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ENHANCEMENT OF POWER QUALITY FOR GRID-INTEGRATED SOLAR PV SYSTEM USING HYBRID NEURAL NETWORK BASED PI CONTROLLER

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ABSTRACT:

The various power quality (PQ) issues in a grid connected solar system arises because of intermittent nature of solar and uncertain loads at the consumer end. A three-phase grid-integrated solar photovoltaic (GISPV) system incorporating Hybrid Neural Network Based Proportional Integral (HNNPI) inverter control algorithm is designed. The HNN is trained with input parameters such as grid power variations and the target gain parameters of the PI controller. During the testing time, the HNN predicts the gain parameters of the PI controller as per the grid side parameter variation and the PQ of the grid side has been enhanced.

KEYWORDS: *Grid-integrated Solar Photovoltaic, Photo Voltaic (PVP), Phase Lock Loop, and feed forward control loop.*

1. INTRODUCTION

Harmonised global effort under the aegis of United Nations framework convention on climate change (UNFCCC) is being endeavoured to contain the rise of global atmospheric temperature below 2^0 C. This convention stresses on the centrality of renewable energy sources (RES) as prominent alternative to the fossil fuel based sources of electrical power generation.RES are grooming especially when petroleum products are being replaced as fuel by electrical energy for vehicles which are among the major sources of environmental pollutants. While RES includes many new and existing and evolving resources in its fold. Solar power leads the pack currently, which is because of the extensive research and development undergoing on the technology making it commercially more competitive.

PV systems can provide clean power for small or large applications. Hence they could be installed as standalone or grid connected system. PV systems are preferred as stand-alone systems, where it is difficult to connect to the grid or where there is no energy infrastructure. Electricity can be imported from the network when there is no sunlight. Such small installations are also easy to set up and connect to the grid. The rules about grid connection vary from country to country, but almost in all countries it is compulsory to contact the local network system operator.

In grid-integrated solar photovoltaic (GISPV) system, inverters are essential interfaces to connect RES with the utility grid. To reduce the investment, operation and maintenance cost ,man-hour, as-well-as the bulk, and enhance the cost-effective feature of the GISPV grid-connected inverters plays important role [17–26].The GISPV inverter control can connect RES and storage devices to utility grid, and simultaneously enhance the power quality at their points of common coupling(PCCs). Hence they are capable of saving capital investment and system space.

A lot of ongoing research has been reported in literature for auxiliary services on power quality improvement through proper control of converters. These converters can perform dual work of interfacing solar system with the grid and also conditions the power at point of common coupling.
The state-of-the-art of the converter is its design feature which optimally achieve the multi-functionality, hence the work done presents a cost effective solution to power quality issues. The power quality (PQ) issues in a grid connected solar system has always been a matter of concern for the system operators. The reasons of PQ issues may be generation aspects, consumer aspects and network aspects.
Effects of poor PQ such as sag/swell distortion in waveform, THD and reactive power generation have adverse effect on both utility sectors and grid. In this paper a three-phase grid-integrated solar photovoltaic (GISPV) system incorporating Hybrid Neural Network Based Proportional Integral (HNNPI) inverter control algorithm is designed.

2. GRID-INTEGRATED SOLAR PHOTOVOLTAIC (GISPV)

Integrating solar power to the grid mostly have adverse effect on the power quality in the grid. In a few PV based framework, the inverter is a key segment which is responsible for the control of power quality in GSIPV. The installation of the GISPV comes along with many challenges that need to be addressed before they can be incorporated into the utility grid. This is because the operation of these plants can be uncertain due to the intermittency of the solar moreover uncertain grid operation. It is important to investigate the establishment of grid codes for the installation of GISPV and how they can help to achieve reliable operation and long-life production. The effect of high GISPV connection to the existing power grid should be evaluated in terms of the power flow patterns to ensure a high quality of the delivered power and overall system reliability and stability. The system under study is presented in figure-1.

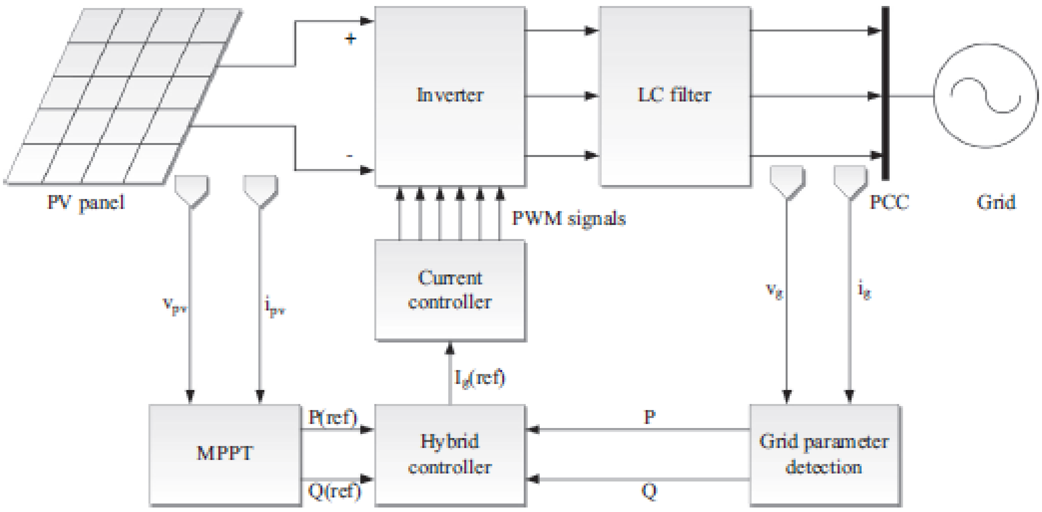


Fig. 1 Block diagram of the proposed system.

3. PROPOSED WORK

The stochastic behavior of the PV system may leads to unreliable grid connected operation. A proper DC-voltage regulator may some extent help to stabilize the solar performance. Also for efficient grid integrated operation; the designed inverter must meet the grid code requirements. Hence in the proposed work, to integrate the PV system with the grid a DC/AC inverter is simulated using NN based PI controller. The designed inverter is also efficient under uncertain loading like unbalance and non-linear loadings. The HNNPI is trained with input parameters such as grid power variations and the target gain parameters of the PI controller. During the testing time, the HNN predicts the gain parameters of the PI controller as per the grid side parameter variation and the PQ of the grid side has been enhanced. For three phase system to reduce complexity an abc-dq transform is used as shown in figure-2.A conventional three leg full bridge universal inverter is used. The inverter is synchronized with the grid using phase lock loop.

A 150 KW PV system with 600 V PV DC output. The proposed system is analysed under these operating conditions;

1) Under normal grid condition.

2) Under the condition of voltage dip.

To reduce complexity an abc-dq transform is used as shown n figure-1. A conventional three leg full bridge universal inverter is used. The inverter is synchronized with the grid using phase lock loop.

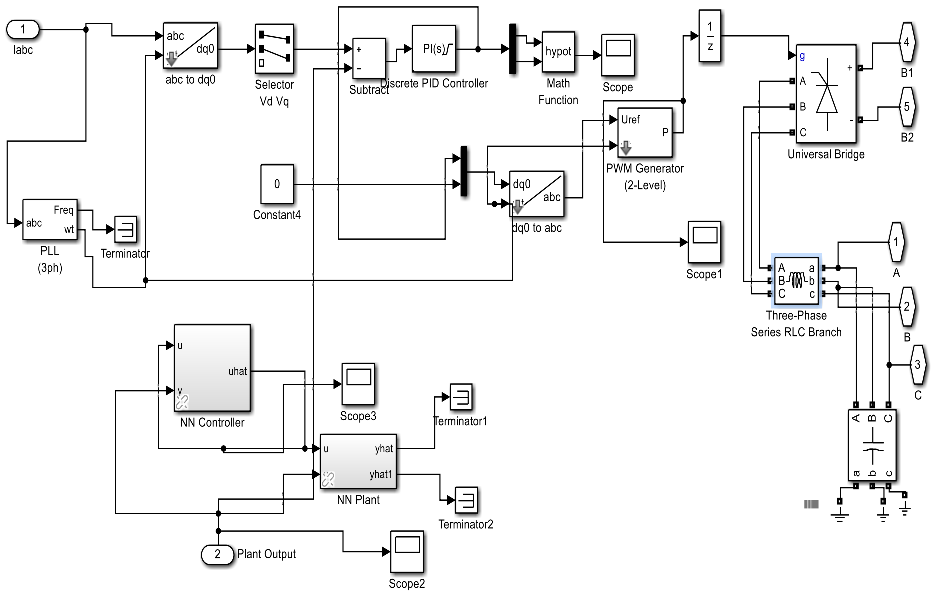


Fig. 2 Simulation model of proposed HNNPI controller.

4. SIMULATION

The HNN is the kind of NN, which is employed to forecast the gain parameters based on the system operating conditions. At the particular target [32] the neurons are taught with the different operating conditions parameters. The HNN includes a lot of artificial neurons in it. Frequently, the HNN possesses three types of layer, namely, the input, the hidden and the output layer shown in figure 3. The learning task is offered as examples, called as training examples.

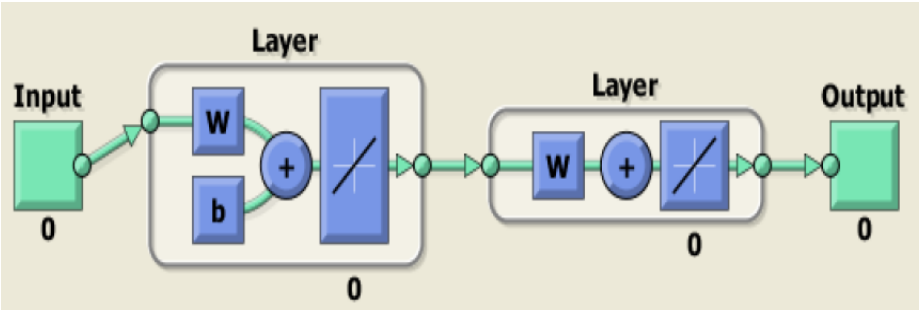


Fig. 3 Types of layers in HNN

The simulation model of the proposed system is presented in figure 4. The designed GISPV HNNPI based converter control. The inverter is designed with PI control and PLL which performs dual function of converting DC into AC and another is mitigating all the power quality issues under uncertainties arise due to nonlinearity, disturbances or unbalanced loads. A filter is designed tuning the system frequency so as to eliminate harmonic in output voltage and current at PCC. The parameter selection for the system designed is presented in table-1.

The static operation for constant irradiance and linear loading presented in figure 5. The constant voltage and current at PCC and grid side is obtained. Also Active power at inverter side is 150KW, a constant linear load side is 100 KW is connected. A three phase programmable source of 120 KV is considered as a replica of grid. The THD for linear loading for load voltage and current is 16 % and 0.04% as shown in figure 6. The voltage waveform for the grid fault is given in figure 7. At this condition the input to the NN. The HNNPI synthesize the input signals to generate an output signal as shown in figure 8. This signal boost the output voltage to the constant grid voltage condition. The THD of voltage and current at the condition of voltage recovery for grid current is shown in figure 9.

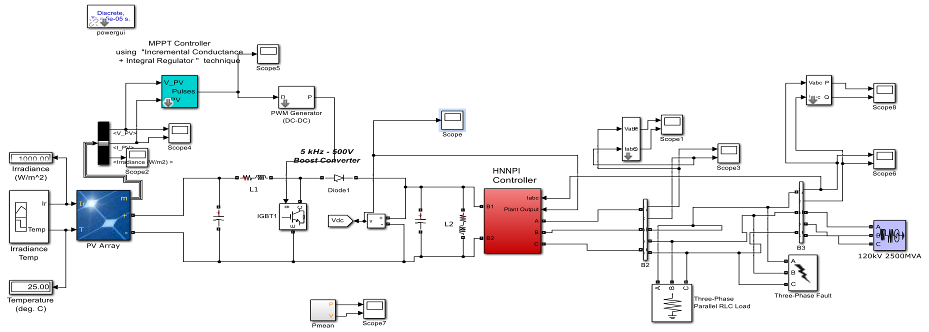
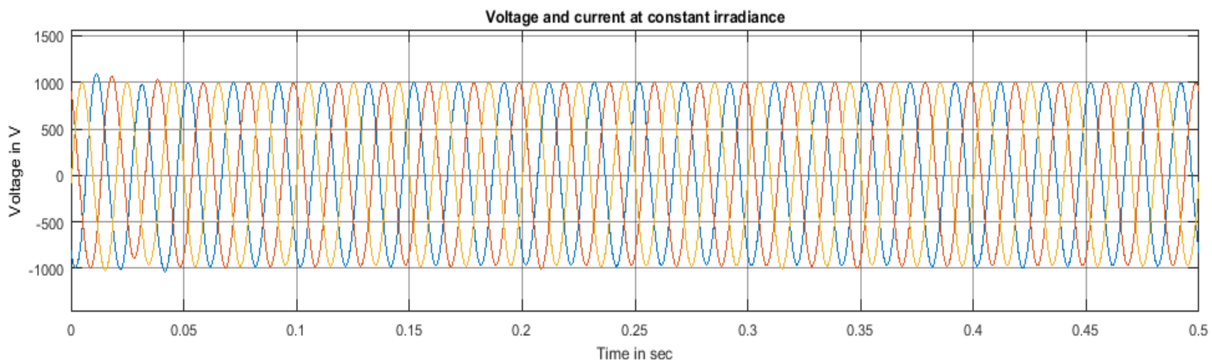


Fig. 4 simulation model of the proposed work

Table 1. Parameter & its value

Parameter	**Values**
PV rating	150KW
C_{dc}	1000µF
DC converter inductance	3 mH
dc-bus voltage Vdc	1200V
Inverter parameter	
Effective nominal voltage of the utility (RMS) Vs	120kV
Nominal utility grid frequency fS	50Hz
Switching frequency of the converters fch	20khz
inductance of filter	10 mH
Series resistance converter	0.01 ohms
Capacitances of the parallel filters	1500µF
Resistances of the converter filter	0.01 ohms
Gain PI; Ki,Kp	500, 0.04

5) RESULT



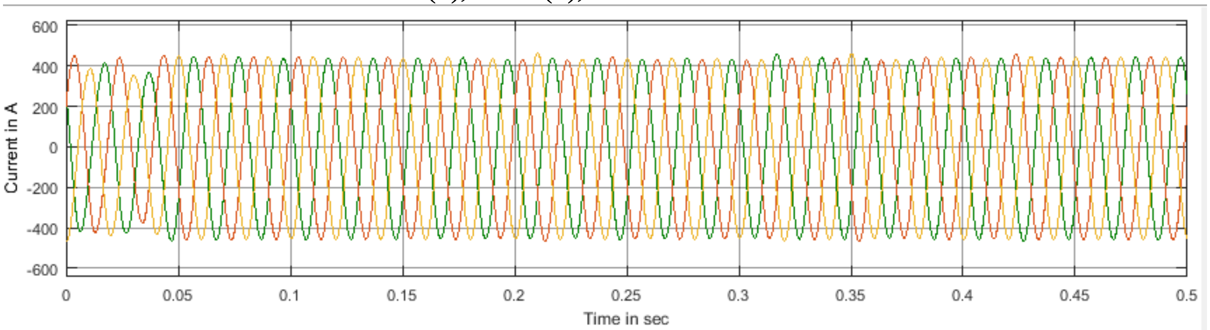
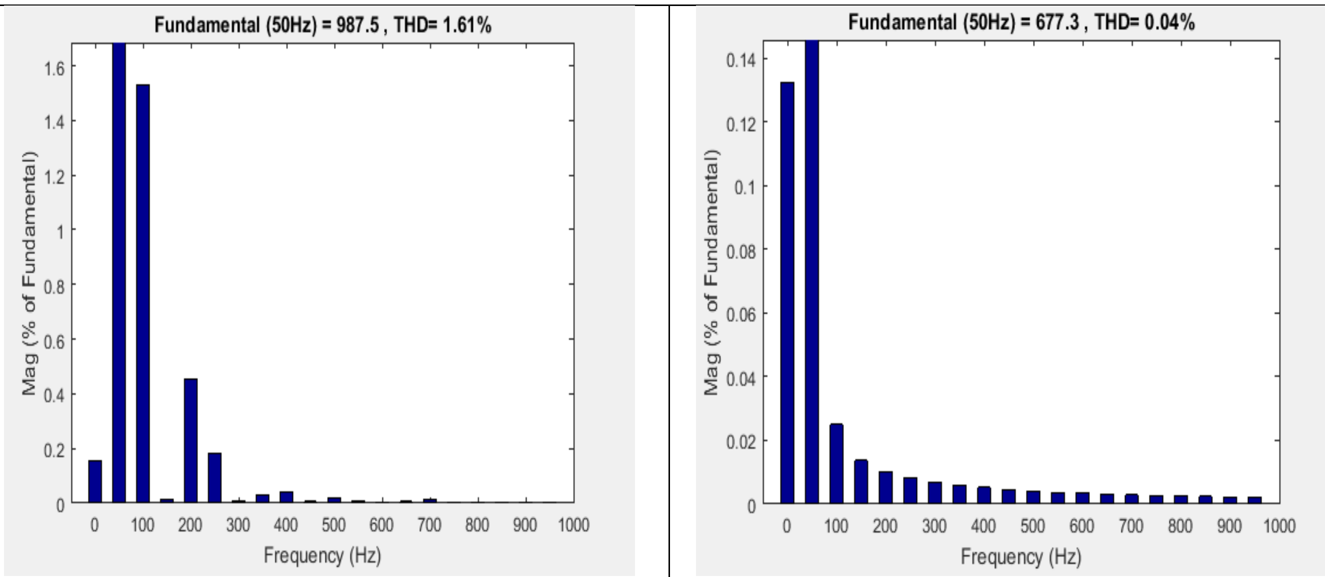


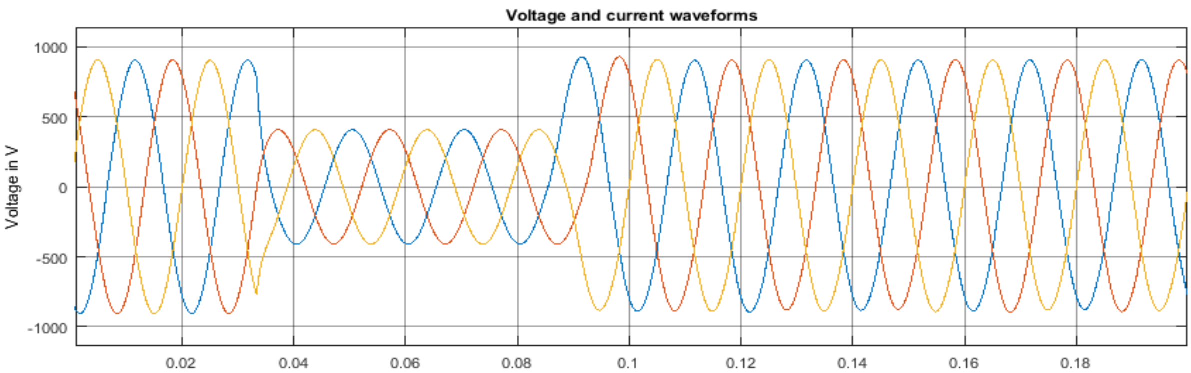
Fig. 5 Output voltage and current of proposed topology for normal grid condition



a) THD of load voltage

b) THD of load current

Fig. 6 THD analysis of Solar system grid connected with proposed topology under normal gird condition.



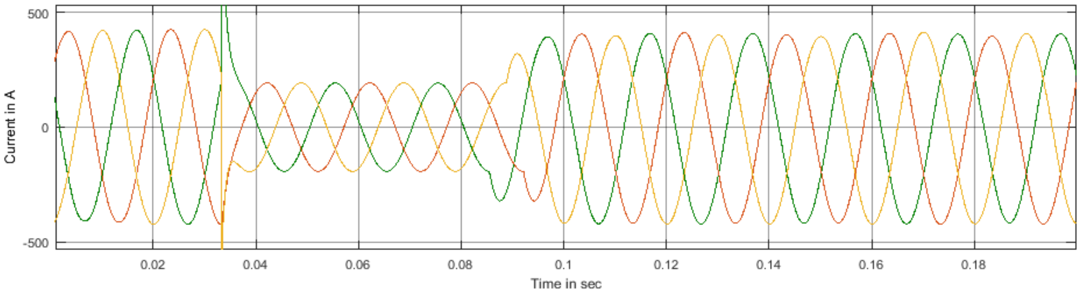


Fig. 7 Output proposed topology for faulty condition without controller

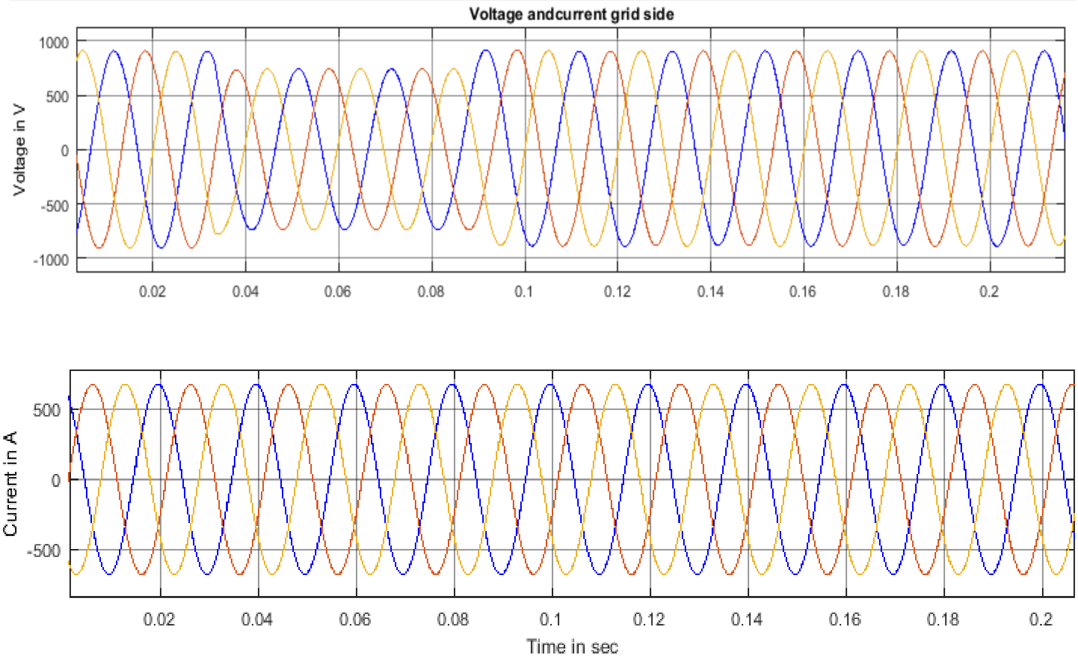


Fig. 8 Output proposed topology with the proposed HNNPI controller during fault

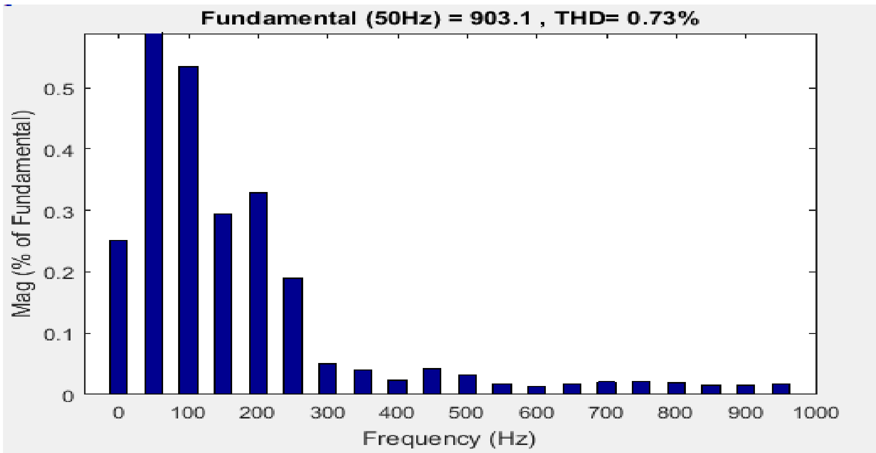


Fig. 9 THD measurement of the load side voltage using proposed controller

5. CONCLUSION

A three-phase grid-integrated solar photovoltaic (GISPV) system incorporating Hybrid Neural Network Based Proportional Integral (HNNPI) inverter control algorithm is designed. The system has been analyzed under static as well as dynamic conditions of fault. The proposed HNNPI results in low harmonics under such conditions. The load voltage THD has been observed as 1.61 % and load current THD is 0.73%, fulfilling the requirement according to the IEEE-519 standard.

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