Novel Grid Connected PV System Model with Anti-Islanding Elimination

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Abstract : Electricity market is moving towards decentralization due to various advantages of deregulation. The change in central system is still facing issues like islanding and anti-islanding methods. This paper proposes a model for PV rooftop system. The response of system according to the need of operation of anti-islanding is a field of research. Novel grid connected PV system model is a proposed model to eliminate unwanted operation of anti-islanding methods. Proposed model uses programmable logic controller for the automatic controlling of system.

***IndexTerms* - Distributed Generation, Islanding, Anti islanding techniques, PLC, Stand alone and grid connected PV system.**

I. INTRODUCTION

Electricity, one of the most important forms of energy, need a clean and efficient generation to meet the ever increasing demand with minimum impact on environment. After perceiving the adverse effects of conventional electricity generation methods on environment, the common concern of the world is about generating clean energy. Maximum integration of renewable energy power plants is admired. There are about 17 countries that already depend on 90% of renewable energy sources and around 57% countries are targeted towards 100% renewable energy generation, [1].

The concept of distributed generation is promoting factor of renewable energy. Distributed generation is generation of electricity near load end i.e. distribution end. The capacity of distributed generators is less than the central power plants, 1KW PV installation, 1MW engine generators to 1000MW offshore wind farms or more, [2,3]. Distributed generation is not necessarily renewable. Reciprocating diesel or natural gas engine, Micro-turbines, Combustion gas turbines, Fuel cell, Photovoltaic PV system, Wind turbines etc are other Dg technologies being used, [4].

Different kinds of DG technologies are available and are expected to grow in future. DG is a philosophy that allows many small generators to get integrated with the central power system and scatter throughout it in order to fulfill the demand of electric consumers. Renewable sources being more popularly used in DG due to the reason that they are generally installed near the consumers' end and convention carbon emitting DG are not permitted to be installed near residential areas.

Distributed Generators are often used for the following reasons-

a. As back-up power to improve reliability.
b. To reduce the investments being done in large transmission and distribution networks.
c. To reduce line losses.
d. To reduce the construction of large generating power stations of large capacities.
e. To improve power quality.
f. To provide environmental benefits.
g. To promote generation renewable sources.
h. To create an atmosphere of competition in electricity market and diminish monopoly.

The concept of DG is useful only when certain issues associated with DG integration to existing power systems are fixed in terms of reliability. There is a tremendous theoretical work done on location, size, controlling, monitoring, coordination and islanding considering the advantages of DG.

Islanding is one of the most important problems that arise in a load end connected DG. A DG is allotted with an area of load which is called its local load. Similarly every area of load is supplied with the respective DG. That local area of a DG is called an Island. When the power on this island is supplied during a power cut from central grid then thus phenomenon is called islanding. That means the island get electrically disconnected from central grid and the local load is supplied by DG. Since the island can energize the disconnected lines outside the island that becomes very dangerous for the workers and field engineers present on line for maintenance. Other possible harms that can be caused by unintentional islanding are equipment and technical problems such as out of phase reclosing. High magnetizing torques and currents are induced in system that causes considerable equipment damages, [5].

Hence, to prevent the unintentional islanding, many anti-islanding techniques have been introduced. They are classified according to their way of operation. There are passive, active, machine learning and remote islanding techniques which are further classified according to their principle of operation and technologies, [5].

Unintentional islanding is one side of coin, there is one more term used as islanding operation of grid. In islanding operation of grid the local load is supplied by DG even if any power failure occurs at central grid end, [6]. Although intentional islanding is very advantageous still it is a very difficult task to implement it on practical central rigid system. A very strong communication system and controlling is require to implement intentional islanding. If there goes any mistake then islanding can harm the system equipments considerably and can be hazardous for field engineers and maintenance personals. And hence, normally anti-islanding is used to prevent islanding during central grid failure.

Along with DG integration in central grid the other form of DG getting popular is rooftop PV generators. These PV systems are used for domestic power generation. They are also useful for electrifying a building or an institute or an organization. Rooftop solar generating systems are small DG that satisfy the local load. Rooftop systems operate in two configurations. The first is grid connected operation and the second is stand alone operation.

Grid connected rooftop PV system is connected with the central grid. the surplus generation of PV system is fed to the grid and when there is deficiency of power for local load it can fetch power from central grid. The power flow in this system is bidirectional. This kind of system is useful for loads located near the central grid, [7]. The Stand-alone system is an independently working system. The surplus power produced is used to charge batteries. When there is no sufficient availability of sunlight the batteries are used to supply power to the load. This system is ideal for remote location where accessibility of central grid is not possible, [7].

II DEMERIT OF GRID CONNECTED ROOFTOP PV SYSTEM

In rooftop grid connected PV system a reference voltage is required for inverter to work. The requirement of reference voltage for solar generation systems is due to the continuously varying solar radiations. The intensity of sunlight is not constant; it varies due to clouds, rain and time. This reference voltage is taken from central grid. When there occurs a power cut from central grid the PV inverter stops working.

The other reason for switching of the PV system during central power cut is anti-islanding. If the rooftop system is not switched off then it may supply the access power into grid which is harmful for working personnel and equipments. This undesirable flow of power is called reverse power flow, [8].

The power is not supplied to the local load even if the sun is present and PV array can generate electricity. This can be considered as power loss in PV system. Also the reliability of DG gets affected with this demerit.

III NOVEL GRID CONNECTED MODEL: PRINCIPLE

Novel Grid Connected System works on a triggering principle. It utilizes the benefits of both stand-alone and grid connected configuration. The system works in simple grid connected mode during normal operation but it triggers itself into stand-alone mode during power failure from grid side. Therefore it is independent and electrically isolated from central grid when there is a power cut from grid side. And when supply from grid is returned it comes back to initial grid connected mode. A delay of clearance time is given before triggering to prevent false operation due to transients and fluctuations.

An automatic triggering circuit is used to trigger the system between grid connected and stand-alone mode of operation. The automatic triggering circuit is a combination of circuit breakers and switches, which operate to make the system work. The operation of all the elements of triggering circuit is automatic and preprogrammed on a Programmable Logic Controller.

IV WORKING OF MODEL

Fig.1 shows the block diagram of PV model in presence of sunlight. The system as a whole is a combination of stand-alone and grid connected system. The green lines represent the flowing power and the red line represents no power flow. When there is sufficient sunlight to produce electricity then the load is supplied through PV array. The surplus power is used to charge the batteries and when the batteries are charged then the surplus power is fed to grid. this is a normal operation of grid connected rooftop PV system. Here note that batteries are not so frequently used hence they don't get discharged frequently and the remaining power, after the batteries are charged, is supplied to the grid. the power flow in this mode of working is bidirectional.

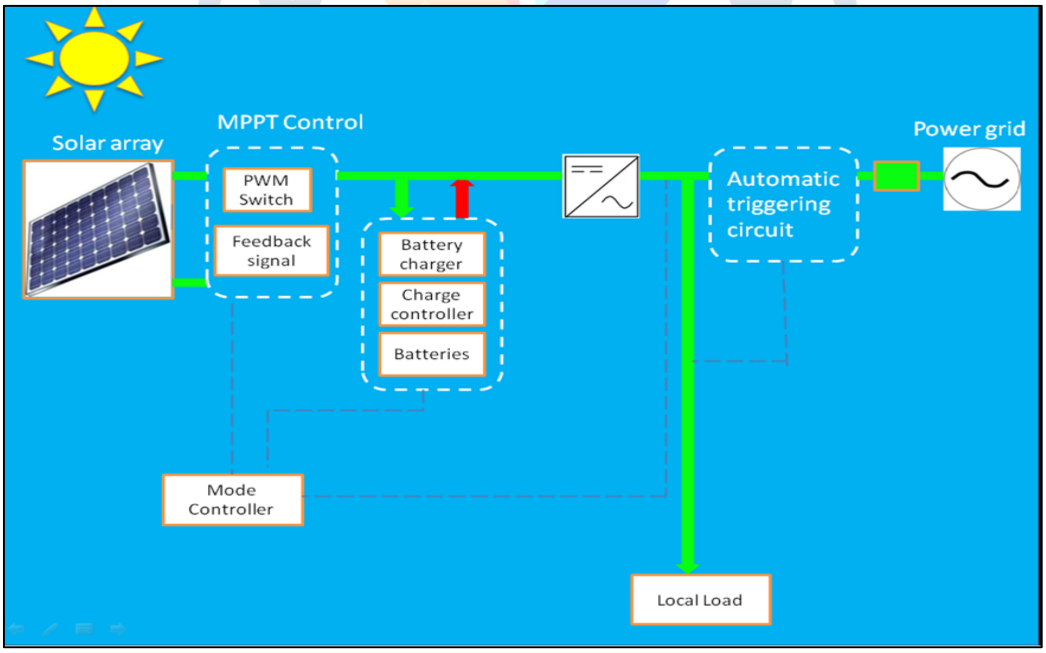

Fig. 1 Novel grid connected PV system in presence of sunlight

Fig.2 shows the operation during power failure from grid. The automatic triggering circuit does not allow the grid to switch off the PV system. In this condition the system is working in stand-alone mode. It is electrically isolated from central grid and is independent just like a stand-alone rooftop system.

In this way the demerit of grid connected system id overcome and the supply to the load is not interrupted. The PV system generates power and supplied the load independently. Here, note that there is no reverse power flow into the grid.

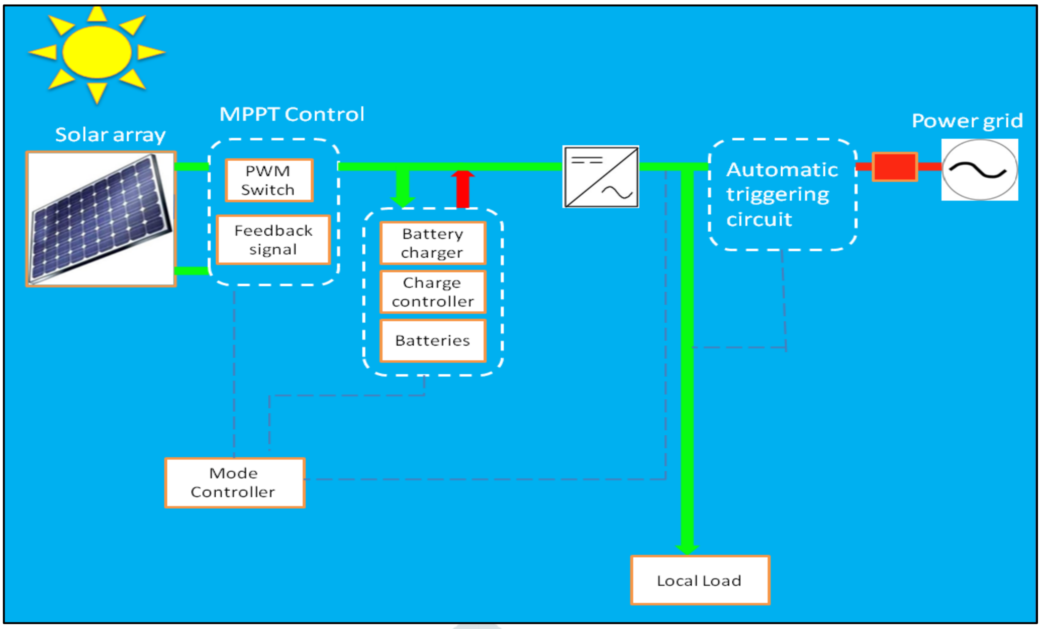

Fig.2 Novel grid connected PV system in presence of sunlight and power failure from grid

Fig.3 shows the working of model in absence of sunlight and grid failure. The absence of sunlight or insufficient sunlight is considered to be same here. Like any other stand-alone system the power is supplied from batteries to the inverter and thus load is fed without interruption.

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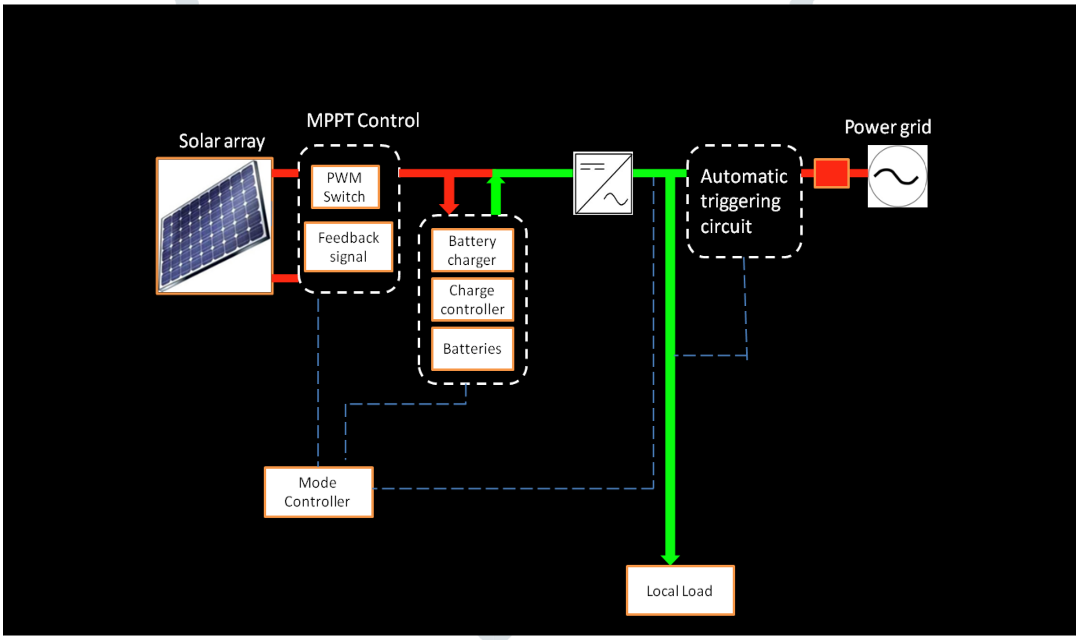


Fig. 3 Novel grid connected PV system in absence of sunlight

When the supply from grid is enabled, the load fetches power from grid and the system returns to the initial state i.e. grid connected mode of operation. In this way the novel grid connected PV solar system works for elimination of anti-islanding operations by using an automatic triggering circuit.

V AUTOMATIC TRIGGERING CIRCUIT (ATC)

As stated before the Automatic triggering circuit is a combination of CBs, switches, auxiliary generator, and dump loads. These elements are operated by PLC (Programmable Logic Controller). ATC triggers the PV system from grid connected mode to stand-alone mode of operation according to the need. Fig.4 shows the working diagram of ATC.

ATC is connected at point of common coupling (PCC). As shown in diagram a current sensor is mounted on grid side which ensures the presence and absence of current from grid. An auxiliary generator is connected to supply reference voltage to the inverter in absence of grid. Dump load is connected to dump surplus power which can't be fed to grid.

The green line indicates power flow and red line indicates open connection. Similarly red box shows open CB and green box shows closed CB. The sensor gets high when it detects no current from grid side and gets low when grid supply returns.

The figure shows normal grid connected operation. the sensor is low and the CBs connected with dump load and aux. generator are open. The generator is in off state. The PV system is directly connected with grid.

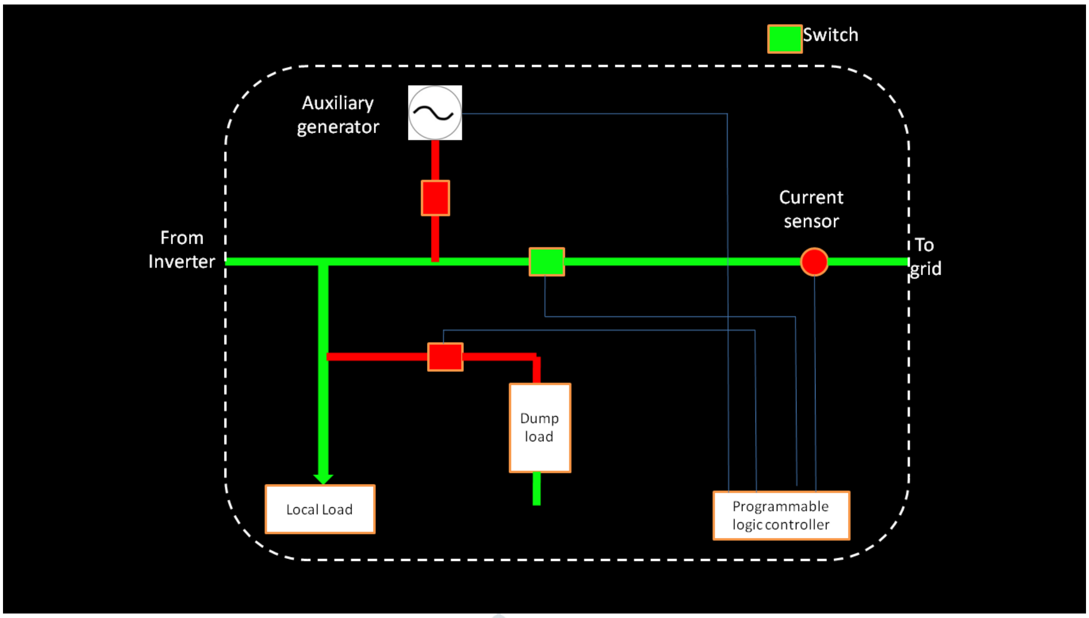


Fig. 4 ATC in normal operation

When the power failure at grid occurs the current sensor goes high. It sends controlling signals to PLC and PLC makes all the elements of the ATC to operate. As shown in fig.5, the CB connected in between opens and isolates the PV system from grid. the CBs connecting dump load and aux. generators are closed; aux. generator and dump load are connected with the circuit.

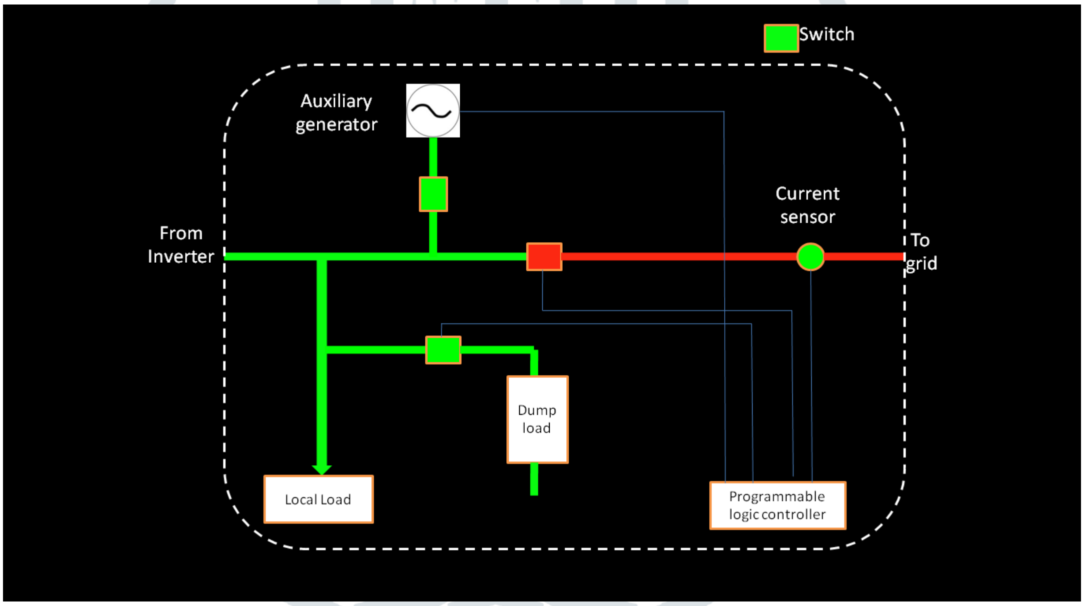


Fig.5 ATC during power failure from grid

As the current sensor with go low the system will return back to its initial condition.

VI PLC & SCADA REPRESENTATION

The PLC is programmed to make the ATC operate automatically. The software on which we have programmed is CoDeSys V2.3.This software consists of inbuilt SCADA that is used to represent the working of program used for ATC operation.

Fig. 6 to 10 shows different states of working of system. The ladder diagram program of every state is followed by its respective SCADA representation.

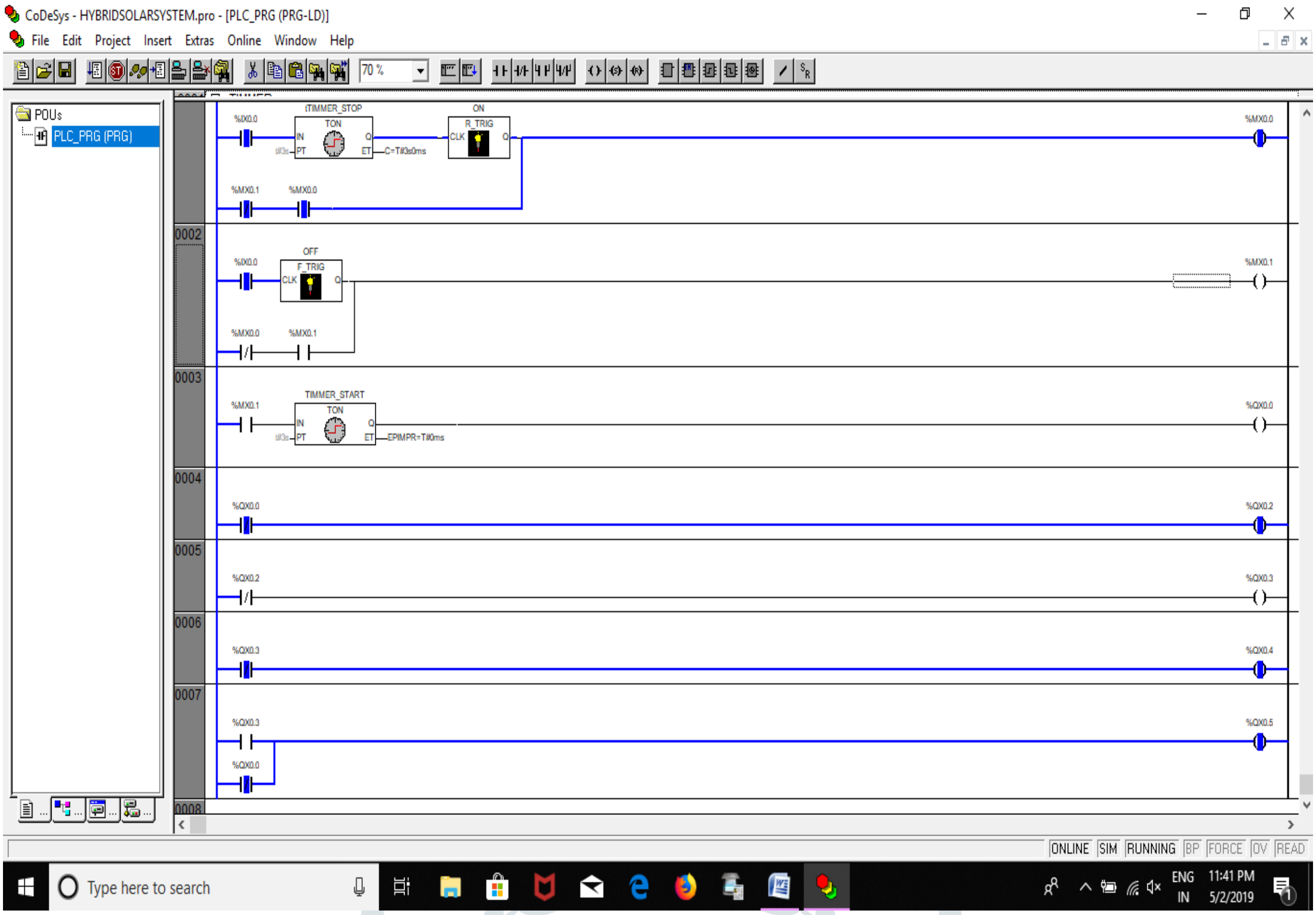
Fig.6 is the initial state of system when it is in grid connected mode. The current sensor is high (does not send signal to ATC to operate). The aux. generator is switched OFF, the circuit breaker that connects grid and PV system is close and the switches that connect aux. generator and dump load are open.

Fig.7 is the time when current sensor goes low (sends signal for operation) but system does not operate because of delay provided. It shows the state of system at $t < T_{clearance}$.

Fig.8 shows the state when current sensor is still low and time extends the clearance time. The system comes in stand-alone mode of operation. In this state the CB connected between grid and PV system is open. The aux. generator is switched on and the switches that connect aux. generator and dump load into the system are closed.

Fig.9 shows the state when power from grid returns but the system maintains its previous state until time reaches clearance time; $t < T_{clearance}$

Fig. 10 shows the system coming back to its initial state that is grid connected mode of operation when grid power returns.



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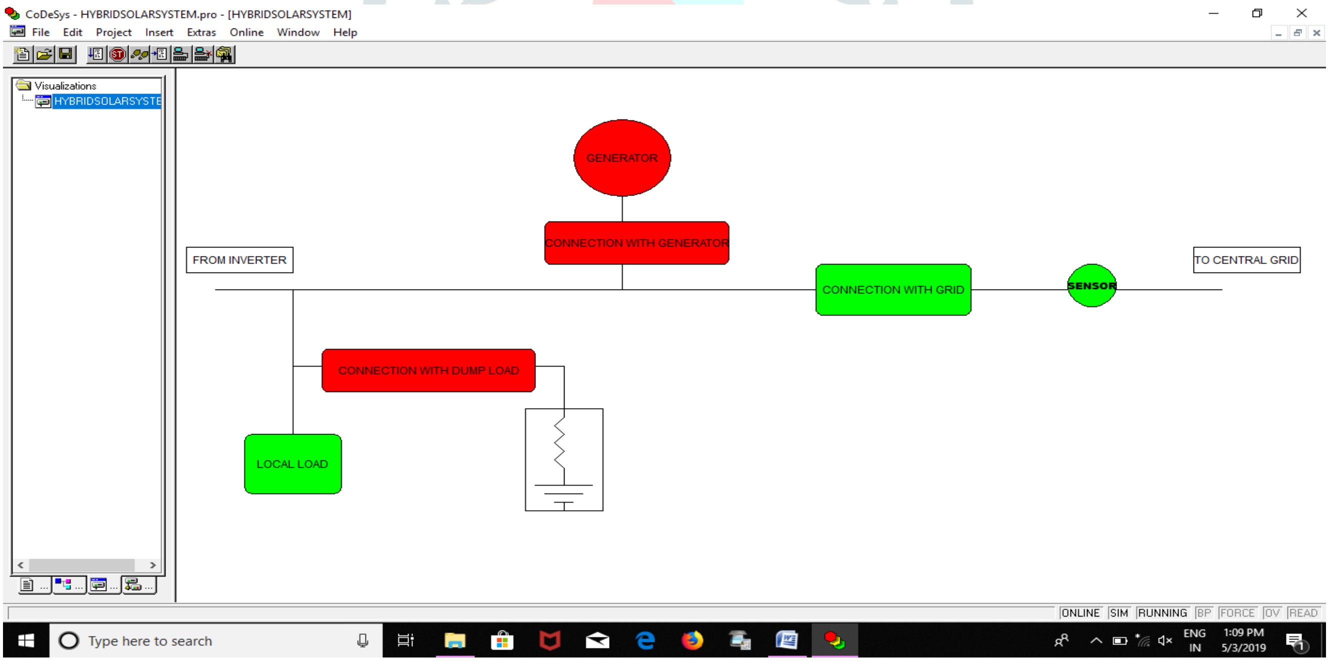


(b)

Fig.6 (a) LD program of initial state of ATC, (b) respective SCADA representation

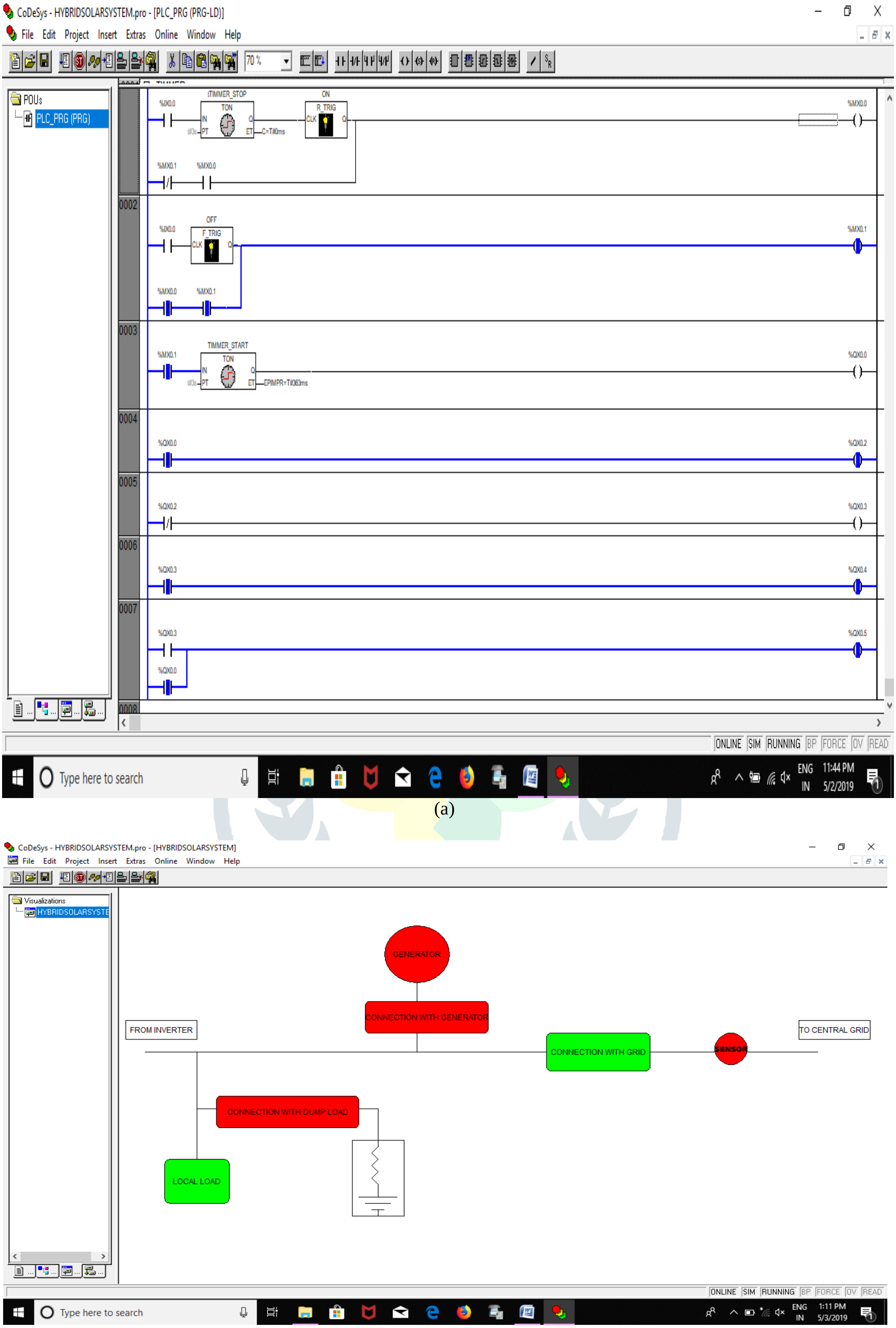
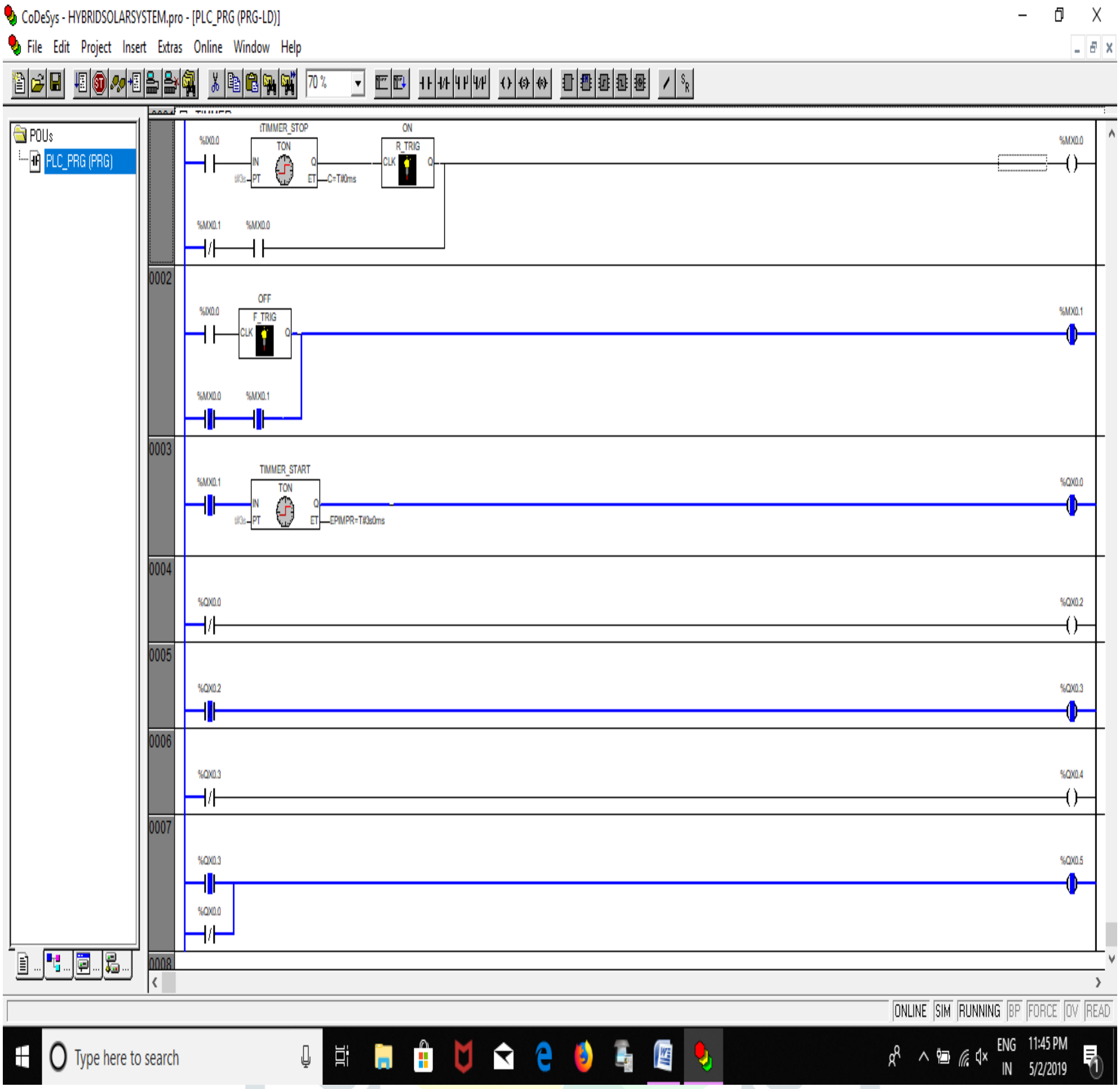


Fig.7 (a) LD program of ATC at t < $T_{clearance}$, (b) respective SCADA representation



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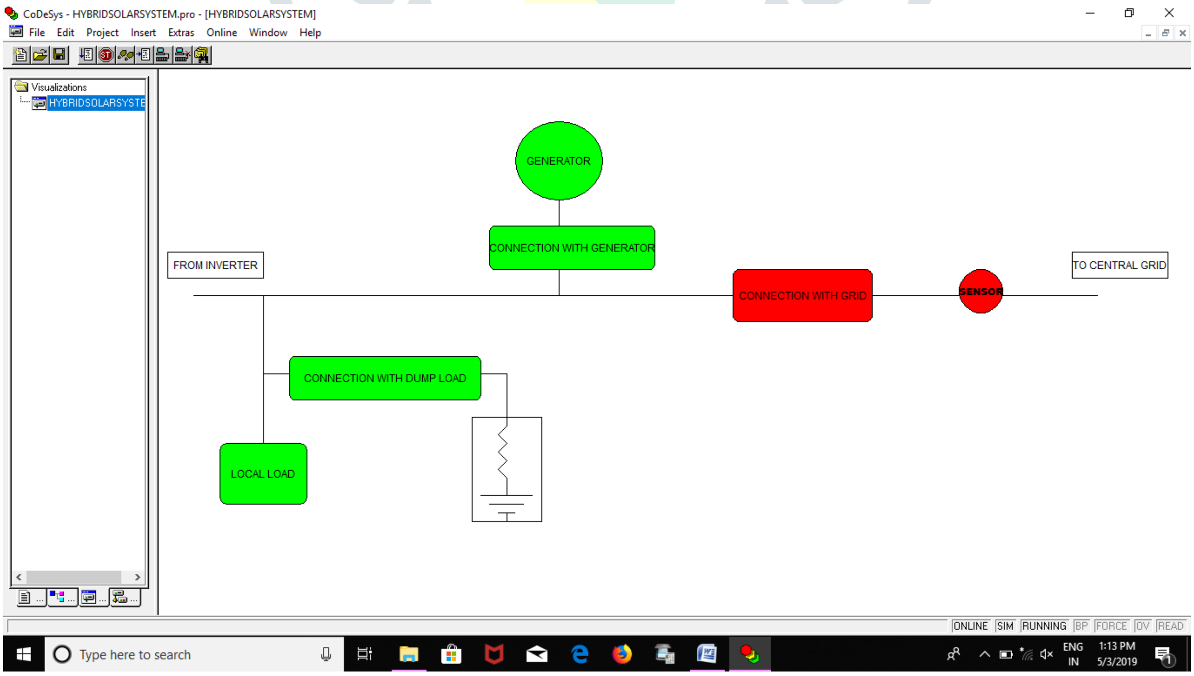
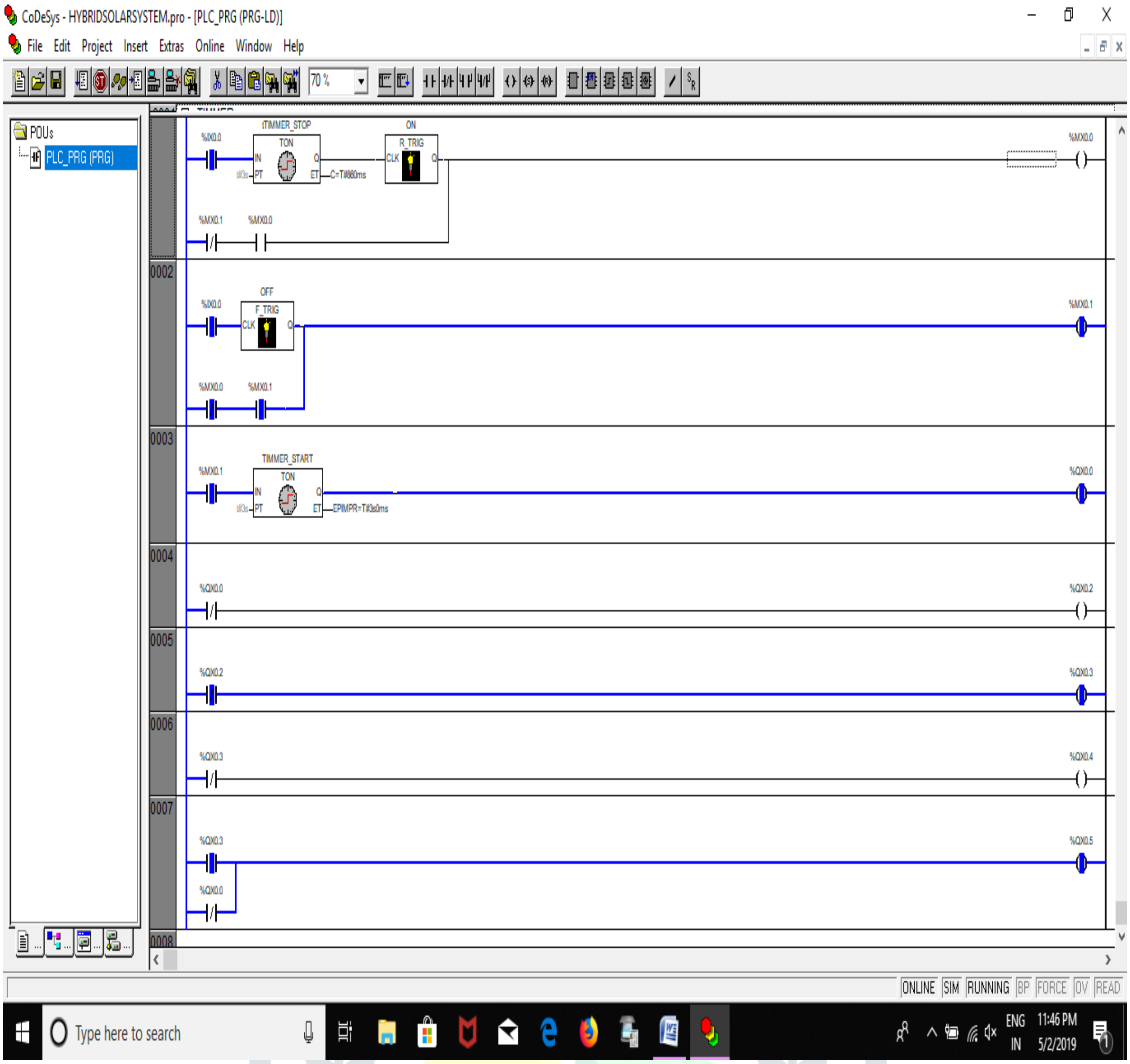


(b)

Fig. 8(a) LD program when ATC triggered system in stand-alone mode, (b) respective SCADA representation



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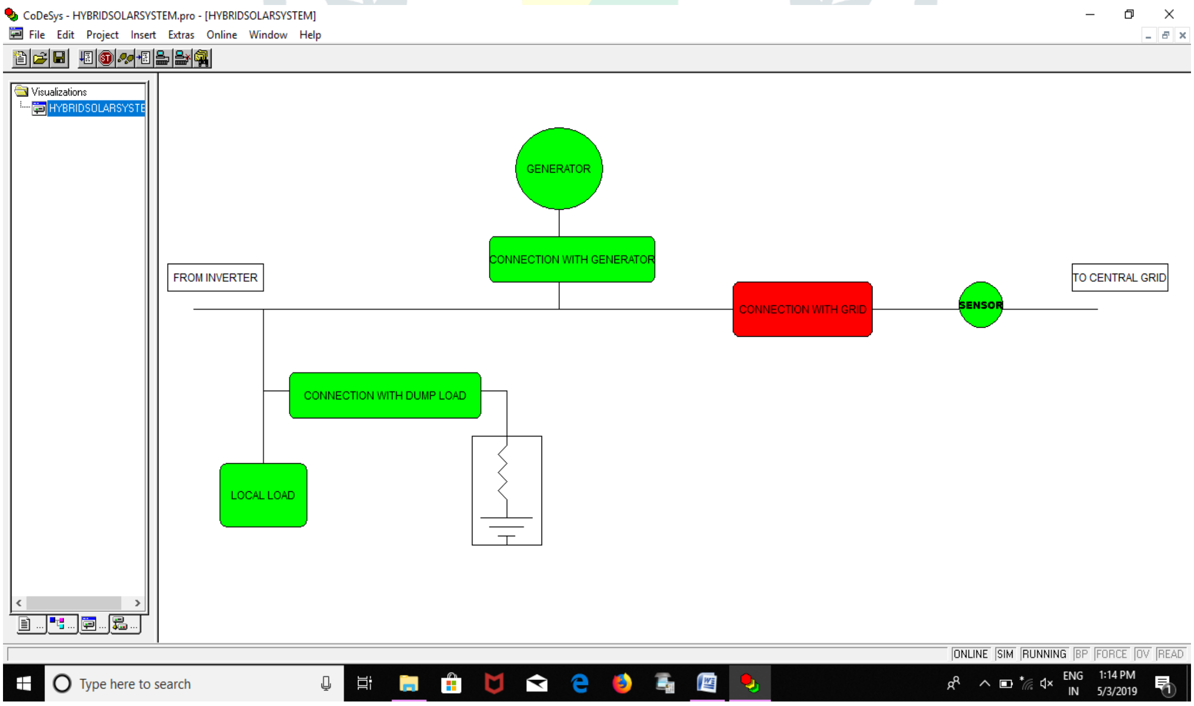
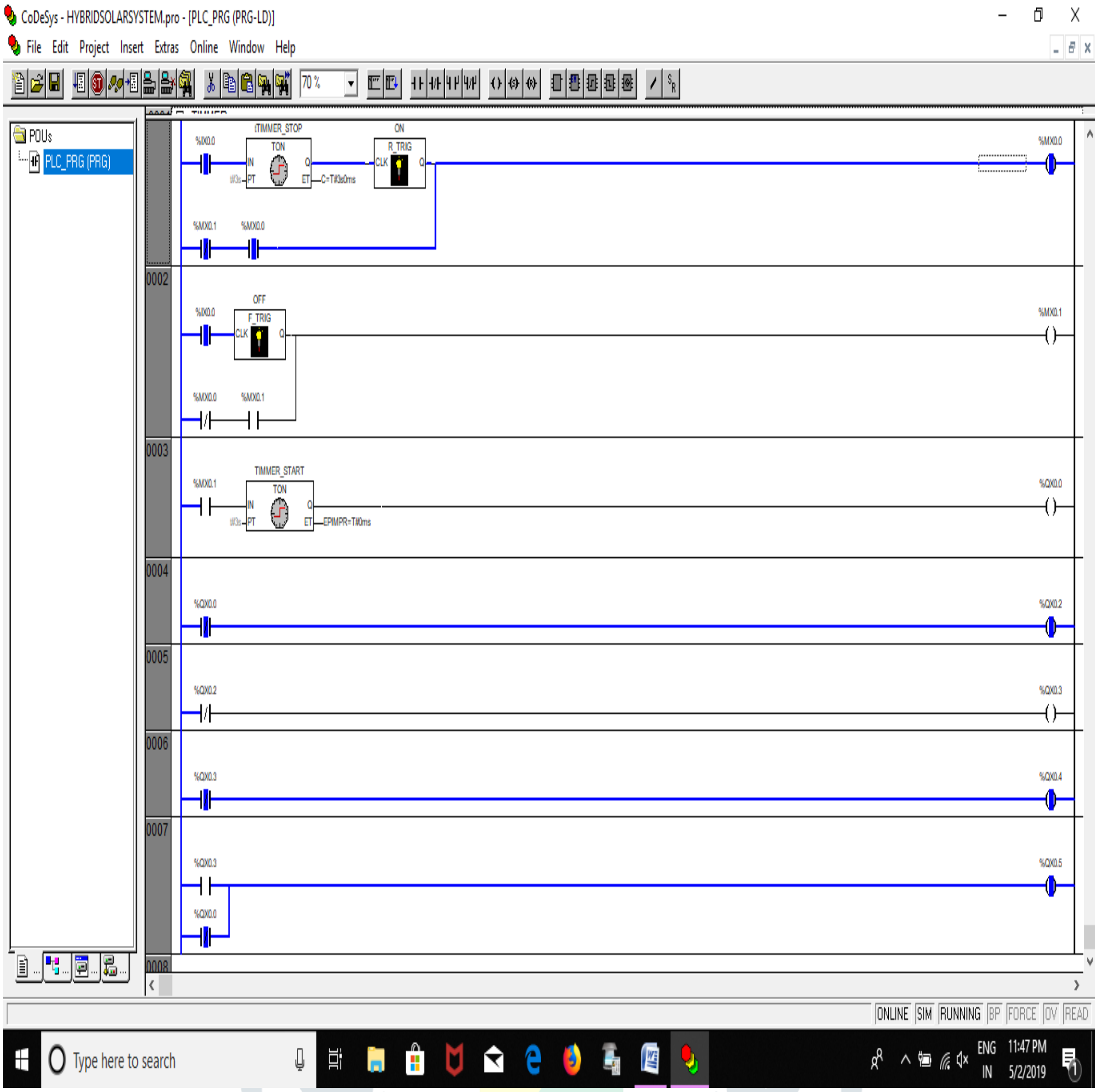


(b)

Fig. 9(a) LD program of ATC at t < $T_{clearance}$, (b) respective SCADA representation



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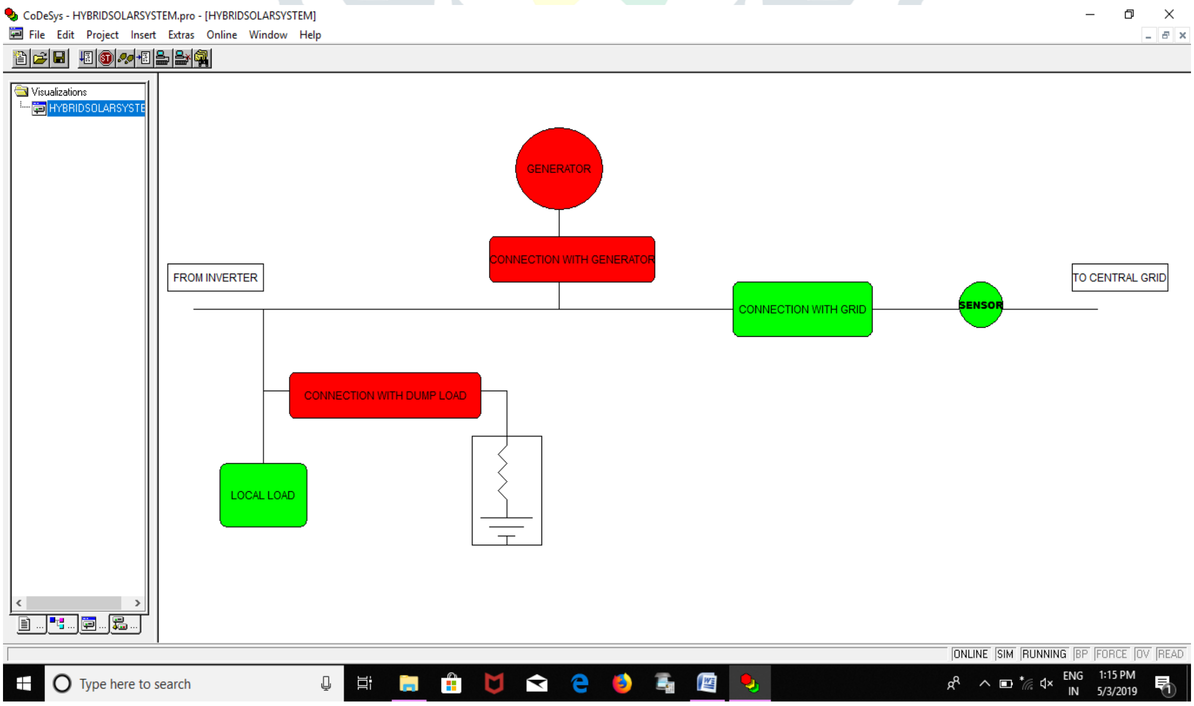

(b)

Fig.10 (a) LD program of initial state of ATC, (b) respective SCADA representation

VII CONCLUSION

In this paper a model is proposed to eliminate the anti-islanding operation of rooftop PV system. The system triggers itself from grid connected system to independent stand-alone system and vice-versa as per need. In this system the load is supplied continuously without being dependent on grid connection. The problem of islanding is solved with this rooftop system. This model is very useful for loads that are needed with 24x7 electricity supply such as hospitals and full time working industries. The wastage of solar power during power failure from grid is eliminated.

This work can be further modified to implement on large size DGs. And prevent anti-islanding operation which does not allow system to take biggest advantage of DG that is to supply the load during fault at transmission end.

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