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Technical Analyses of MHP ELCS; An Analysis of KPK MHP Project, Pakistan

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***Abstract*—**Energy is the basic requirement for the development of a country. Pakistan is fronting meaningful contests in the sector of energy on the way to conference the demand which is significantly increasing annually. The government of Pakistan have initiated various renewable energy projects for the provision of electrical energy particularly to the rural areas where population is less, and extension of main grid-system is not fiscally and technically practicable due to huge rate asset essential for transmission network. In electrical power system the users need uninterrupted power supply at rated frequency and voltage. Due to existence of different kinds of loads having different structure and load demand the frequency and voltage of micro hydro plant (MHP) may not be continuous. To keep these constraints in the specified boundaries appropriate control approach must be recognized for the system. Frequency is maintained by eliminating the difference among generation and load demand through Electronic load controller (ELC). ELC function is to dump extra power into dummy loads, when consumers switch their loads off, maintaining system frequency constant. The purpose of this research paper is to analyses the connected MHP ELCs in KPK via considering the case study of Ashran Valley District Swat and Tehsildar kali district Mardan to know the impacts of voltage, frequency and power factor of these MHP ELCs likewise to recommend for improvement. Comprehensive literature review was carried out to achieve these goals. The real time data was collected using the site observation, and the analyses of real time data (voltage, frequency and power factor) of MHPs ELCs are analyzed through Microsoft Excel software. This research work concludes that these MHPPs requires proper management, quality work and skillful operators to have a sustainable and reliable system for the community.

***Keywords*—** Micro hydro system, Electronic load controller, Dummy load, Microsoft Excel

I. INTRODUCTION

Any nation that want to advance their living standards and raise their economy must have secure and sustainable energy system. Since our environment suffers from gas emission, the use of clean and renewable energy sources is one of the best solutions that would help limiting the global warming effect [1]. In a suitable location micro-hydro power is one of the most cost-effective and reliable renewable energy technologies. It has several advantages over solar and wind power, with a prominent level of predictability. Micro hydropower system is one of the most environmentally benevolent energy conversion options available. Unlike large-scale hydro power, it does not attempt to interfere significantly with river flows. Micro-hydro power plants (MHPP) are usually built on mountains to provide electricity for rural communities.

However, they are mostly isolated from national electric grid. In addition, variations of the consumed power on the load side cause deviations between the produced and the consumed power, which causes variations of both MHPP frequency and voltage outputs [2].

Thus, MHPP that work in isolated mode require the mixture of good and price moderate control system to ensure the stability of both MHPP frequency and voltage with changing load demand. MHPP is a nonlinear and non-stationary multivariable system whose characteristics vary significantly with unpredictable load on it. Generally, two main control strategies could be used to automatically control the rotational speed of the generator shaft, and thus the frequency of the voltage waveform. The turbine speed can remain constant either by acting on the gate opening position (mechanical regulation of the turbine water flow) or by using an electronic load controller (ELC).

First, triggering the gate opening position aims to produce just the necessary power according to the connected load [3]. However, this speed governor must be slow to avoid the water hammer effect, and so, it takes a considerable time to stabilize the turbine speed when a load disruption occurs. It becomes insufficient in case of large load variations [4]. Moreover, the cost of such governor is often dearer than the cost of the generator [5].

The accepted alternative to the speed governor is the ELC which maintains the speed of the set by adjusting an electrical ballast load connected to the generator terminals through a power electronic system [1,5]. Typically, the cost of the ELC is about one tenth that of the speed governor and so the economic advantage of the ELC is double, because of the lower capital

cost of the governor and of the turbine. Pakistan power sector is an emerging market. For years the matter of balancing the supply and demand for electricity has remained an unsolved issue [6]. For these reasons government of KPK is deploying different projects of micro hydro power for the electrification of those rural areas where there is no access to the national grid.

The purpose of this research paper was to analyses the connected MHP ELCs in KPK via considering the case study of Ashran valley district swat and Tehsildar kali district Mardan to know the impacts of voltage, frequency and power factor of these MHP ELCs. Different site visits were conducted for the data collection of MHP ELCs.

II. STANDARD TECHNIQUES OF ELC'S

A. *Binary Load Regulation*

The dump/ballast loads are created from a swapped mixture of binary procedure of individual resistive load in binary loads regulation. A switching choice was made to attach the suitable grouping of load phases, in reply to an alteration in the user load. In transient period only the switching action happen, afterward complete "system" voltage was functional toward the novel segment of the dump loads then later harmonic were not formed through this technique in the solid states. Steady states swapping relay contains a zero-voltage switching circuit which eliminates the harmonics distortion related thru the transient switching period [7]. Solid state relay has higher prices than the TRIACS as individually it comprises navigation electronics. To gain the even adjustment, all the ballast loads must have precisely the accurate capacity. System cannot adjust evenly, and stages b/w ballast load grouping stay too big thru less number of ballast loads.

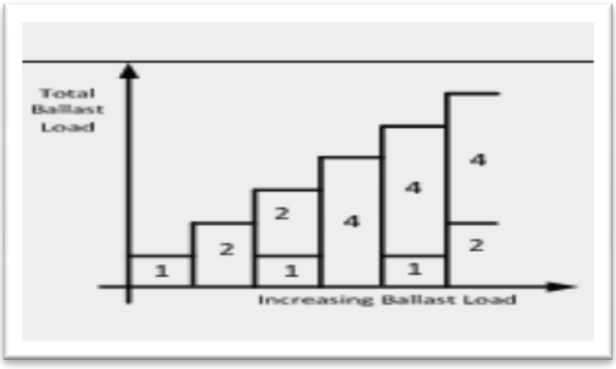

Figure.1 Principle of binary loads

The load share supported by apiece of the stages is in the proportion of "1: 2: 4: 8" and once "switched" in order, the dump load displays a stepped feature, realize figure 1. The addition of all the dump load ladders are identical to (or somewhat larger than) the esteemed production of the generator. In reply to a verdict to adjust the level of the dump load a switching order is done to choose a novel mixture of the load stages. The switching action is for a temporary period solitary, subsequently complete scheme voltage is functional toward the novel portion of the dump load and later harmonics are not formed entirely in the steady state situation.

B. *Pulse width modulation*

Pulse width modulation (PWM) is a variation method utilized to translate a communication into a pulsating indicator. The modulation method could be utilized to translate data for transmission purposes. The key use of PWM technique is to permit the control of the power provided to "electrical devices", specifically to inertial loads such as motors [8]. Pulse width modulation is usually utilized method for modifying voltage's indicator. The advanced transistors like MOSFET or IGBT was utilized by PWM, to set up a pulsation indicator. Generally, in PWM the signal is either 1 (on) or 0 (of). PWM technique utilized the thickness of pulses signals to govern the middling voltages signals (realize picture 2). Width is described as the duty cycle at the time when the signal is on. Thru changing the duty's cycles, it's out-put voltages signals are altered. Meanwhile that voltages levels are comparative towards the powers, in ELC circuit it will be monitoring the power to the ballast loads.

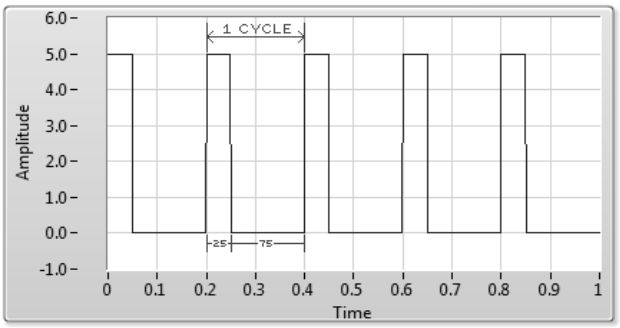

Figure.2 Principle of PWM at 25% duty cycle

For case: The generator voltage level surges, after the feeding load declines. The power "must" be abstracted to the ballast loads to preserve a continuous voltage level. By rising the duty cycle of the signal this process can be attained. The power abstracted to the ballast loads rises as the middling voltage signal rises. To deliver stability to the system the frequencies of the pulse width modulation signals must remain arranged greater than the alteration of that systems. To control advanced power transistors like MOSFET and IGBT, PWM has a benefit with a simple electronic circuit. Drawbacks of PWM consist of tall prices, reduced convenience and sensitivity of the power transistors [9].

C. *Controlled Bridge Rectifier*

To proficiently transform the fluctuating current into Direct Current (DC) bridge rectifier practices four otherwise extra diodes in a bridge circuit construction.

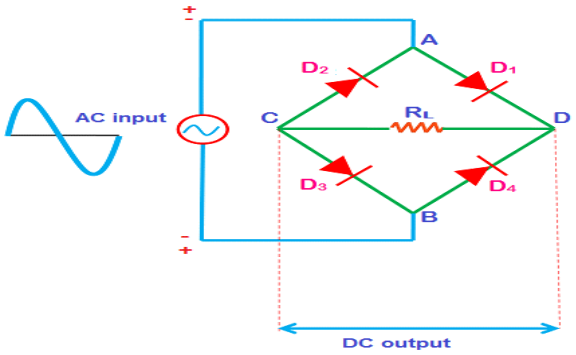

Figure.3 Controlled bridge rectifier

The construction of bridge rectifier is done through 4 diodes i.e. D4, D3, D2, D1 besides resistor load R-L [10]. These diodes are linked inside a locked circle formation to proficiently transform the fluctuating current into DC. This key benefit of tie path formation is, that we don't need luxurious centres tapped transformers, thus deducting its magnitude besides price. AC input signal is functional crossways the two ends B & A and the DC output signal is gained across the resistor load RL which is linked between the ends D & C. The diodes D1, D2, D3, D4 are organized in succession with solitary two diodes permitting electric current throughout individually half cycle. For illustration, diodes D3 and D1 are well thought-out as one couple which permits electric current throughout the +ve semi cycle while diodes D4 and D2 are well-thought-out as additional pair which permits electric current throughout the negative semi cycle of the AC input signal.

D. *Phase Angle Regulation*

The dump load includes a forever linked, solo resistible loads circuit of scale identical towards the complete loads valued out-puts of the generators. The firing angle of a power electronics switching device is regulated, such as a TRIAC due to the alteration in user load and, accordingly varying the level of the voltage nourished and the power degenerate by the dump load [11]. This method makes known to unwanted harmonics against the electrical system with all power electronic switching of this flora. The different form of the voltage waveform of the dump load is specified in below figure.

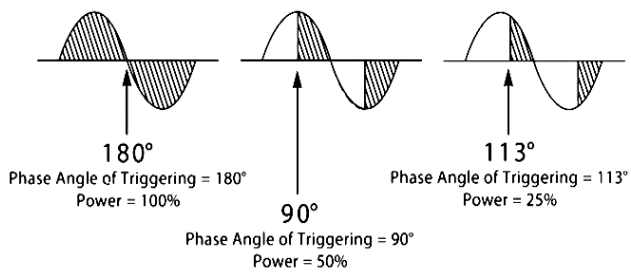

Figure.4 Phase angle control voltage-waveform

"It must be distinguished that these chopped-sine waveforms are unendingly existing for all phase angle control apart from complete dump load". The existence of the harmonics might be the reason of "overheating" of electrical apparatus linked to the generator and the system, generally responded thru the "derating" of the plant [12]. In sure cases, "high neutral currents" might be formed owing to the TRIACS switching at irregular periods in reply to disturbed loads [11].

III. METHODOLOGY

To communicate the difficulties and research questions in the way of MHP projects existing rural zones, simple approach was followed. For collecting useful information relating to such systems, different site visits were conducted to different areas in the Khyber Pakhtunkhwa province, Pakistan which includes Charsada district, Mardan district, Abbottabad district and Upper Dir District. The Tehsildar kali Mardan district was recognized for the case study to understand the influence of frequency of these MHP Electronic load controller (ELC). Using the site observation, real time data was collected, and analyses was done through Microsoft Excel software.

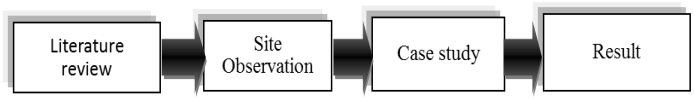

Figure. 5 Research Methodology steps

IV. RESULT AND ANALYSES

A. *Case study of Tehsildar kali and Tableeghi Markaz*

The installed capacity of Tableeghi Markaz and Tehsildar kali was 30 KW each, but the output power delivered by Tableeghi Markaz was 10 KW and 14 KW for Tehsildar kali maximum. The users linked to the Tehsildar kali MHPP ELC are currently 28, including one mosque and 27 residents. Electricity bills were collected by the concerned operator, as billing meter were installed at each user premises. Turbine belt was the main issue of the Tehsildar kali MHP ELC which cost them Rs 6500 by replacing them twice. ELC was used for the frequency control purpose of existing MHPs.

The aim of ELC was to balance the power generated through turbine and the power consumed by the user. The case study of these MHP ELC was passed out to analyses the diverse parameter of the system with the change of load. The data for the calendar year cannot altogether due to the unavailability of data storing system, so only real time data was collected available on the ELC panel screen to show the response of frequency with the load alteration.

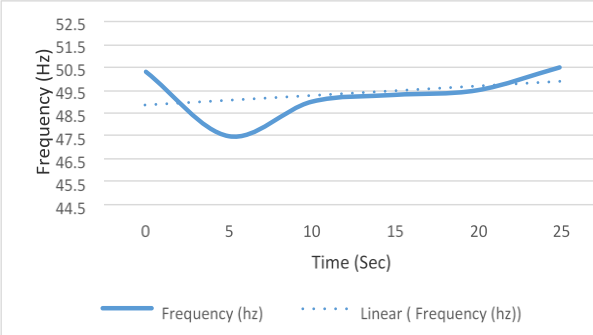

Figure. 6 Frequency response to the load variation with time

The above figure 6 shows the response of Tehsildar kali MHP frequency once load abruptly oscillates. To recover the frequency to its original state ELC use the dummy loads to balance the power generated through turbine and the power consumed by the user. ELC done the alteration by diverting the surplus power to the dummy load. The procedure of deviation was done through the thyristor switch, measured thru the ELC main panel based on the variation of frequency on the system. ELC has very fast recovery time and can handle the large load variation within 10 ms.

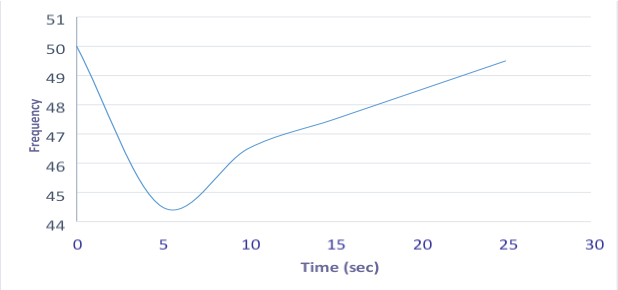

Figure. 7 Frequency variation with 20% increase in load with respect to time

The above figure 7 shown us that when 20% load is increased on the turbine, frequency of the system abruptly changes from its normal state, to control that frequency variation ELC used dummy load of water heater to reestablish the frequency to its original value. As we know that the standard frequency recovery time is 10 ms but in the above figure the situation is quite diverse and obviously seen that the frequency recapturing time is 15-20 ms because of not using the standard rating dummy load according to standard technique and use of local made turbines.

B. *ELC Technique of ballast load Tehsildar kali*

The ballast load used in Tehsildar kali MHP for ELC was water heater as given in the above figure 8, was not in good health because 3 of the resistor coil was broken due to heat, which need continuous water flow to prevent from drying and overheating.

Figure. 8 Water heater Tehsildar kali Mardan

The chances of erosion are also there because of that, heater water tank might leak, and overheating may occur. Due to all these facts ELC operation was not at their standard rating.

C. *Tableeghi Markaz ballast load*

The technique of ballast resistive loads used by Tableeghi Markaz can be seen from the below figure 9, which is against the standard procedure of ELC. First of all, these dummy resistive loads were not according to the rated capacity of MHP turbine and are local made. There are the chances of short circuit any time and the damage probabilities of apparatus as well the injury of living being is sure, because of these high resistive loads are hook with the iron metal.

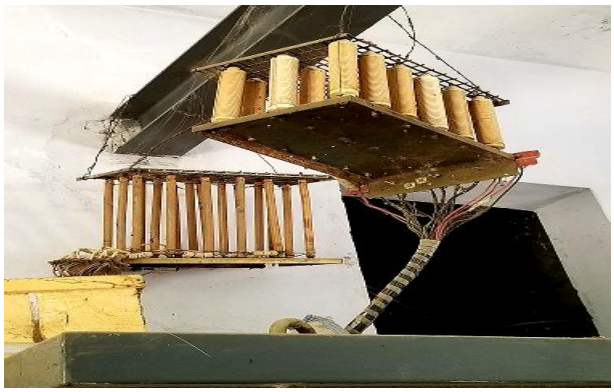

Figure. 9 Tableghi Markaz Mardan dummy resistive load

Due to all these facts ELC operation was not at their standard rating and cannot adjust the load deliberately due the derated capacity of the dummy load.

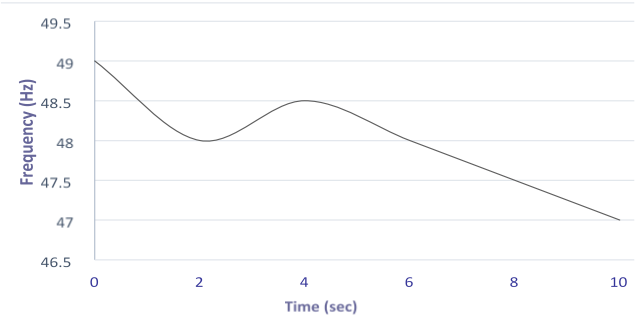

Figure. 10 Tableeghi Markaz frequency with load alteration

We can clearly see from the above figure 10 that the Mardan Tableeghi Markaz MHP frequency is unstable and undershoot with the load variation and due to the poor ELC technique with derated capacity of resistive loads, frequency does not come to its original value. The dummy resistive loads used by Mardan Tableeghi Markaz MHP is local made having no standard capacity rating, which does not adjust the surplus power deliberately.

D. *Standard dummy loads*

Two types of dummy frame have been followed as standard, closed type with wired mesh screen to defend the element from external substances and open type without screen. The heater type used is tubular air heater, which make it less maintenance requirements, longer lifetime and easy in installation comparing to water heater type. Air heater type does not need forced air convection (fan/blower), only install it in place with good air circulation for heat evacuation i.e. windows. The standards versions of ELC comes with open types ballast frame. The rated total power of the ballast normally overrated 10-30% of design turbine power in case of bigger turbine output then design and longer life time of element.

Tubular air heater is industrial standard heater which normally used on heating and drying process. Usual lifetime about 15 years and should be more in ballast load application, meanwhile it's not fully used at all time. Avoid dummy load from water splash, rain and combustible material. It should be out of reach of children and access of public. Never replace damaged dummy element with other type of dummy or distinct size of power. It might disturb the stability and safety of the plant.

CONCUSLION

The intention of this thesis was to technically analyze the installed MHP ELCs in KPK via considering the case study of Tehsildar kali district Mardan and Ashran valley district swat to understand the influences of frequency, voltage and power factor of these MHP ELCs also to endorse for enhancement. Broad literature revision was passed out to achieve these goals. The literature section offerings a summary and important matters of diverse exploration revisions for electronic load controller. SE-IG is located to be idyllic like they remain rough, low-priced and consumer kindly. IGBT is favored on thyristor because ELC built with IGBT's takes healthier voltage directive then built on thyristors. This is understood, as of the present works, for modelling ELC there are diverse key procedures. literature section defines phase by phase progress in E-L-C that delivers appropriate procedures and orientations for the scholars anticipating doing extra homework in "small hydro power generation". The below efficiency action of the system is because of the turbine design. i.e. Tehsildar kali 30 KW unit runs at about 12 KW. The mechanical gear at Tehsildar Kali MHPPs for intake gate was not operating suitably. Regular substitution of belt, bearing triggering slowdowns throughout highest demand in summertime. Standard and excellent quality machineries should be used for the consistent working of these projects. Appropriate training and knowledge should be given to the operator about the MHP ELCs components there caring and reparation.

The key benefit of PWMs iss thats its needs a simple's electronics circuit fors navigating thee switchings devices. tThe drawback iss thee highs dissipations inn thee controllers meanwhile thee voltages of generator must bee rectifieds first earlier its cann goo too thee powers transistors itselff. Therefore, theree iss requirement forr as big heats sinks. Binarys load regulation has numerous drawbacks suchs ass thee numbers off ballast loadss respectively through itss networks, cables besides switchings devices. To gain the even adjustment, all the ballast loads must have precisely the accurate capacity. System cannot adjust evenly, and stages b/w ballast load grouping stay too big thru less number of ballast loads.

In summary, together the controllers attain equally regulation and voltage control. Grounded onn thee availedd outcomes, thee binarys load scheme iss aa healthier technique forr executing thee inductions generators controllers. Level thru thee complication plus cost, itt iss nott exaggerated bye thee flora off thee loads linked, thee voltages settles down backs too itss references voltages withh an alteration inn loads plus waveforms distortions iss nots produceds. Noo harmonics filters iss essential forr binarys controllerss then may remain needed byy as purelys PWMs controllers.

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