/CN1/PMBE/RB4
SOSCO/T1CK/CN0/PMA1/RA4
VDD
PGED3/ASDA1/RP5(1)/CN27/PMD7/RB5
AVDD
AVSS
PWML1/RP15(1)/CN11/PMCS1/RB15
PWMH1/RTCC/RP14(1)/CN12/PMWR/RB14
PWML2/RP13(1)/CN13/PMRD/RB13
PWMH2/RP12(1)/CN14/PMD0/RB12
PGEC2/TMS/PWML3/RP11(1)/CN15/PMD1/RB11
PGED2/TDI/PWMH3/RP10(1)/CN16/PMD2/RB10
VCAP
VSS
TDO/PWM2L1/SDA1/RP9(1)/CN21/PMD3/RB9
TCK/PWM2H1/SCL1/RP8(1)/CN22/PMD4/RB8
INT0/RP7(1)/CN23/PMD5/RB7
PGEC3/ASCL1/RP6(1)/CN24/PMD6/RB6




M- master;
x(t)=f(t), i(t), u(t) – masters control (input);
y(t)= f(t), i(t), u(t) – controlled quantity (adjustable);
CE- comparison element;
MPD- microprocessor controller;
AG- asynchronous generator;
E(t) – the difference between x(t) and y(t);
z(t) – control action, z1(t)= f(t), i(t), u(t), z2(t)= f(t), Φ(t);
M(t) – turning moment;
R – rotor;
S – stator;
Uconst- dc voltage
L – load.

**Fig.3 - Control block scheme of FS on microprocessor base.**

**MODELING OF INDUCTION GENERATOR**

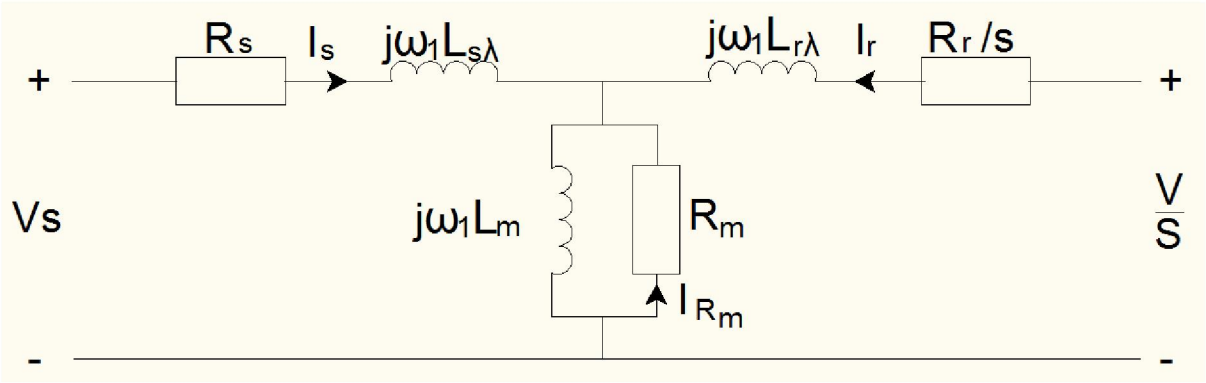



**Fig.4 - Circuit of wound-phase asynchronous machine**

**VOLTAGE EQUATIONS** [6]**:**

$Vs = Rs\mathrm{I}s + j\omega 1Ls\lambda \mathrm{I}s + j\omega 1Lm(\mathrm{I}s + \mathrm{I}r + \mathrm{I}Rm);$

$\frac{Vr}{S} = \frac{Rr}{S}\mathrm{I}r + j\omega 1Lr\lambda \mathrm{I}r + j\omega 1Lm(\mathrm{I}s + \mathrm{I}r + \mathrm{I}Rm);$

$0 = Rm\mathrm{I}Rm + j\omega 1Lm(\mathrm{I}s + \mathrm{I}r + \mathrm{I}Rm);$

where:
V*s* stator voltage; *Rs* stator resistance;
V*r* rotor voltage; *Rr* rotor resistance;

I*s* stator current; *Rm* magnetizing resistance;
I*r* rotor current; *Lsλ* stator leakage inductance;
I*Rm* magnetizing resistance current; *Lrλ* rotor leakage inductance;
$\omega$1 stator frequency; *Lm* magnetizing inductance;

The slip, $s=\frac{\omega_1-\omega_r}{\omega_1}=\frac{\omega_2}{\omega_1}$;

where: $\omega_r$ is the rotor speed and $\omega_2$ is the slip frequency.

Stator flux and rotor flux,
$\Psi m = Lm(Is + Ir + IRm)$;
$\Psi s = Ls\lambda Is + Lm(Is + Ir + IRm) = Ls\lambda Is + \Psi m$ ;
$\Psi r = Lr\lambda Ir + Lm(Is + Ir + IRm) = Lr\lambda Ir + \Psi m$;

Ohmic loss,
$Ploss = 3\_Rs|\mathbf{I}s|^2 + Rr|\mathbf{I}r|2 + Rm|\mathbf{I}Rm|^2$;

Electro-mechanical torque,

$Te = 3n_p\mathrm{Im}[\Psi m\mathrm{I}\square\, r\,] = 3n_p\mathrm{Im}[\Psi r\mathrm{I}\square\, r]$
where: $n_p$-pole pairs.

**Algorithm on assembler-program for dsPIC33F**

```
// Headers
#include "p33FJ64MC802.h"
#include "config.h"
#include "init.h"
#include "utils.h"
// Initialize conf bits:
_FOSCSEL(FNOSC_FRCPLL);                          // Use FRC Oscillator with PLL
_FOSC(FCKSM_CSDCMD & OSCIOFNC_ON  & POSCMD_NONE & IOL1WAY_ON);
                                                 // Clock Switching DIS, Fail Safe
Clock Monitor DIS
                                                 // OSC2 Pin Function: IO
                                                 // Primary Oscillator Mode DIS
                                                 // 1 time remapping conf possible

_FWDT(FWDTEN_OFF);          // WD Timer Enabled/disabled by user software
// Global variables
volatile datacon_packed DATACON;   // Data IO
volatile stat_packed STAT;         // Status flags
volatile proc_packed PROC;         // Processed data
int main(void) {
InitBoard();
InitFilters();
while(1){
// Data IO
dataio();
proc();
}
}
```

**CONCLUSION**

During the work on this project were created:

1. Block scheme of FS on microprocessor base for balancing output voltage and frequency;
2. Prototype of the FS on microprocessor base for balancing output voltage and frequency which need consumer;
3. Algorithm for our goal;

For continue this project we need field test of FS on microprocessor base for balancing output voltage and frequency on output AAG.

**REFERENCES**

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**Резюме**

**Фазалық роторлы автономды асинхронды генератордың қоздыру жүйесін микропроцессорлық техника арқылы жетілдіру**

Бұл жұмыста фазалық роторлы автономды асинхронды генератордың қоздыру жүйесін микропроцессорлық техника арқылы жетілдіру мысалдары көрсетілген.

**Кілт сөздер**: автономды асинхронды генератор, фазалық ротор, қоздыру жүйесі.

**Резюме**

**Совершенствование системы возбуждения автономного асинхронного генератора на базе микропроцессорной техники**

В статье приводятся примеры совершенствования системы возбуждения автономного асинхронного генератора на базе микропроцессорной техники.

Система возбуждения автономного асинхронного генератора с фазным ротором была совершенствована контроллером семейства: dsPIC33F. Система возбуждения выполнялась для асинхронного генератора с фазным ротором с помощью PI контроллеров, RMS выпрямителя и инвертором. Идея заключается в снижении стоимости и повышении качества электроэнергии микроГЭС, путем использования в качестве генератора электрическую машину с фазным ротором с новой системой возбуждения. При этом, подавая на трехфазную обмотку ротора генератора регулируемый по величине, частоте и чередованию фаз трехфазный ток, добиться регулирования ЭДС обмоток статора генератора, как по частоте вращения основного магнитного потока, так и по его величине, тем самым стабилизируя выходное напряжение генератора при переменной величине оборотов гидротурбины и нагрузки генератора.

**Ключевые слова:** автономный асинхронный генератор, фазный ротор, система возбуждения.

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The field system (FS) was improved by microprocessor controller like: dsPIC33F for autonomous asynchronous generator (AAG) with wound-phase rotor. An implementation of FS for AAG is carried out using an asynchronous generator with wound-phase rotor, PI controllers, RMS board and inventor. The main advancement with the AAG with wound-phase rotor is the rotor windings that allow a supplemental current to be injected directly to the rotor which affects the stator voltage and current. This concept is the basis of this project. The AAG with improved FS on microprocessor base provides a viable and cost-effective solution to achieve power quality improvement, voltage and frequency control on variable rotations of generator's rotor, harmonic elimination and load balancing for feeding nonlinear loads. Experimental results are presented to validate the effectiveness of the FS on microprocessor controllers for AAG with wound-phase rotor for micro hydroelectric power station.

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