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Design and Construction of Wireless Instrumentation System for Measuring Solar Module Performance Parameters

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Abstract
This paper presents the development of a wireless instrumentation system for accurate characterization and evaluation of solar modules performance parameters under variable atmospheric conditions. A wireless transmitter that operate at 5V (315MHz) was designed and constructed to transmit electrical parameters of three different solar panels measured via current, temperature and voltage sensors to a constructed Omni-directional receiver that is made up of inbuilt storage system. The measured electrical parameters from individual panels were evaluated in terms of their responses to variable atmospheric conditions and compared with that of manufacturer's ratings. The results based on the plotted curves show that as individual panel temperature increases the output voltage also increases. Increase in output voltage result into increase in output current measured across the load resistor which also results into corresponding increase in output power of individual panel. The measured electrical parameters are within the manufacturer's ratings range, except maximum output currents and maximum powers which show little differences from that of manufacturer's ratings due to choice of load resistors used in the design which impede the free flow of current to some extent.
Keywords: Design, Construction, wireless instrumentation, solar modules
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1. Introduction

Solar Panels applications require accurate panel's parameter specifications and reliable material characterization from the modules or panels manufacturers before site installations for efficient energy utilization (Biicher, 1997). These prompt, the need for re-evaluation and re-characterization before installations so as to ascertain the accuracies of the manufacturer's specifications, since some researchers has pointed out that manufacturer's ratings are not always accurate (King, 1997; Ugwuoke & Okeke, 2012). Meanwhile, significant part of inaccuracies observed during evaluations, characterizations or performance predictions of solar panels are due to error accrued from the parameters measuring instruments particularly when it is desired to measure their performances before installations. Over the years measurements have been conducted on already made solar panels manually during characterizations and performance evaluations using measuring devices such as thermometers, pyrometers, rheostat, ammeters and voltmeters. Some of the results obtained using these instruments were subject to some errors such as human and instrumental errors, which might have resulted in underestimation of their specifications and performance contrary to the manufacturer's specifications as reported by some researchers. Recently, an instrumentation method which requires the use of cables for transmission of measured panel data into storage system was developed but with little sensitivity and accuracy due to losses in measured parameters as a result of instrumental faults like partial cable contacts, increase in insulation at certain points caused by dirt or corrosion, inconsistency in data obtained due to power fluctuations (Sanusi, 2012). In view of some of the limitations of manual and cable methods, some of the measured data obtained during characterizations and performance evaluations cannot be said to be very accurate or precise due to human and instrumental errors. Hence, there is need to improve on the existing measuring methods or techniques. Efficient transmitter and receiver with sensitive sensors are necessities of effective signal transmissions and receptions systems (Chan *et al*., 2004). Hence, the measuring instrumentation components were thoroughly designed to realise its higher accuracy.

2. Materials and Methods

In the course of the design and construction, the materials that were coupled together to form the instrumentation system are microcontroller – PIC18F452, current sensors – ACS712 (X4), temperature sensors – DS1820 X4, storage battery – sealed lead acid (7AH), charging unit and solar panel for charging, transmitter – XY –MK- 5V (315MHz), processor board ,voltage regulators – 7805 and LM317 while the receiving system components are LCD display – HD7768 (2.0 character X4 lines), receiver module – XY – FST (315MHZ), Micro controller – PIC18F452, memory card holder + memory card 2 Giga byte and LED Indicators while the materials specifications are as shown in table 1

3. Design and Construction Procedures

The wireless instrumentation system were designed as shown in figure1and figure 2 while the constructions were carried with specified components as shown in plate 1 and plate 2. The constructed measuring instrumentation system was setup with the panels and implemented as shown in plate 3.

4. Result and Discussion

In this paper an instrumentation system has been designed and constructed for accurate measurement of solar panels performance parameters. The measured data were collated and plotted for analysis using Microsoft excel. Figures 3, 4 and 5 show the plots of variations in output voltage versus panel temperature, current versus voltage and power versus voltage of the three solar panels under consideration. The result in figure 3 shows that as panel temperature increases, a corresponding increase in output voltage is observed. Figure 4 shows increase in output current with increase in output voltage of the solar panels while figure 5 also shows that increase in panel voltage increases the output power. Figures 6, 7 and 8 show the variations of output power, output voltage and output current with the time of day. Figures 6, 7 and 8 show that the three solar panels give maximum output when the sun is at zenith (12noon), from the three graphs it can be observed that the measured output parameters begin to increase from 9:30am when the sun rises (increasing ambient temperature) and decrease when time is beyond 5:30pm when the sun set (decreasing ambient temperature), this result shows the influence of variation in ambient temperature on panels output performances. Figure 9, 10 and 11 show the comparison of the manufacturer's ratings with the experimental results. All the experimental results obtained were within the manufacturer's ratings ranges, which show that the constructed wireless instrumentation system is highly efficient than the usual manual methods of employing multimeter, rheostat, thermocouple for measurements and characterizations which are usually stressful, time consuming, inconsistent and prone to human and instrumental errors.

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5. Conclusion

The importance of solar modules and solar panels accurate specifications cannot be overemphasized for efficient energy utilization otherwise inadequate energy delivery or overloading resulting to damages of appliances and huge capital lost is inevitable. Moreover, manual method of measuring and characterizing solar modules and solar panels during research activities could result to accrued errors and inaccurate evaluation and prediction of results. Hence, accurate measurement and characterization of solar panels using efficient wireless instrumentation system before installation as demonstrated in this work is necessary for accurate energy and power delivery as well as time saving.

References

Biicher, K. (1997). Site Dependence of the Energy Collection of PV Modules, Solar Energy Materials and Solar Cells, Vol.47, No.1-4, pp. 85-94.

Chan, Y. K. et al. (2004). Transmitter and Receiver design of an experimental airborne synthetic aperture radar sensor, Progress in electromagnetic research, PIER vol.49, 203-218.

King, D. L. (1997). Photovoltaic Module and Array Performance Characterisation Methods for All System Operating Conditions. Proceedings NREL/SNF Photovoltaic Program Review Meeting, November 18-22, 1997, Lakewood, Co, Aip press, New York.

Sanusi, Y. K. (2012). Performance evaluation of polycrystalline and monocrystalline modules under standard test condition using cable transmission method.

Ugwuoke, P. E. & Okeke, C. E. (2012). Performance Assessment of Polycrystalline Silicon PV Modules Low Latitude Regions as a function of Temperature, International Journal of Applied science and Technology (IJATS) vol. 2. No 3. PP 295-301.

Table I: SELECTED SOLAR PANEL SPECIFICATIONS

Panels	Maximum power	Current at P_{max}	Voltage at P_{max}	Short Circuit Current (Isc)	Open Circuit Voltage (Voc)	A.M	E(W/m^2)
Monocrystalline	2watts	0.12A	(8.6-9.0)V	0.21A	8.4V	1.5	1000
Polycrystalline	10watts	0.57A	(17.5-21)V	0.63A	(21-2.05)V	1.5	1000
Amorphous	5watts	0.35A	(17-20)V	0.45A	(21-22)V	1.5	1000

Figure1: Block diagram of the measuring and transmitting system.

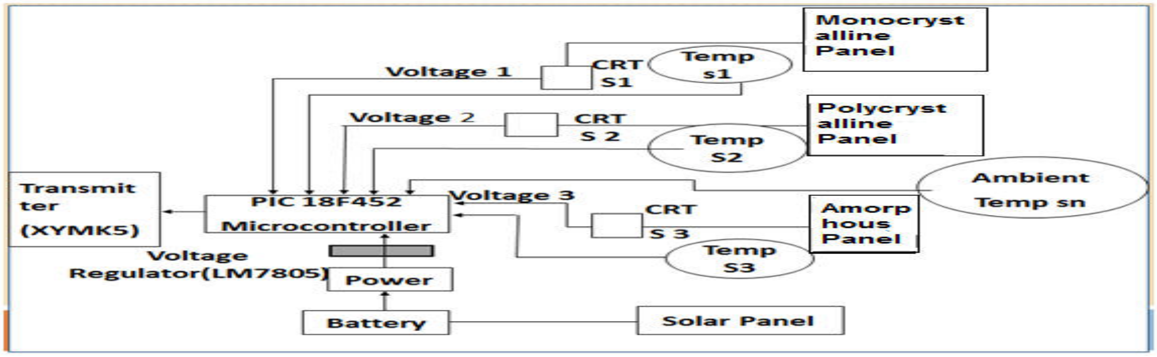
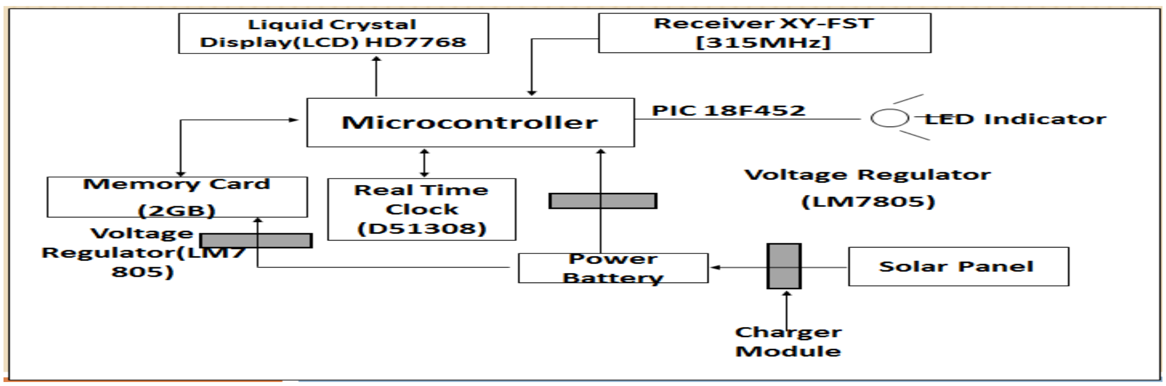


Figure 2: Block diagram of the receiving and storage system.



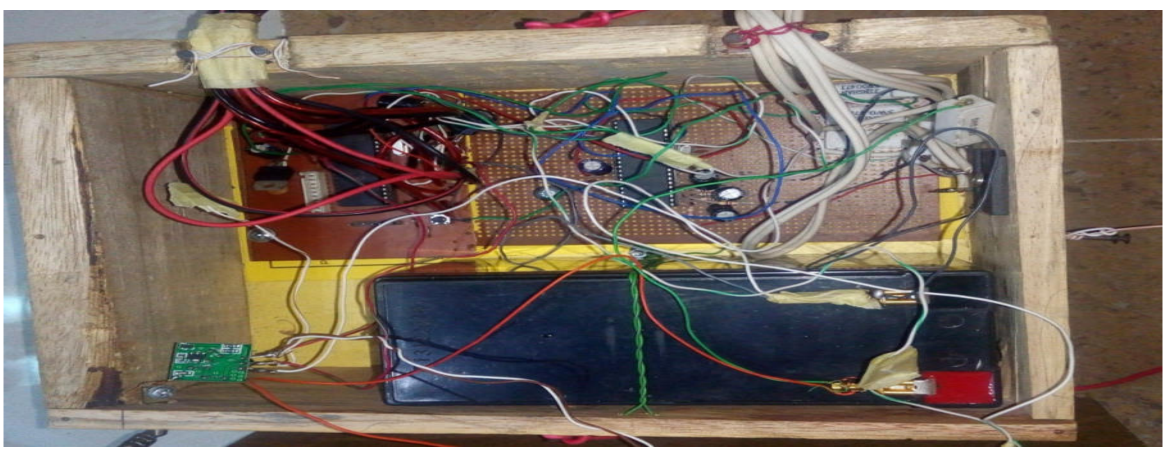


Plate 1: The internal structure of the constructed transmitting system.

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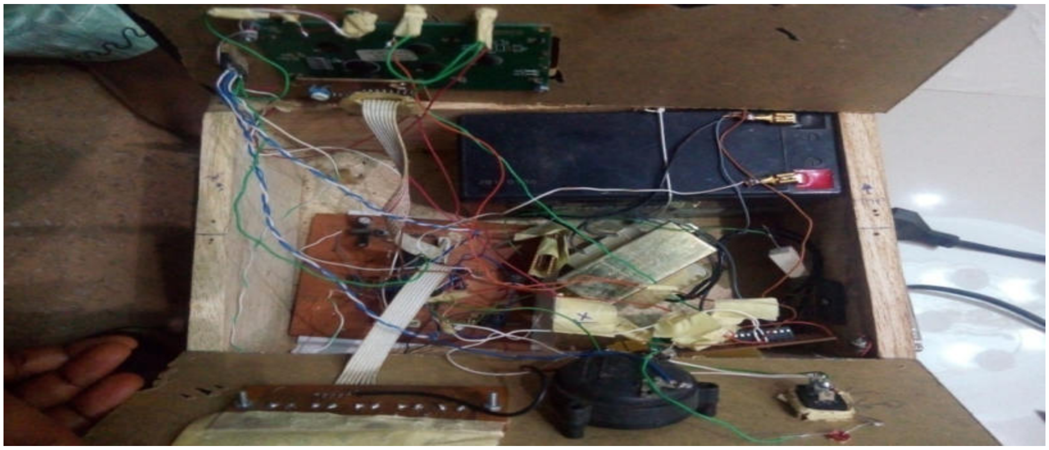

Plate 2: Internal structure of the constructed receiving system

Plate3: The experimental setup showing the panels, transmitter and receiver.

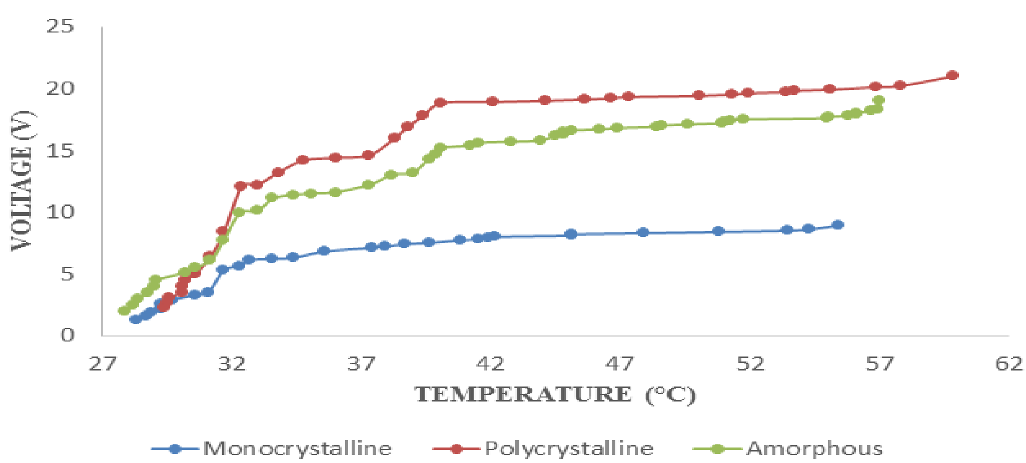

Figure 3: Variations of output voltage and panel temperature

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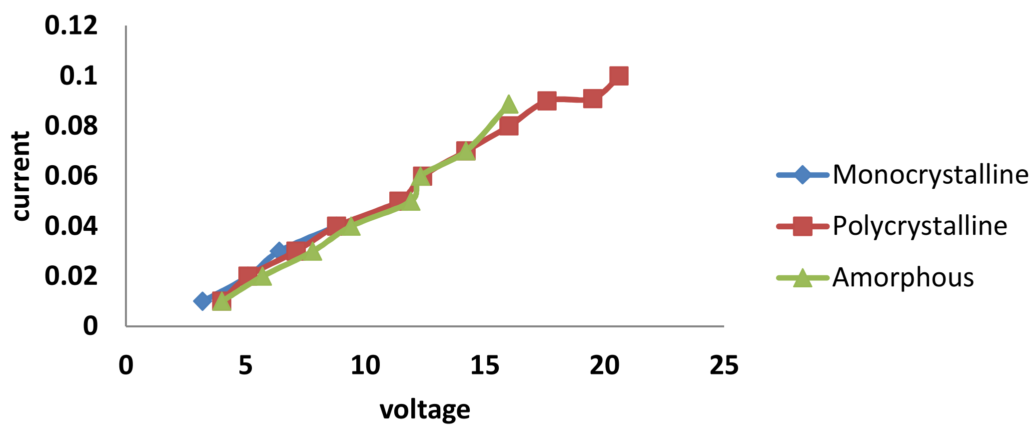

Figure 4: Variations of output current and voltage

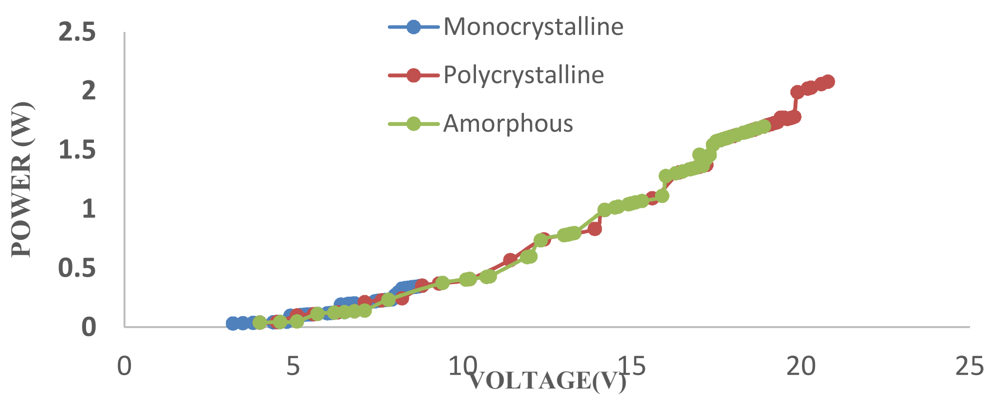

Figure5: Monocrystalline, Polycrystalline and Amorphous Power and voltage relationship.

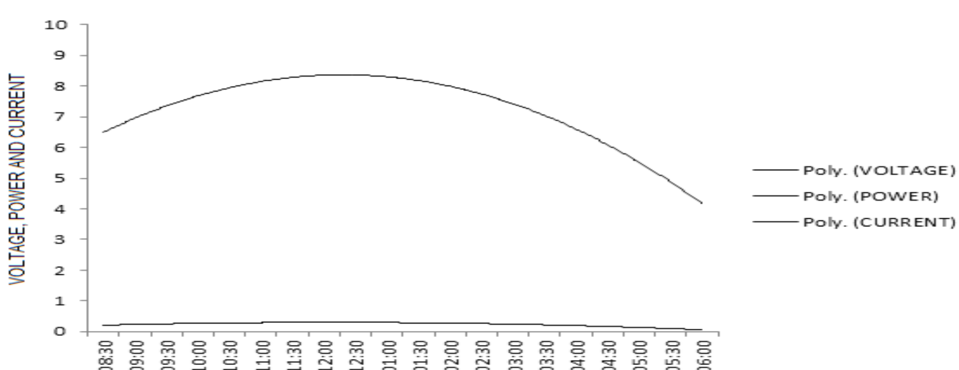

Figure 6: Variations of monocrystalline current, voltage and power with time of the day

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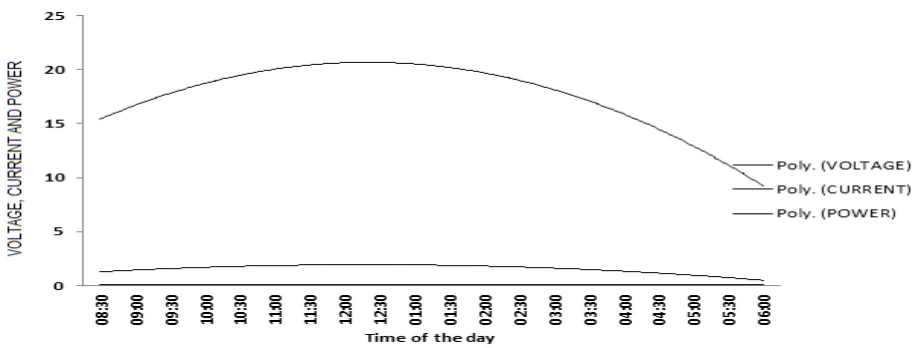

Figure7: Variations of polycrystalline current, voltage and power with time of the day

Figure 8: Variations of Amorphous current, voltage and power with time of the day

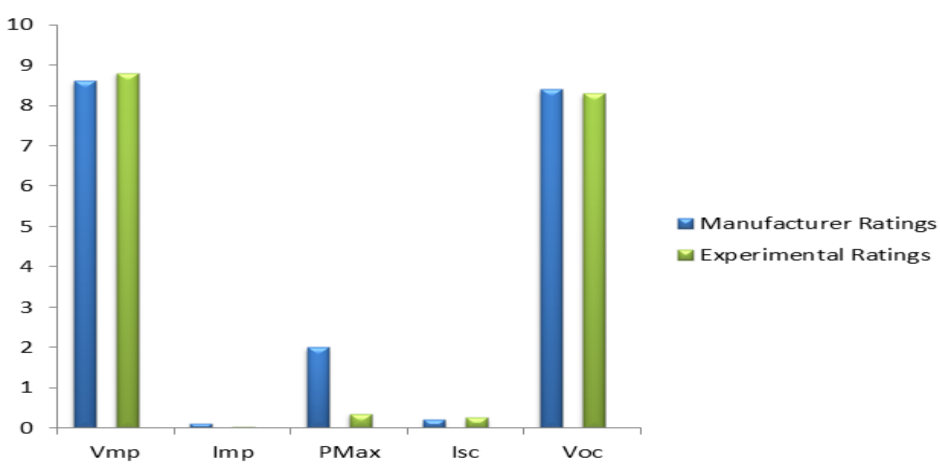

Figure 9: Comparison of Monocrystalline experimental results with manufacturer's rating

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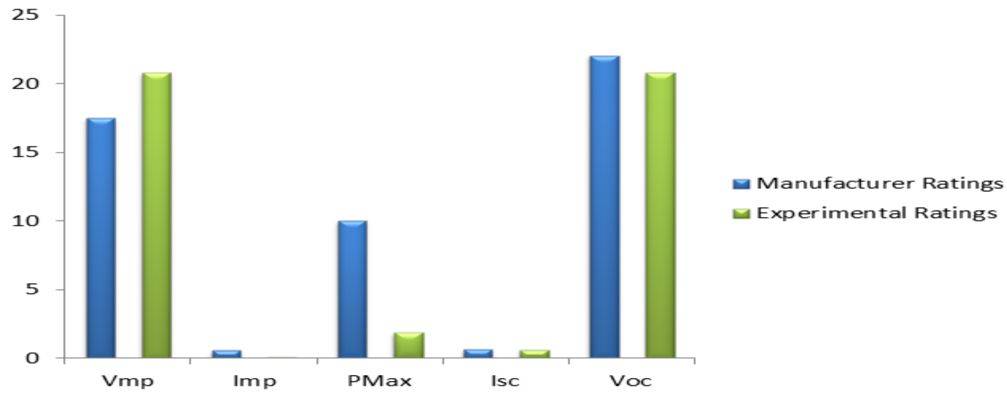

Figure10: Comparison of polycrystalline experimental results with manufacturer's rating

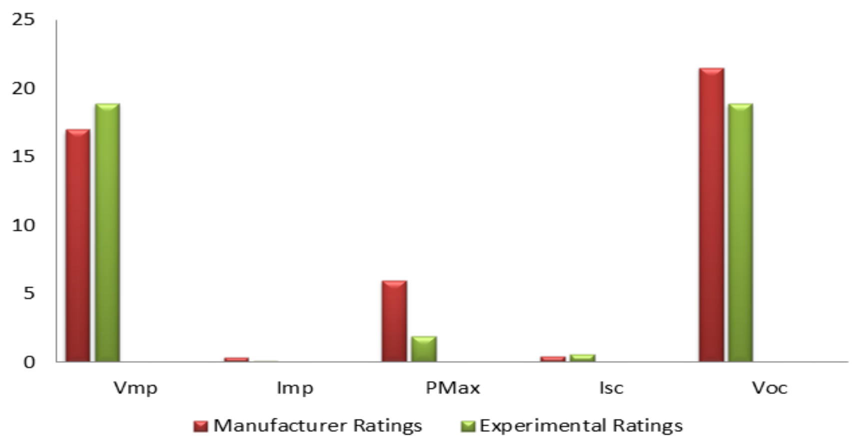

Figure11: Comparison of Amorphous experimental results with manufacturer's rating