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DEVELOPMENT AND TESTING OF AN ADVANCE SEISMIC MONITORING TO EVALUATE THE PERFORMANCE OF NEW MINI REGION IN THE ONAN GANJANG STATION

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ABSTRACT

The new shelter of a mini region station in Onan Ganjang, North Sumatera had been deployed in October 2019 and had been operating in November 2019. The new shelter called ONSM station also includes a solar panel to power the batteries and freestanding communication module transmit real-time data via satellite or internet. The power of solar cell installation could be affected to communicate the waveform availability data at the new shelter. In this case, we design and testing the solar power system for a new mini region station at ONSM station. The result represented the ONSM station in November to December 2019 is unstable with 42.4 % and at beginning of January 2020 will be stable in 70.4 % after installation of the solar power system for the communication module to transmit waveform data. The probabilistic density function (PSDPDF) and data gaps analysis of ONSM station as a new mini region station helped determine seismic station performance and could be useful for the installation of the seismic mini region.

Keywords: *Solar Power System, New Mini Region Station, Waveform, PSDPDF, Performance*

1. INTRODUCTION

The Indonesia seismic network was designed in 2008 as an advance research seismic network, and following it is development, it is now in the phase of completion by BMKG as Indonesia government. It has been supported and has a complete, new communication and site infrastructure, and its completely digital and fast acquisition communication machine renders it perfect for early-warning application studies.

The communication of seismic network is depended to the VSAT system [1] for produced the waveform or signal as a real-time with a private hub at BMKG are used for data transmission. In this case, the mini region station should be able to locate an earthquake within 5-min time limit. Information communication technologies (ICT) and sensor networks for earthquake alert are very important for evaluate the performance of seismic sensor and digital tools and resources used to communicate, disseminate and store information of earthquake [2], [3]. The mini region station had been deployed in the end 2019 as seismic network of Indonesia. Installation of mini region distributed in Northern Sumatera Indonesia. There are several mini regions had been installed in Northern Sumatera which are connected with real-time communication to an Indonesia Seismic Network System that is generally located in urban area with major communication of backbone. The seismic stations are placed in shelters that are placed interior 6 m x 4 m fenced areas. Each station is supplied with two (120 W) photo voltaic panels, two one hundred thirty Ah gel cell batteries (which avoids freezing damage), and a custom switching circuit board between the batteries. With this configuration, 72-h autonomy is ensured for the seismic and radio verbal exchange equipment. Each website is additionally geared up with a programmable control/alarm machine connected to quite a few environmental sensors (door forcing, solar panel controller, battery, fire) and thru which the website popularity is recognized in real-time. The solar panel is a very useful way and significant to seismic station work. The majority of the mini region seismometer is connected and controlled exclusively by solar panels or a combination of solar panels and a fuel cell. One of the ways of obtaining electricity from renewable sources is through photovoltaic (PV) cells. The solar PV is now the third most imperative renewable energy source [4]–[6].

The fundamental and PV research had been growth, [7]–[9] realization and characterization of

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PV with digital control depending on weather conditions or temperature changes. The meteorological characteristics can be measurement of the performance and efficiency of the system [10], [11]. The principle of the mini region seismometer station [9], the installation of solar power and deployed the sensor of mini region are generally located away from rods and cities and low power for operated the seismic station.

The performance of seismic station is the most critical aspect for installation [12]–[14] for availability the waveform data and to the reduce the ambient noise. The characteristic of ambient noise had been introduced by [15]–[19] based on the climate, human activity and earthquake. The performance computation of digital signal seismic can be analyzing by using Power Spectral Density and Probability Density Function (PSDPDF). Digital signal seismic processing is one the most powerful technologies, that will shape science and engineering for combine the computation signal or waveform from the seismic sensor. The observation of earthquake monitoring station in Northern Sumatera had been deployed in the last end 2019 with seismic code ONSM as mini region. The ONSM is mini region of the seismic network for recorded the earthquake waveform in real time. The essential function of a seismic network is to supply brilliant records for earthquake monitoring after installation. The attribute of seismic information wishes to be researched and analyzed for the communication waveform of the mini area station. The utility of waveform information is considerably accelerated when noise ranges are reduced.

In this case, we not only design the solar power system by using the solar cell LEN 260 Wp Monocrystalline, battery and solar regulator in the new mini region of seismometer shelter but also testing the availability and performance ONSM station after installation in the end year 2019 by computed the signal or waveform using PSDPDF. The ONSM station is a new mini region for recorded the waveform and can be coverage the small earthquake in near of area. The solar cell of LEN 260 Wp Monocrystalline had been produced from solar cells with high efficiency so that it can be produced maximum power up to more than 260 Wp. The goal of this study to develop and testing the signal which recorded from the new mini region seismic of ONSM station based on the availability and performance ONSM station after installation of a solar power system.

2. RELATED WORK

Several approaches exist to obtain the signals and phase from broadband seismic station three-channel recordings. The several aspects of performance seismic network had been introduced by [20], [21]. The performance of sensor had been related to the power supply in situ. Based on the principle of the seismometer [22], There are two advantages to low power. The first is that decrease strength ability a physically smaller footprint and a less steeply-priced set up for stations which have to be placed a way from important electricity systems. Such stations are frequent because the exceptional seismic websites are generally located away from roads and cities and human recreation in general, so-called sources of cultural noise. For a temporary deployment, decrease strength skill fewer batteries are wished for a given length of time. And the second lower electricity relates particularly to overall performance at very long intervals in vault-type installations. Power dissipation internal the sensor and digitizer capability heat generation. This warmness reasons convection inside the vault, and the ensuing airflow tends to be turbulent and chaotic, heating and cooling a number of surfaces round the vault, in precise the floor, inflicting small but measurable tilts.

3. DATA AND METHOD

In this study, the material of the solar power system consists of a solar cell, battery, and solar regulator. The solar cell development the mini region seismometer shelter using the Len 260 Wp Monocrystalline. Len 260 Wp Monocrystalline Solar Module is made from solar cells with high proficiency [23]. The battery type used the ES200 for the rechargeable backup battery pack and automatic descending door emergency operation at power failure. The es200 battery can automatically detect the situation of the sliding door system in the mini region seismometer shelter. The solar power system for a new mini region station using the solar regulator. The charge controller or solar regulator work in aggregation with a standalone system or a grid connect solar power system that incorporates a backup battery bank. A solar regulator is a small box consisting of solid-state circuitry that was placed between a solar panel and battery [18]. The characteristics curves of solar cell I-V show the current and voltage (I-V) of a particular photovoltaic (PV) cell module offering a detailed explanation of its solar energy conversion ability and efficiency [24], [25]. Expressive the electrical I-V characteristics, it is, more highly, P max of a solar cell, or panel is critical in determining the

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device's output performance and solar efficiency. Solar Cell I-V Characteristics Curves are a graphical representation of the operation of a solar cell or module summarizing the relationship between the current and voltage at the existing conditions of irradiance and temperature. I-V curves provide the information required to configure a solar system so that it can operate as close to its optimal peak power point (MPP) as possible [26], [27]. The solar cell I-V characteristic curve of Len 260 Wp Monocrystalline can show in figure 1. Solar Cell I-V characteristic curves are graphs of output voltage versus current for different levels of insolation and temperature and can tell you a lot about a PV (Photovoltaic-which converts light energy into electricity) cell or panel's ability to convert sunlight into electricity. The most important values for calculating a particular panel power rating are the voltage and current at maximum power.

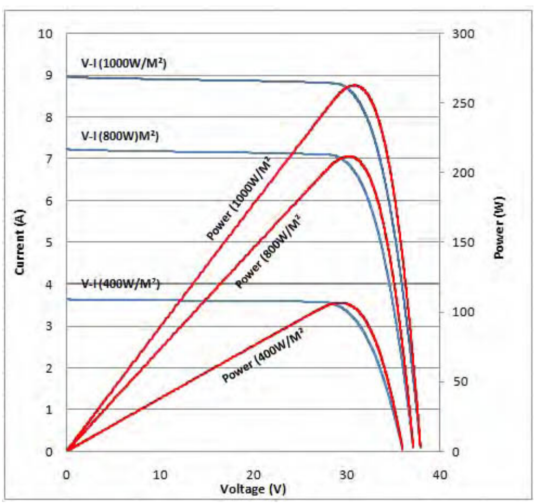

Figure 1. Current voltage and Power Voltage curve [18]

Open circuit voltage is the maximum voltage that the array provides when the terminals are not connected to any load (an open circuit condition). This value is much higher than which relates to the operation of the PV array which is fixed by the load. This value depends upon the number of PV panels connected together in series. Short circuit current is the maximum current provided by the PV array when the output connectors are shorted together (a short circuit condition) [28]. This value is much higher than which relates to the normal operating circuit current. The maximum power is related to the point where the power supplied by the array that is connected to the load (batteries, inverters) is at its maximum value. The maximum power point of a photovoltaic array is measured in Watts (W) or peak Watts (Wp).

The current, for maximum power to the load, is difficult to obtain analytically but it can be graphically evaluated from the I–V characteristic. The maximum power is equal to the product of and, the maximum power point occurs near the knee of the curve. An important parameter related to solar cell efficiency [29]–[31] is the Fill Factor (FF), defined as Eq. 1.

$$FF = \frac{V_m \cdot I_m}{V_{OC} \cdot I_{SC}} \quad (1)$$

where I_SC is the SC short circuit current. The FF is a measure of how well the area (V_OC. I_SC) is filled by the area (V_m .I_m). Typical values of FF are between 0.7 and 0.9. The FF is strongly affected by R_S and R_SH. The solar cell efficiency [26] (energy conversion efficiency) is define as Eq. 2.

$$n_c = \frac{P_m}{P_{in}} = \frac{V_m \cdot I_m}{P_{in}} = \frac{V_{OC} \cdot I_{SC} \cdot FF}{P_{in}} \quad (2)$$

where P_in is the input power to the cell.
The design of the solar power system in the ONSM station can show in Figure 2.
The power of the station mini region seismometer is needed, to operate, transmitted and collected the waveform data. The performance of seismic station is very dependent on good power. The performance of the station can represent from background noise by power spectral density and probabilistic density function (PSDPDF) methods [16], [18], [32]–[34]. In this case, we used the vertical component (SHZ) to evaluate the performance new station and show the availability in horizontal and vertical component

The seismometer instrument response is removed by dividing the PSD estimate on instrument transfer function to acceleration from eq (3) [35] .

$$P_a = P_k.\omega^2 = P_v.\omega^2, P_k = P_v, [(\frac{m/s^2)^2}{Hz}] \quad (3)$$

where, the power spectral density estimate, and for direct comparison of the low noise model and high noise model using, the PSD estimate is converted into decibels (dB) concerning acceleration. The general methods in this study based on the PSDPF method can show in Fig. 2. The PSDPDF method can perform the new mini region station.

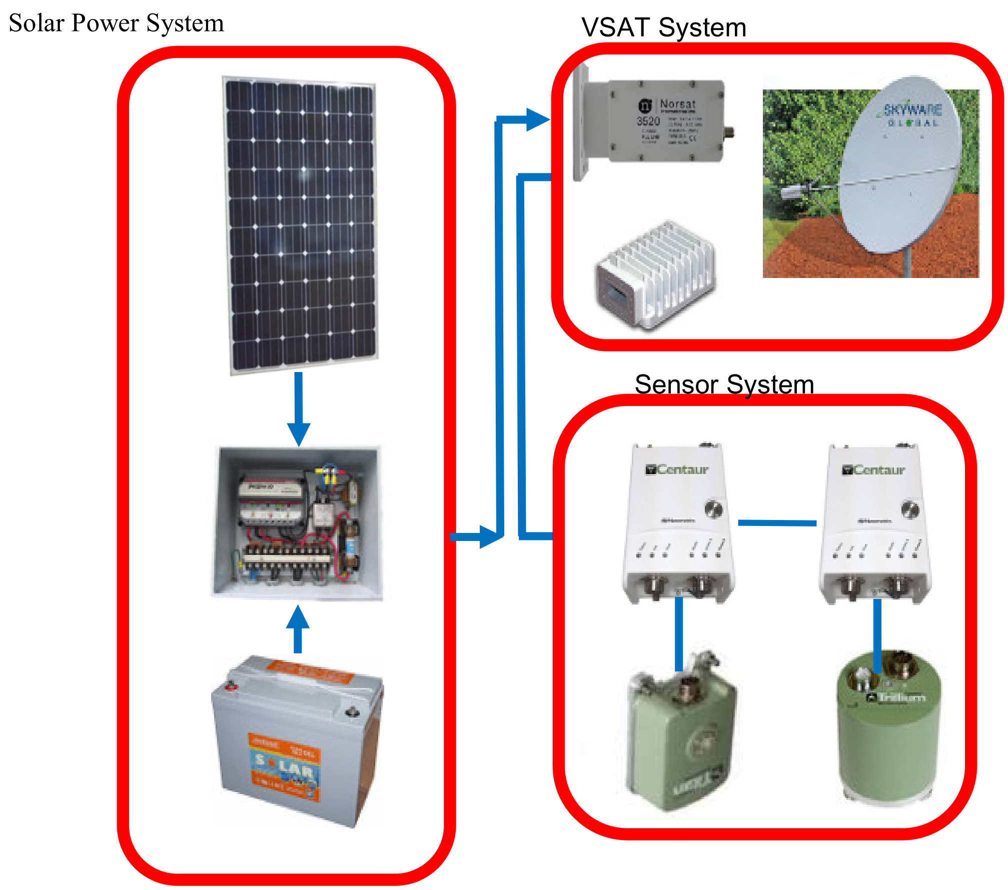

Figure 2. Design of solar power system in new broadband shelter

4. EXPERIMENTAL SETUP

The experimental set-up had been deployed and tested in Onan Ganjang, North Sumatera Indonesia on October 2019 with located in 2.1599 N and 98.6301 E at the height of 1158 m from the sea level.

Table 1. The electrical Characteristic STC

NO	Characteristics	Value
1	Optimum Operating Voltage (Vmp)	30.60 V
2	Optimum Operating Current (Imp)	8.50 A
3	Open – Circuit Voltage (Voc)	37.70 V
4	Short – Circuit Current (Isc)	9.15 A
5	Maximum Power at STC (Pmax)	260 W
6	Modul Efficiency	16 %
7	Operating Module Temperature	-40 °C to +85°C
8	Maximum System Voltage	1000 V DC
9	Maximum Series Fuse Rating	15 A
10	Power Tolerance	+ 0 – 3 %
11	***STC***	**Irradiance 1000 W/m², module temperature 25 °C, AM=1.5**

The temperature characteristic of these tools shows in Table 2. The characteristics of temperature classify based on the nominal operating cell temperature (NOCT), temperature coefficient of power, temperature coefficient of Voc, and Temperature Coefficient of Isc

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Table 2. Characteristics of Temperature

NO	Characteristic	Value
1	Nominal Operating Cell Temperature (NOCT)	45 ± 3 °C
2	Temperature Coefficient of Power	-0.41 %/°C
3	Temperature Coefficient of Voc	-0.31 %/°C
4	Temperature Coefficient of Isc	0.047 %/°C

5. RESULTS AND DISCUSSION

The testing of the solar charge controller (SCC) in situ, shown in Table. 3. The polarity condition of SCC, in this case, is good for transmitting and collecting the waveform data.

Table 3. Solar Charge Controller (SCC)

No	Solar Module	V_m (Volt)	I_m (A)
1	SCC 1	13.2	3.67

The condition of the battery shown in Table 4, the testing of each battery shows the good polarity for the installation of a new shelter of mini region seismometer at ONSM station

Table 4. Battery Testing

No	Solar Module	Vm (Volt)	Im (A)
1	Battery 1	13.6	5.48
2	Battery 2	13.4	4.70
3	Battery 3	13.2	3.43
4	Battery 4	13.1	2.97

The result of the test commissioning of mini region from solar power system in the new shelter consisted of a solar module, solar charge controller and battery. The testing commissioning PV power system in Onan Ganjang, North Sumatra, Indonesia show in Table 5.

Table 5. Testing and result of Solar Module

No	Solar Module	V_{OC} (volt)	V_m (volt)	I_m (A)	FF
1	Solar Module A	35.4	13.3	1.74	0.07144577
2	Solar Module B	35.5	13.3	1.70	0.06960671
3	Solar Module C	35.7	13.3	1.69	0.0688096

Based on the Eq. 1, the fill factor (FF) for each module shown in Table 5. By computing with eq. 2, the result of the Maximum Power, P_max of the solar module A, is 24.5148 W with solar efficiency based on Eq. 7, the n_c is 2.4515 %, the of P_max of the solar module B is 23.8838 W with solar efficiency (n_c) 2.3884 and the P_max solar module C is 23.6103 W with solar efficiency (n_c) 2.361 %. The P_max of each solar module indicated can supply the power for recorded and sent the waveform of new shelter of broadband seismometer at ONSM station. The maximum efficiency of the solar module of Len 260 Wp is 16 %, if we compared with the result of efficiency indicate the performance of the solar cell will be good for the installed new shelter.

The test commissioning in this study had been done in the day at 12.00 pm at a local time with the weather condition in the situ is cloudy. The solar power system for the new mini station seismometer shelter had been built in October 2019 and can be operated in November 2019. The visual of solar panels in Figure 3.

Figure 3. New mini region Shelter and Solar Panel System: a. Solar Panel, b. Panel Battery at mini region shelter

The Figure 4 is the Panel Battery at mini region shelter in ONSM sensor. The result of this study indicated the solar module of Len 260 Wp Monocrystalline can produce maximum power up to more than 260 Wp, its performance at low lighting intensity can also be very good so that this module can still work in cloudy conditions and rainy times.

Figure 4. Panel Battery at mini region shelter

This module is the right choice used in various applications for the development of new mini region shelter in remote areas, instrument equipment. In this case, the quality of waveform data from ONSM station shows a good performance. The performance of ONSM in November to December show in Figure 4.

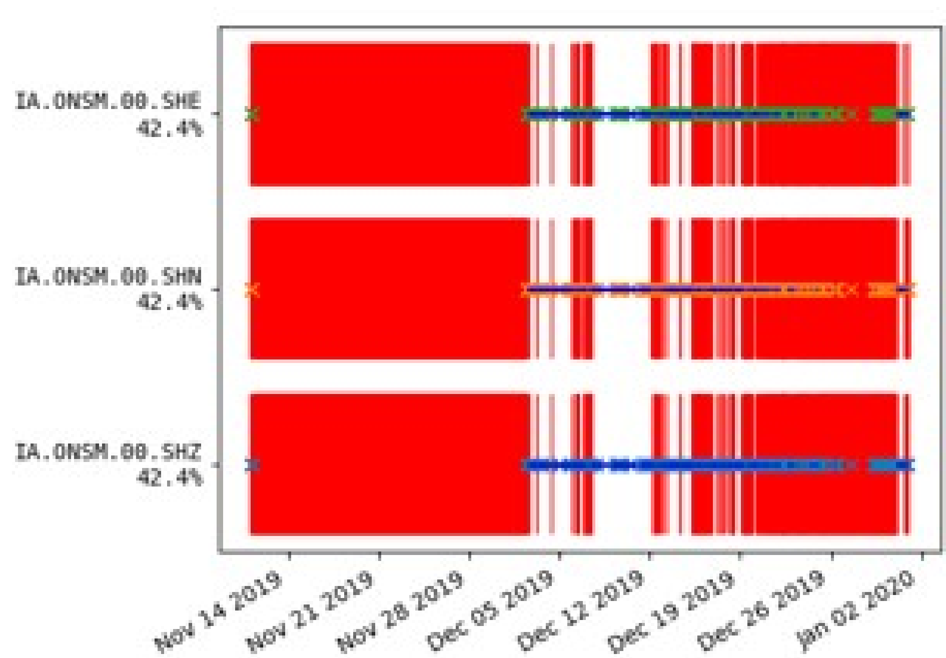

Figure 5. The availability and performance of new shelter of ONSM station in November to December 2019

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Figure 5. is visualize data availability of waveform based on horizontal and vertical component. In this study, the result of horizontal (SHE and SHN) and vertical component (SHZ) have availability 42.4 %. It means that the percentage of availability indicate there are some gaps from the solar, come from the noise.

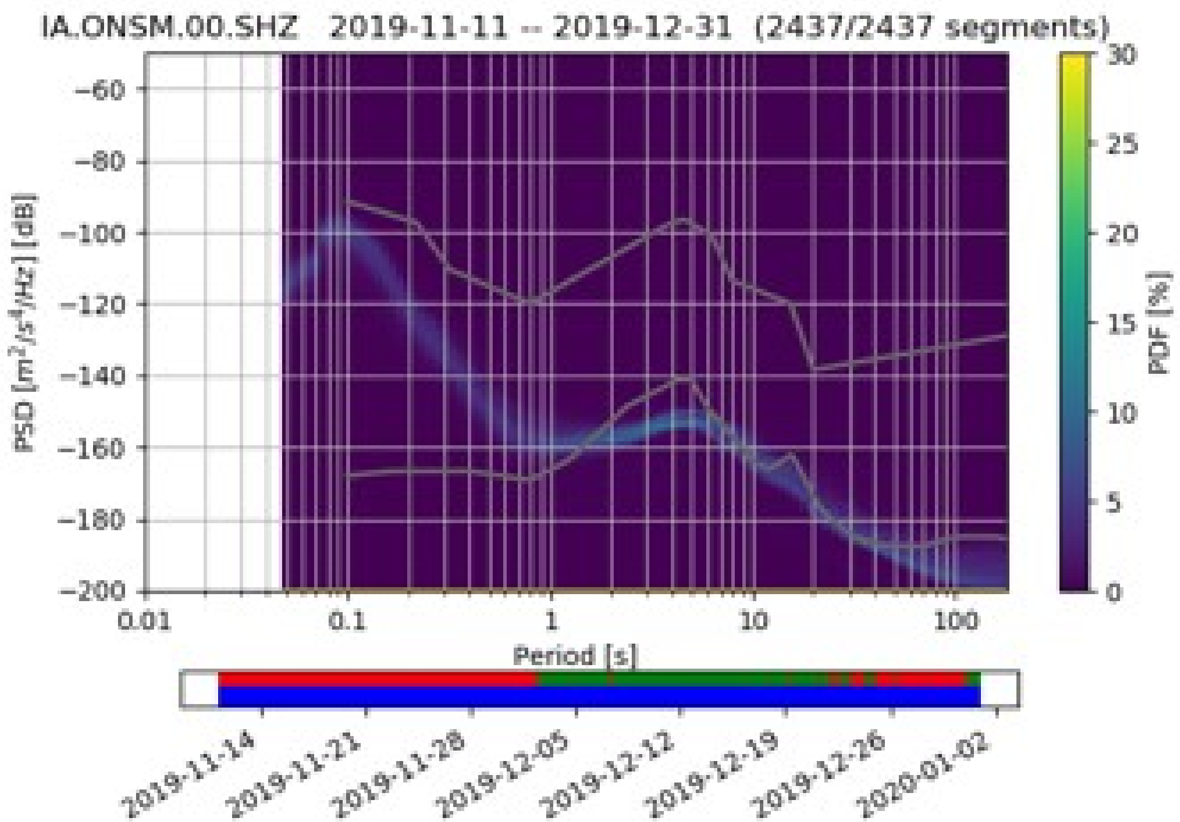

Figure 6. The availability and performance of new shelter of ONSM station in November to December 2019

Figure 6. is the power spectral density and probabilistic density function which produced from the condition of the sensor. The spectral means there are many gaps can be represented in the period. The green patches in periods represent the available of waveform data, and the red patches represent gaps in the stream of ONSM. The waveform computing by using PSDPDF to show the performance of the sensor for more than one month, 11 November 2019 to 31 December 2019.

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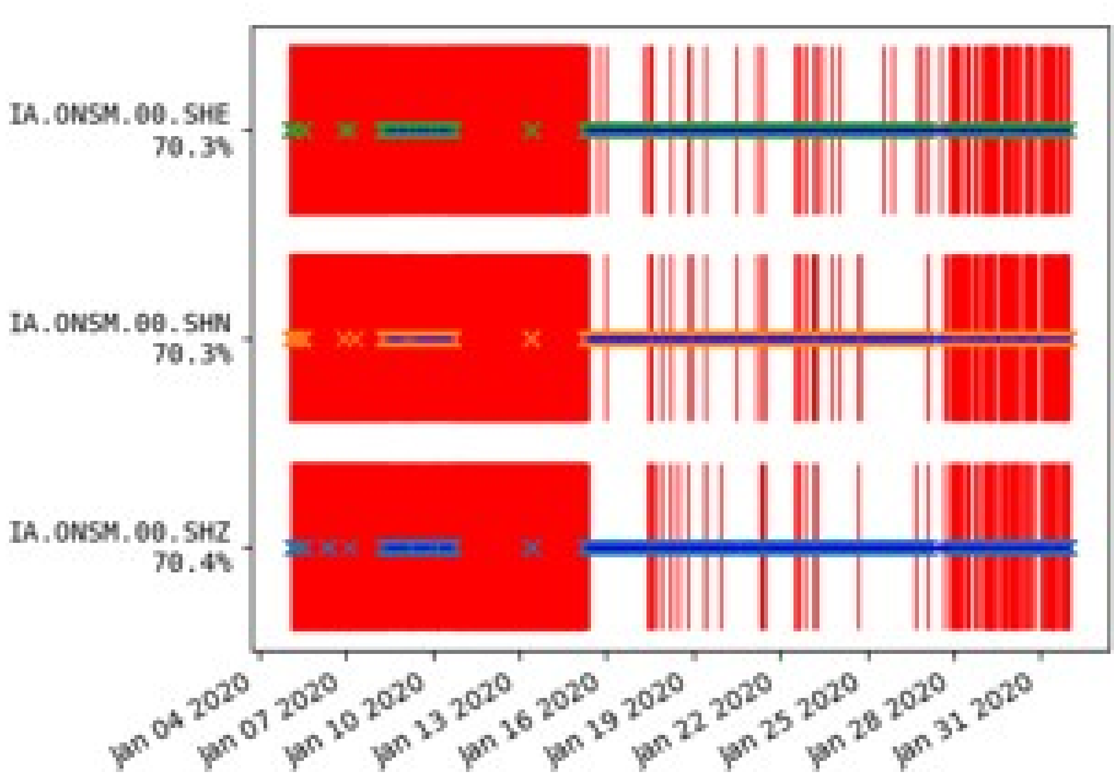

Figure 7. The availability and performance of ONSM station in January 2020

Figure 7. is the availability of waveform ONSM station in January, 2020. The result shown the availability of horizontal component (SHN, SHE) is 70 .3 % and vertical component (SHZ) is 70.4 %. The performance of ONSM station in January after installation in the end year 2019 is better than previous waveform recorded in November to December 2019.

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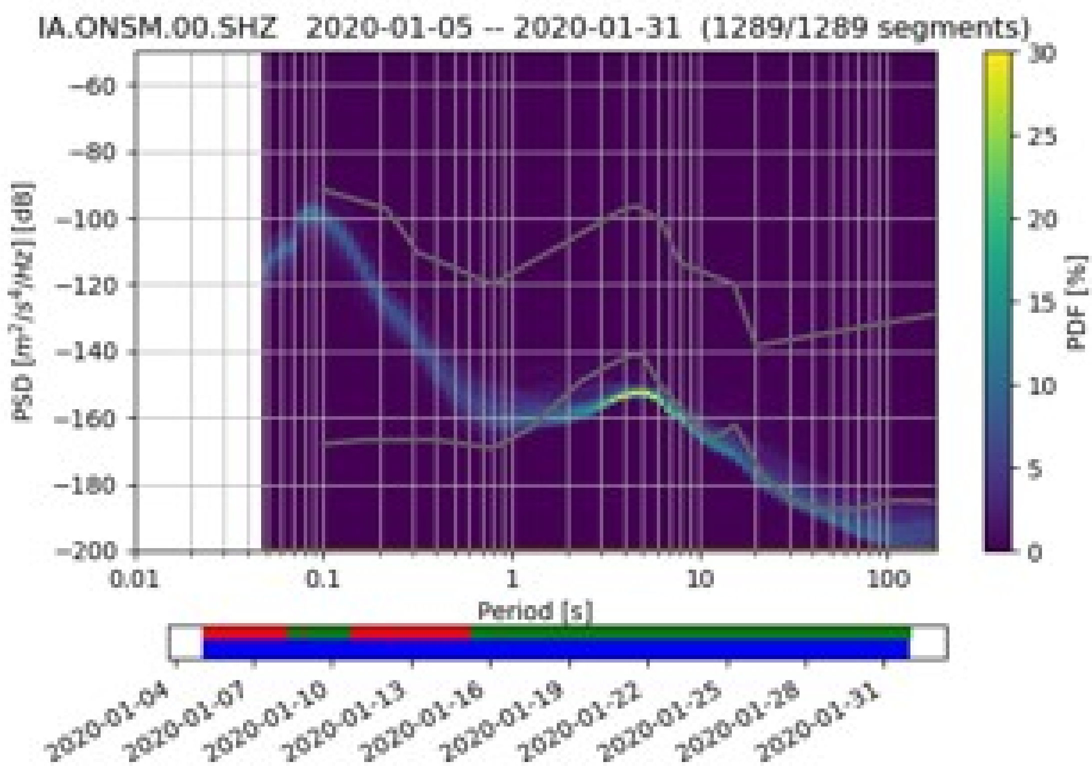

Figure 7. The availability and performance of ONSM station in January 2020

Figure 7. is a performance of ONSM station in January 2020, the computation of the spectral in January indicated the performance of ONSM station still not stable, the dominance of green patches had been represented in period and there are small gaps (red patches) in this month.

6. CONCLUSION

The mini regional seismic network analysis is very important for determining the earthquake information. The good performance of a solar power system for the installation of a new broadband seismometer shelter for generated the transmission of the waveform data. The performance of the solar module of Len 260 and power supply in the new mini region seismometer shelter had been developed and operating, the low lighting intensity can still work in cloudy conditions and rainy times. The result, compared with the availability waveform data and performance of ONSM station helped determine seismic station and could be useful for in the installation and performance of seismic mini region. The good physics condition of new shelter included the solar power system making the sensor can be operated and record the event or waveform data. The result represented the ONSM station in November to December 2019 is unstable with 42.4 % and at beginning of January 2020 will be stable in 70.4 % after installation of the solar power system for the communication module to transmit waveform data. The computation waveform data based on probabilistic density function (PSDPDF) and data gaps analysis of ONSM station as a new mini region station helped determine seismic station performance and could be useful for the installation of the seismic mini region.

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