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Performance Characteristics of the 2Kw Experimental Stand-Alone Wind Power System at KIER

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1. INTRODUCTION

Utilization of new and renewable energy in electrical generation is in an early stage in Korea. As of May 1985, three small hydro-electric power plants of 6,550Kw are in operation with integration into the main grid. A total of 80Kw photovoltaic power systems is utilized to provide electricity for lighthouses, telecommunication equipments, family houses in a remote island, etc.

Utilization of wind power system is relatively new. As of May 1985, the total installed capacity amounted to approximately 35Kw. All of the systems are of small scale(2-14Kw) and most of them have been installed for an experimental demonstration. Several wind power plants were removed due to various problems which include reduced output power due to low wind speed, damage of rotor blades due to sudden change of wind direction, and system maintenence problems.

Under a grant awarded by Ministry of Energy and Resources a program was developed to examine field operating characteristics of small wind power system, aiming at reducing the problems as much as possible.[1] In the program, a 2Kw small wind generating unit(SWGU) was built in Korea Institute of Energy and Resources (KIER), Daejeon.

In the paper, the performance of the 2Kw-SWGU developed as a part of KIER's wind energy program is evaluated, and the data acquisition and analysis system for the evaluation is discussed.

2. FUNDAMENTALS OF THE 2KW-SWGU AT KIER

(A) System Configuration

As seen in Fig. 1, the system operation of the simple stand-alone power system is basically dependent on the electrical interaction of the wind generator, the battery, and the loads.

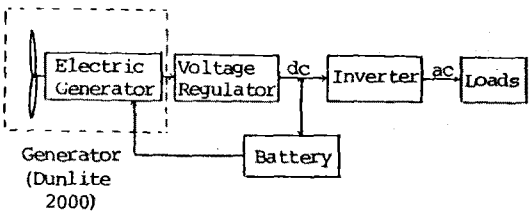

Figure 1. Blockdiagram of the 2Kw-SWGU

The ac generator contains a rectifier using 3-phase diode-bridge, and thus, output power is 120V dc. The specifications of the rotor and the ac generator are:

rotor : 4.1m(diameter), 160rpm, 12.2m/sec
generator: 120V, 900 rpm, 2Kw(rated).

The voltage regulator prevents voltage excursion above a desired maximum. A total of 60 lead-acid batteries was employed, whose specification is: 120V,42Kwh. The inverter used is a PWM type using power transistors and its maximum rating is 120V, 5KVA.

The SWGU provides electricity for the loads:
lights: fluorescent and glow lamps(0.7Kw)
heater: 1 commercial heater(1 Kw).

(B) Theoretical Output Power

The theoretical power which can be extracted from wind energy is given:

$$P_{th} = \frac{1}{2} \rho A V^3 \quad \text{(watts)},$$

where P_{th} is the electrical power, ρ the air density(ρ =1.225Kg/m^3), A the cross-sectional area of the wind stream($A=\frac{1}{4}\pi D^2$, D=rotor diameter), and V the wind speed, respectively.

For the 2Kw-SWGU with a rotor of 4.1m-diameter, the P_{th} is written in:

$$P_{th} = 0.00809\ V^3 \quad \text{(watts)}.$$

(C) Data Acquisition and Analysis

The functional block diagram for the data acquisition and analysis system developed for evaluating the performance of the SWGU is shown in Fig. 2. The system consists mainly of a 8-bit microprocessor(R6502), peripheral devices, and related instruments.

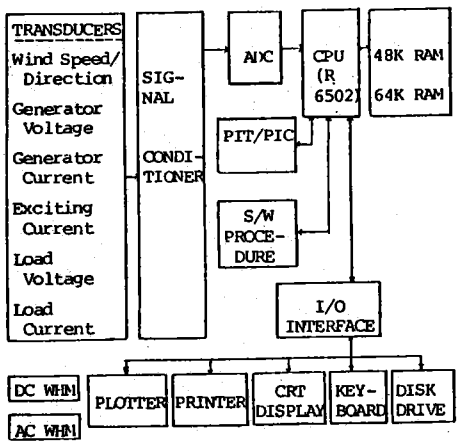

Figure 2. Data Acquisition and Analysis System

The transducers monitor corresponding properties listed in the diagram in Fig. 2, and send electrical signals to the analog-to-digital converter(ADC) 1211 via the signal conditioner. The programmable timer,INS 8253, and the programmable interrupt controller,INS 8259, transfer and interrupt input/output data. The dc WHM measures the total electrical generation, and the ac WHM determines the total electricity consumption. Fig. 3 is the flow chart for main program.

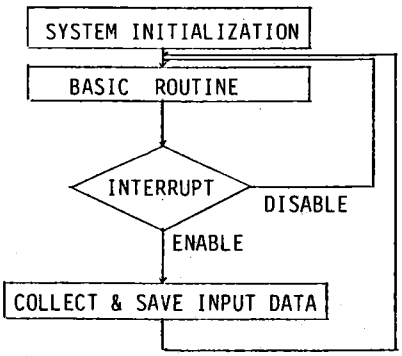

Figure 3. Flow chart for main program

3. EXPERIMENTAL RESULTS

All data were collected at a period of 30 minutes for 9 months. The range of wind speed reading(0-20 m/sec) was partitioned into 20 intervals with an increment of 1 m/sec.

Performance data collected has carefully been evaluated by means of the method-of-bins[2] and the results are given in Table 1.

In Fig. 4, the experimental output power is compared with the reference output provided by the manufacturer. It is seen in Fig. 4 that the cut-in wind speed of the SWGU is 4.5m/sec from which the output power is gradually increased.

Table 1. Output power

BIN OF WIND SPEED(M/S)	WIND SPEED(M/S)	POWER OUTPUT(W)
4 - 5	4.5	100
5 - 6	5.5	221
6 - 7	6.5	400
7 - 8	7.5	640
8 - 9	8.5	961
9 - 10	9.5	1,123
10 - 11	10.5	1,308
11 - 12	11.5	1,500
12 - 13	12.5	1,750
13 - 14	13.5	2,010
14 - 15	14.5	2,210
15 - 16	15.5	2,530
16 - 17	16.5	2,700
17 - 18	17.5	2,540
18 - 19	18.5	2,800

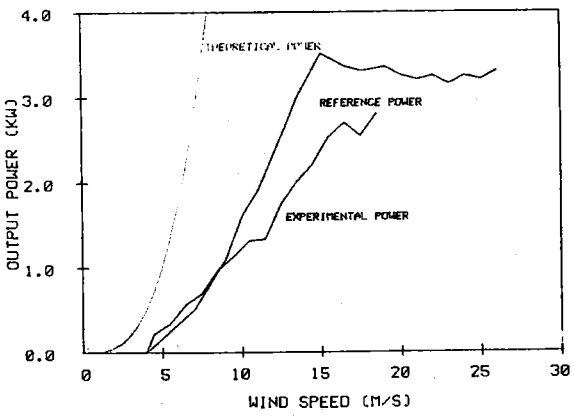

Figure 4. Power curve of the 2Kw-SWGU

4. CONCLUDING REMARKS

The results discussed in the paper are preliminary findings of an on-going project at KIER. It is expected as more data and field experiences become available that the 2Kw SWGU presented provides a baseline design of simple stand-alone wind power plants for remote island applications.

Electrical power generated by wind generator is a fluctuating quantity. An application of simple load management technique is, therefore, recommended for more efficient utilization.

REFERENCES

1. B.C. Son, et al, "Research and Development on Wind Power Generations", Report KE-83-4, KIER, 1983.
2. R.E. Akins, "Performance Evaluation of Wind Energy Conversion Systems Using the Method of Bins", Report SAND77-1375, Sandia Lab., Albuquerque, New Mexico, 1978.