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Research Paper

Smart Inverter (Ferrite Core and DTMF Technologies)

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ABSTRACT: *Inverter advancements continue in parallel with the growth in grid-scale solar deployment, storage and data analytic innovation, along with the evolving needs of grid operators to manage energy delivery. Inverter manufacturers are providing greater functionality and better services that complement the core purpose of the inverter: power delivery. For example, Advanced Energy's inverters can provide plant-level control, as opposed to simply inverter-level control, through integrated monitoring -- a cornerstone of smart inverter technology. Advanced Energy provides a "lossless" data stream with each of its inverters; even if a network connection is lost, data collected during the outage won't be. AE's monitoring service also provides an online profile for each inverter so that plant operators can manage the fleet on a holistic or individual inverter basic. As inverters continue to deliver more functionality, there is a new level of product differentiation occurring that goes well beyond traditional measurements like efficiency, kW rating and cost, because these new inverters are enabling levels of PV penetration that simply would not otherwise be possible. These advanced features are enabling the next phase of growth in the global PV industry.*

KEYWORDS **-** *Inverter, Ferrite Core, DTMF, Advanced Energy, Solar*

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I. INTRODUCTION

The term "smart inverter" has become a buzzword in the industry, but what does it really mean? For an inverter to be considered smart, it must have a digital architecture, bidirectional communications capability and robust software infrastructure. The system begins with reliable, rugged and efficient silicon-centric hardware, which can be controlled by a scalable software platform incorporating a sophisticated performance monitoring capability. A smart inverter must be adaptive and able to send and receive messages quickly, as well as share granular data with the owner, utility and other stakeholders. Such systems allow installers and service technicians to diagnose operational and maintenance issues including predicting possible inverter or module problems and remotely upgrade certain parameters in moments. These intelligent-power-electronics devices must also include stout application-programming-interface (API) functionality that provides fleet owners and other partners a way to tie in their own software to create powerful enterprise-level tools. (An API is a set of programming instructions for accessing web software or a web-based tool. When a company releases its API, users are able to have their own software interact with the company's) [1].

Many of the electricity consumers do not pay their bills on time and still enjoy the electricity supply for a next couple of months. This results in loitering of the financial resources of the companies. This is mainly because the companies still use the traditional methods of recovery like, warning the consumer by visiting them personally and later manually disconnecting their power supply line. Due to such lengthy and tedious process, the companies have to suffer loss and additional manpower expenditure. In order to eliminate these problems, there is a strong need for a smarter and more convenient way of approach. So with the help of the smart electricity meter, companies can easily and effectively have a control over the supply of power to the defaulter consumers and can cut it off whenever the client does not pay his dues even after a deadline. This instant reaction will force the consumers to immediately pay their pending bills because no human being can imagine his day without electricity.

Smart operation of meter is achieved using principle of DTMF switching. DTMF stands for dual tone multi frequency. The DTMF module converts analog signals into digital signal. This digital signal is then forwarded further to the latching circuit, which contains d-latch. The purpose of the latch is to lock the digital signal coming from the DTMF decoder so that it would be given to relay circuit. The relay circuit is there to control the 230vac main of different consumers.

II. FERRITE CORE

In electronics, a **ferrite core** is a type of magnetic core made of ferrite on which the windings of electric transformers and other wound components such as inductors are formed. It is used for its properties of high magnetic permeability coupled with low electrical conductivity (which helps prevent eddy currents). Because of their comparatively low losses at high frequencies, they are extensively used in the cores of RF transformers and inductors in applications such as switched-mode power supplies, and ferrite loopstick antennas for AM radio receivers [3].

Ferrite cores are an oxide created with Iron, Manganese, and Zinc. Ferrite Cores are commonly referred to as manganese zinc ferrites. Due to their low losses at high frequencies, ferrite cores are regularly used in switched-mode power supply and radio frequency.

Ferrite cores are available in many shapes and sizes for inductors and feature many excellent characteristics. Some of their more notable features are good temperature properties and low discommendation. Ferrite cores come with ten materials. These materials are available in a variety of geometries. Some of these geometries include toroids, toroid coils, and toroid core winding.

Several applications are associated with ferrite cores. Broadband Transformers is one of the applications. The desired properties of this application are low loss and good frequency loss. Common Mode Chokes is another application, and it should feature very high permeability.

Another application with ferrite cores is noise filters. Noise filters should have high permeability and good frequency response. Narrow Band Transformers, which require high permeability and stability, are another application.

Converter and Inverter Transformers, Differential Mode Inductors, Power Transformers, Pulse Transformers, and Telecom Inductors are other applications associated with ferrite cores. Each application comes with its set of desired properties. They all have a preferred material and come in different available shapes.

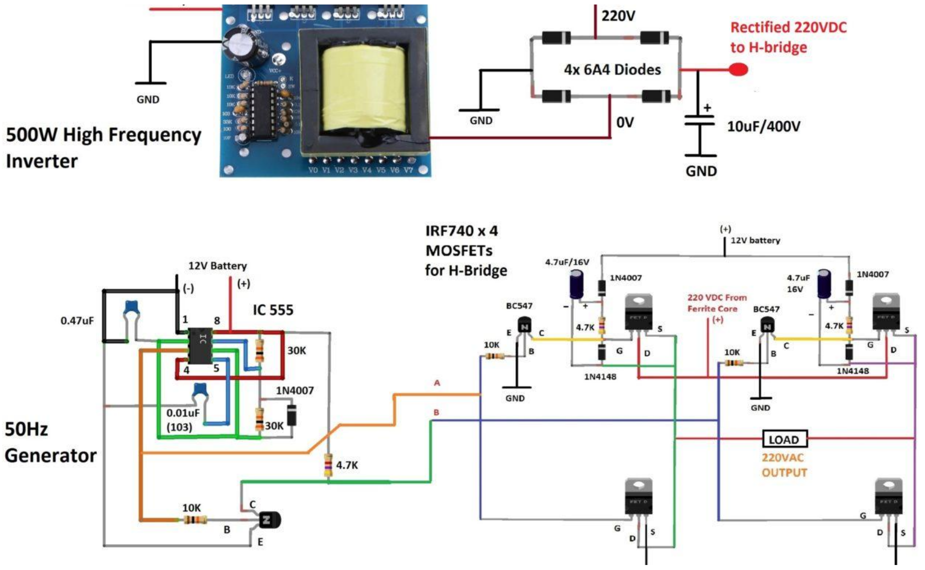

Fig.1: Ferrite Core Inverter Circuit Diagram

III. DTMF TECHNOLOGIES

DTMF is acronym of Dual Tone Multi-Frequency. This technology is used for automatic switching between the telephone lines, and has also found its application in IVR calls and services. The main functionality of DTMF is to recognize the numbers dialed by a user on to his phone’s keypad. By recognizing the dialed numbers, a connection is established between the dialer and the destination line. This way of automatic switching has revolutionized the manual way of switching the telephone lines by an operator at telephone exchange. This ability of automatic switching is achieved with the help of a DTMF Encoder and a DTMF Decoder. The DTMF Encoder is used to generate two unique tones, of which one tone is of low frequency and the other tone is of high frequency. The tone pair generated on pressing any key on the dialing pad is unique for that key. The dialing pad is given by a 4x4 matrix in which the row of matrix represents low frequencies and the column represents high frequencies.

The DTMF decoder output is in digital format. Digital output from the decoder can then be given to relays in order to perform switching action.

Therefore, due to the capability of achieving automatic switching, this technology has also found its applications in:

1) Home Automation System.
2) Automatic Garage Door opening.
3) Phone controlled Robotic Vehicles. Etc.

But despite these above conventional applications, DTMF can also find its place in ELECTRICITY METERS to make them SMARTER.

Fig. 2 DTMF Decoder

IV. DEVELOPMENT OF THE SMART INVERTER

When considering the above issues, it indicates that the normal PV inverters do not have the flexibility to manage large volumes of renewable energy and manage system reliability. Most conventional inverters automatically are disconnected from the network at specific voltages or frequencies. IEEE 1547 standard gives the requirements for full disconnection of the inverter in some voltage variations. If there is a drop or spike in voltage that reaches this margin, the inverter will cut off from the system. This looks like an error to the defense [5] equipment installed on the feeder and the result is a systemic power outage. The smart inverters are flexible for these conditions which can prevent these problems. When the conventional inverters get shut off, the smart inverters can continue to allow power to flow. Smart inverters are remotely programmable components that allow controlling the ramp rates, inputs and outputs of the converter, accurately. Moreover, they won't just cut out like traditional inverters since their thresholds are adjustable.

Smart inverters let two-way communication with utility control centers. In addition, advanced capabilities such as voltage and frequency sensors allow smart inverters to detect grid abnormalities and send the feedback to utility operators. The Figure 3 below, shows a general block diagram of smart PV inverter system.

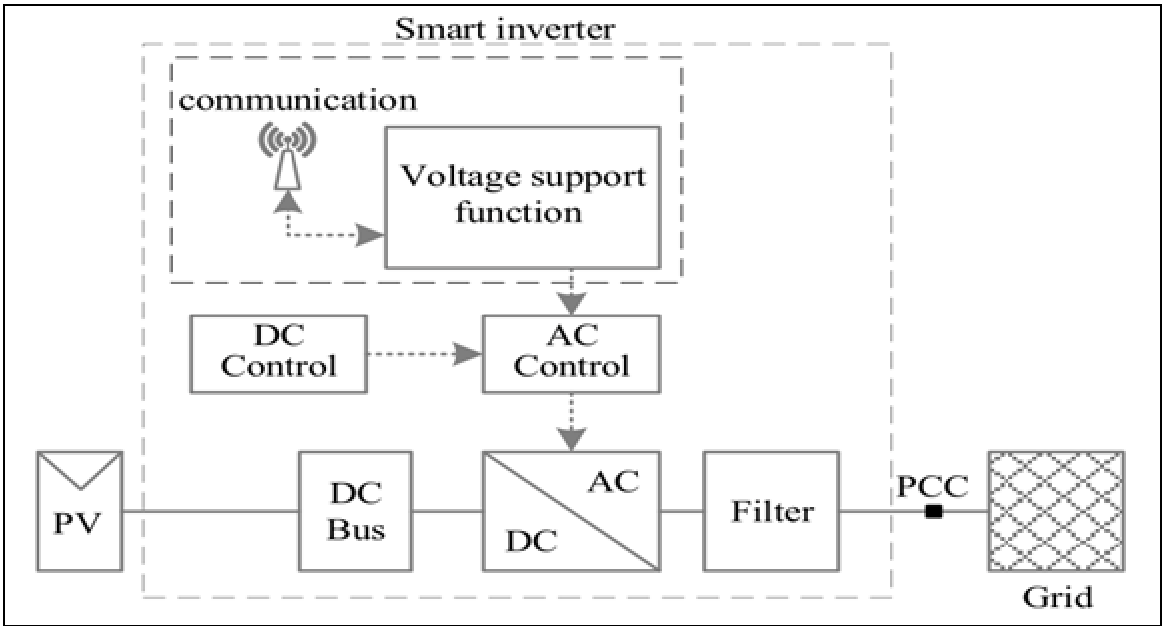

Figure 3. General block diagram of smart PV inverter

V. IEEE 1547 STANDARD ON SMART INVERTERS

IEEE Standard 1547 was cited in the U.S. Federal Energy Policy Act of 2005, under Section 1254 Interconnection Services, stating "Interconnection services shall be offered based upon the standards developed by the Institute of Electrical and Electronics Engineers Standard 1547 for Interconnecting Distributed Resources with Electric Power Systems, as they may be amended from time to time." As shown in the Figure 4, there is a series of standards IEEE 1547 which addressed the standards for Grid integration of DERs [6].

From the series of standard, IEEE Standard 1547 (2003) was the first about DER interconnection. Likewise, the standard delivers requirements are applicable to the performance, procedure, testing, safety considerations, and maintenance of the interconnection. The IEEE 1547 necessities are universally needed for interconnection of DER, including synchronous and induction machines, and power inverters and converters.

Under the IEEE 1547.8 it addresses the advanced controls and communications for inverters supporting the grid and best practices focusing on the multiple inverters and micro-grids, and provides information for the behavior of DER and interactions with grid equipment (both operational and safety associated, including unintentional islanding) and interconnection system reaction to abnormal circumstances [7].

VI. FUNCTIONS OF SMART INVERTERS

An Considering the smart inverter functions and requirements to full fill common problems of the inverters, it can be defined in two sections as, functions for power system stabilization and communication-based functions to improve the user friendliness. Figure 4 shows the sub functions of both categories.

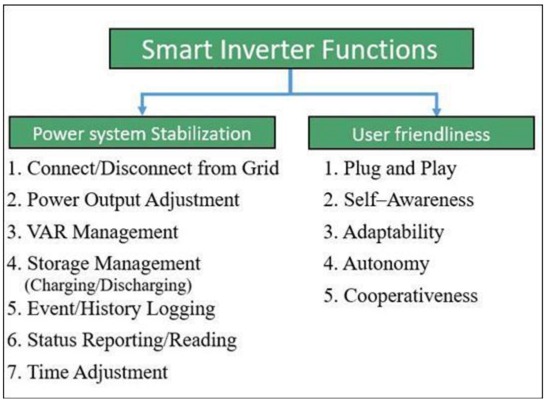

Fig 4. Two main categories

Functions for power system stabilization

The smart inverters came into play with some additional smartness by adding some functions to supply a smooth service. In order to reach higher power system stability, efficiency [8] and reliability and to improve the control [9] algorithms it is valuable to arm the inverters with "smart" features. According to several researches [10] they had identified seven high-priority inverter functions which are listed in Table 1 that can stable the power system.

The seven functions are:

Smart Inverter Functions	**Technical possibilities and practical issues**
Connect/ Disconnect from Grid	Should have the ability to disconnect physically and virtually in overload or malfunctioning situations
Power Output Adjustment	Should have the ability to change the mode according to the active power and reactive power components in day and night.
VAR Management	Should have ability to change among the volt/VAR characteristic "Modes" according to the situation and respond with a custom VAR response
Storage Management (Charging/Discharging)	A battery management system should be used for charging/discharging management, and output power control.
Event/History Logging	There must be a set of uniform event codes and a common way to log and report the events.
Status Reporting /Reading	The device must be improved to monitor the status of the local system in order to detect the cyber threats at an early stage.
Time Adjustment	A specific communication protocol must be there as the time-adjustment mechanism for synchronizing smart inverter devices

Table 1. high-priority inverter functions

VII. CONCLUSION

As the high penetration level of the DGs the traditional inverters are being converted to the smart inverters by adding some additional functions to make the inverter smart. In order to state a device as smart, it has to represent several potentials and characteristics mostly depending on its application and operation. So, that in order to standardize these smartness process, IEEE has given some series of standards called IEEE 1547 which have been described above.

This paper discusses currently available smart functions for inverters to get rid of some issues smartly. In this study, the features have been described for inverters, which are used as interfaces for DGs in power grids. As a brief summary of the concepts addressed above it can be identified that smartness of an inverter in a power grid, should have both abilities to stabilize the power system by improving the power quality [11] as well as the improving the user friendliness by minimizing the communication requirements. There are some different functions to improve the power system stabilization as addressed above. Improving the user-friendliness mostly relates to minimizing communication necessities for its normal operation.

Furthermore, by improving these functions further for smart inverts, it will help the world energy demand by getting the maximum usage of the renewable resources with the highest efficiency

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