Effect of Installation of Photovoltaic (PV) Generation to Power Quality in Industrial and Residential Customers Distribution Network

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***Abstract*-Objective of research is to analyze the influence of the photovoltaic (PV) generator installation to power quality on distribution network. There are two models of load distribution network, namely industrial and residential costumers distribution network. Reseach show that the value of bus voltage THD on distribution network of industrial and residential customers are still under of voltage THD limit recomended by IEEE 519-1992 equal as 5%. The majority of the value of TDD conductor in two models of the distribution network is under the limit conductor current TDD recommended by IEEE 519-1992. In network industries and residential customers, the more number of PV plants installed, then the value of current harmonic (TDD) at PCC bus will be even greater. The most value of conductor current TDD average generated by conductor that is connected directly to the PV generator bus The using of single tuned passive filter able to improve THD Bus and TDD conductor which still does not meet the standart requirements.**

Keywords: Photovoltaic Generator, Harmonics, Total Harmonic Distortion, Total Demand Distortion

I. INTRODUCTION

Utility customers are becoming more and more demanding in energy consumption and they need good supply to operate reliably. At the same time they tend to disrupt the utility supply with the equipment used for their main daily activities. Such kind of equipment may include variable speed drives, computers, electronic ballasts, and power electronic devices. This is imposing of higher burden on utilities to supply good quality electrical energy. Consequently, renewable energy sources and distributed generator (DG) will play a significant role in the energy mix in the future and a number of further research is require to optimize the number of grid development strategies and improve of power quality [1]. Microgrid is a group of loads and generators that operate as a controlled system that provides electricity to a particular region with relatively limited power. The concept provides a new view to define the operation of distributed generator [2], [3]. In microgrid technology, which is commonly used plant is a plant with renewable energy sources. One source of renewable energy is photovoltaic (PV) generator. The use of PV as an energy source requires an inverter to convert DC into AC voltage. In addition to function as a kind of change of voltage, inverter also cause damage to existing fundamental wave and commonly called harmonics. If it can not be controlled, then the harmonics will cause damage to equipment such as transformers, cables, and other electrical devices. One way to reduce the harmonics is using a filter [4].

The purpose of research is to analyze the influence of the photovoltaic (PV) generator installation to power quality on distribution network. There are two models of load distribution network, namely industrial and residential costumers distribution network. The research method begins by determining network modeling is connected to PV system, PV array circuit model, PV inverter circuit topology model, and network topology model of industrial and residential costumers. The next step is to determine a mathematical model of current control circuit PV inverter. The next process is to determine the strategy of the PV generator installation in the distribution network of industrial and residential customers. The next stage is to determine the value of bus voltage THD, conductor current TDD, and conductor power factor in the distribution network of industrial and residential customers on a different strategies PV generator installation.Futhermore is comparing value of bus voltage THD and conductor current TDD refers to IEEE Standard 519-1992 and conductor power factor refers on to the standard Indonesian Electricity Company (PLN) as a basis for determining level of power quality in industrial and residential costumer distribution network. Single tuned passive filter are selected to improve THD bus and TDD conductor value which still does not meet the standart requirements.

II. THEORY

A. Power Quality Standart

Power quality has become a major concern in electrical world for recent decades. One issue that arises is the emergence of the current and voltage waveform is not sinusoidal or defects caused by the emergence of harmonics generated by the power system [5]. Figure 1 shows distorted waveform signal due to harmonics.

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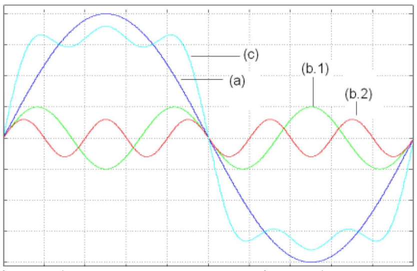


Figure 1. Distorted Wave Cause Harmonics. Where: a = Fundamental Frequency Wave, b.1 = 3rd Harmonics Wave, b.2 = 5th Harmonics Wave, c. = Distorted Harmonics.

The first parameter is the Total Harmonic Distortion (THD). THD is the ratio of the rms value of the harmonic components to rms value of fundamental component and is commonly expressed in percent (%). This index is used to measure periodic waveform deviations contains harmonics of a perfect sine wave [6]. In a perfect sine wave THD value is zero percent. THD value is expressed in Equation 1 as follows:

$$THD = \frac{\sqrt{\sum_{n=2}^{k} U_n^2}}{U_1} \times 100\,\% \qquad (1)$$

Where: U_n = Harmonic Component; U_1 = Fundamental Component; K = Maximum Harmonic Component

The second parameter is Individual Harmonic Distortion (IHD) is ratio of the rms value of individual harmonics to the rms value of fundamental component. The third parameter is Total Demand Distortion (TDD) is amount of current harmonic distortion and defined in the following Equation 2 [7]:

$$TDD = \frac{\sqrt{\sum_{n=2}^{k} I_n^2}}{I_L} \times 100\,\% \qquad (2)$$

Where I_L is maximum load current (for 15 or 30 minutes) at fundamental frequency at the Point of Common Coupling (PCC), is calculated from current average of maximum load of 12 months before.

Maximum THD value which allowable for each country is different depending on the standard used. THD standards is most often used in the electric power system is the IEEE Standard 519-1992. There are two criteria that are used in the analysis of harmonic distortion is the limit voltage distortion and current distortion limits. Table I shows voltage distortion limit (THD) on power distribution system. Table II shows current distortion limit is based on the IEEE Standard 519-1992 [5].

B. Single Tuned Shunt Passive Filter

Shunt passive filters always considered as agood solution to solve harmonic current problems [8], shunt passive filters can be classified into three basic catagories as follows:

1. Band pass filters (of single or double tuned).
2. High pass filters (of first, second, third-order or C-type).
3. Composite filters.

The single tuned filter (Figure 2) consisting of inductor L_f, capacitor C_f and small damping resistor R_f are connected in parallel with non linear loads to provide low-impedance paths for specific harmonic frequencies, thus resulting in absorbing the dominant harmonic currents flowing out of the load. Furthermore it also compensates reactive power at system operating frequency.

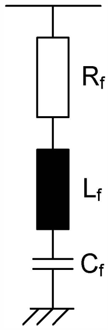


Figure 2. Single Tuned Shunt Passive Filter

The impedance versus frequency of this filter is shown [9]:

$$Z_f(S) = \frac{1 + R_f C_f S + L_f C_f S^2}{C_f S} \qquad (3)$$

Where $S = j2\pi f$

Generally the filter capasitor is sized for known reactive power compensation Q_c required to improve power factor, C_f can be expressed as:

$$C_f = \frac{1}{2\pi f_1 U^2}\left(1 - \frac{1}{n^2}\right) \qquad (4)$$

Where U is the supply voltage, n is the harmonic order and f_1 is a fundamental frequency.

At the harmonic frequency $f_n = n\ f_1$ the filter reactor provides a series resonance.

$$L_f\, 2\pi f_n = \frac{1}{C_f\, 2\pi f_n} \qquad (5)$$

The inductive value of filter can be obtained from equation 6 as:

$$L_f = \frac{1}{(2\pi f_n)^2 C_f} \qquad (6)$$

The value of the low-impedance R_f for each single tuned filter is affected by the quality factor of filter Q.

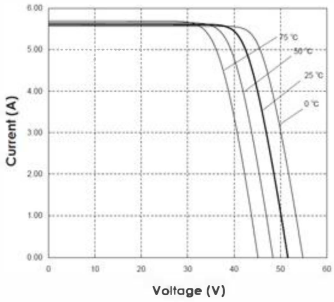
$$R_f = 2\pi f_1 n \frac{L_f}{Q} \qquad (7)$$

The quality factor Q determines the sharpness of tuning. Usually, a value of Q ranges between 20 and 100. High Q-value filter give the best reduction in harmonic distortion. The interaction of the filter with the source reactance L_s, creates a parallel resonance condition addition to the series resonance frequency of the filter.

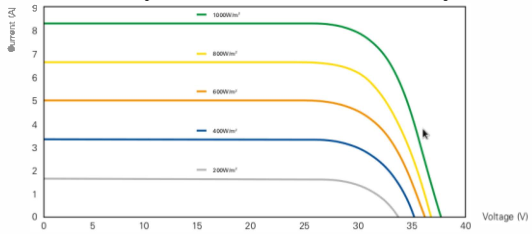
$$f_p = \frac{1}{2\pi(\sqrt{(L_f + L_s)C_f}} \qquad (8)$$

C. Photovoltaic System

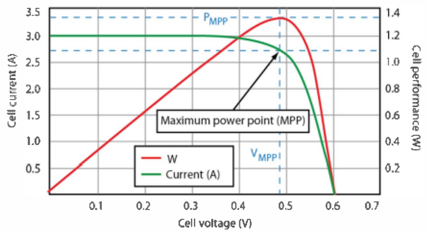
Photovoltaic systems (PV) or solar panels is one of renewable energy power generator that utilize sun as main source and then converted into electrical energy. In general, solar power has to be accepted as an alternative energy source. The issue now is the price is still expensive compared to electricity generated by other energy sources, so its use is now limited to a limited scale such as in electrical devices and are also used as power generator in areas that are still inaccessible by electrical network [10]. Figure 3 shows PV characteristic curve.



(a) I-V curve for PV panel PV for fix radiation and temperature change



(b) I-V curve for PV panel for radiation level change and fix temperature



(c) Curve of current versus voltage and power

Figure 3. Curve of PV panel characteristic

III. METHODOLOGY

A. Research Method

Research method begins by determining network model (grid) is connected to the PV system, PV array circuit model, PV inverter circuit topology models, as well as the distribution network topology model of industrial and residential customers. The next step is to determine a mathematical model of current control circuit of PV inverter. The next process is to determine the strategy of PV power generator installation in the distribution network of industrial and residential customers. PV system model which has been subsequently simulated in two distribution network topology. The first network representing industrial area measurements made before and after the installation of 150 kW PV system and the residential area. In the industrial customer case studies, three 150 kW PV system connected to the distribution network and subsequent evaluation of response of distribution network. A residential customer distribution topology then proposed with a 150 kW PV system. The next stage is to determine value of bus voltage THD, current TDD, and power factor (power factor) conductor in the distribution network of industrial and residential customers on a number of strategies installation of PV generator. Futhermore, comparing value of bus voltage THD and current conductor TDD refers to IEEE Standard 519-1992 and conductor power factor refers to the standard PLN. Single tuned passive filters are installed to improve THD bus and TDD conductor value still does not meet the standart requirements. Simulation and analysis of research using ETAP 7.0 software.

B. PV Model Description

The PV system model proposed for the simulation consists of PV array, diode, inverters and a power grid interface as shown in Figure 4. The PV array is modeled according to its equivalent circuit shown in Figure 5, by using the equation deriving from aforemention circuit representation.

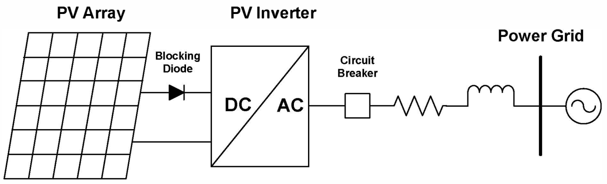


Figure 4. Proposed model for grid-connected photovoltaic system

In particular, the behavior of the PV array model is affected by the solar irradiance, the temperature and the specific characteristics of the chosen PV module technology. The PV inverter circuit is composed of a DC to DC converters which is necessary to determine maximum power point tracking of PV arrays, a DC to AC converter to transform DC power into AC, means of energy transfer to absorb fast voltage variations and filters to eleminate undesirable harmonic components. The modular circuit of the PV inverter is shown in Figure 6.

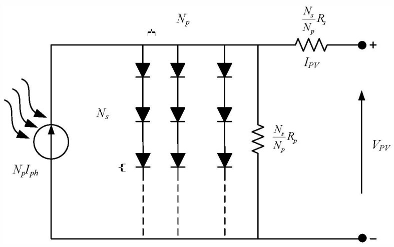


Figure 5. Equivalent circuit of PV array

A maximum power point tracking mechanism to extract the maximum power available from the PV array is also considered. The maximum power point tracking adopted is the incremental conductance method with integral regulator to minimize the errors in tracking MPP. More information about the specific algorithm is found in reference [1]. Distribution network model of industrial and residential customers is shown in Figure 7 and 8.

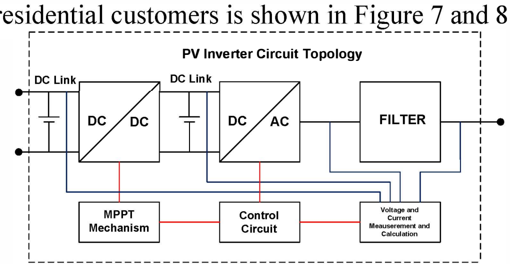
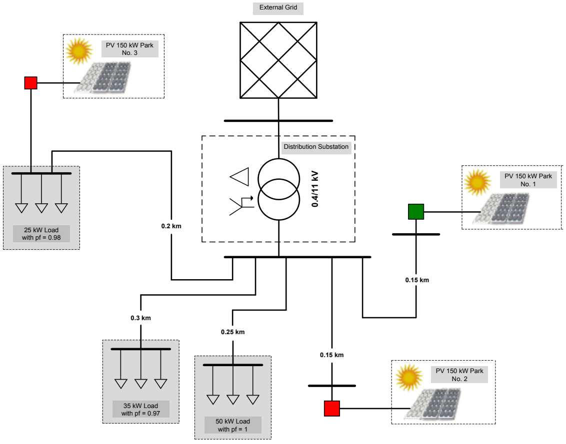
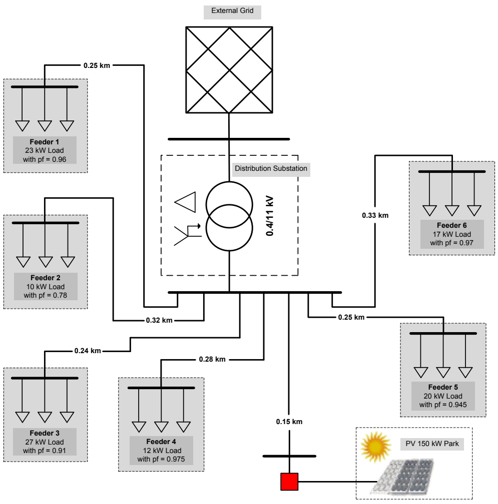


Figure 6. PV inverter circuit topology

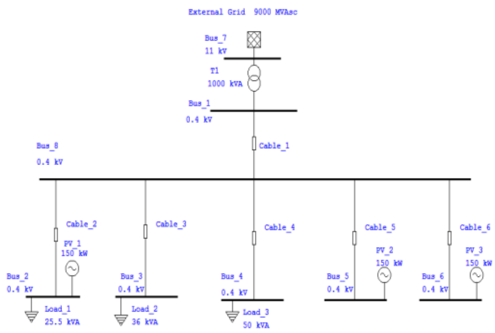


(a) Industrial costumer

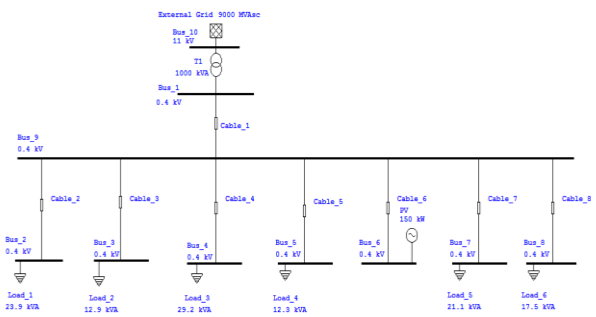


(b) Residential costumer

Figure 7. Two model of distribution network



(a) Industrial costumer



(b) Residential costumer

Figure 8. Two model of distribution network for industrial and residential customer using ETAP

IV. RESULT AND DISCUSSION

Research was conducted on the condition of system is connected to microgrid. There are two models of network topology, namely distribution network of industrial and residential customers. Both grid distribution network supplied by a power transformer 1000 kVA, 11/0.4 kV Δ /Y connection, which is connected to the external grid MVA_{sc} 9000. The first distribution network connected to 5 buses, respectively 2 load buses, connected to the PV plant, as well as one other bus connected to the PV generator and also serves as a bus load. The second distribution networks connected to 7 buses, each 6 load buses and 1 bus is connected to PV generator. Data load, transformer, conductor, and PV generator on the distribution network of industrial and residential costumer are shown in Table III. PV generator in addition to functioning supplying power to the distribution network, is also a source of harmonics due to the presence of inverter as a medium to transform the DC voltage into AC voltage. Data of harmonic current generated by the PV generaton is shown in Table IV [11]. Harmonic order are generated according to the ability of ETAP 7.0 software.

TABLE IV. HARMONIC CURRENT GENERATE BY PV

Order	Mag (%)	Order	Mag (%)
2	0.71	11	0.24
3	1.85	12	0.08
4	0.57	13	0.16
5	0.52	14	0.25
7	0.61	15	0.05
8	0.07	17	0.06
9	0.08	19	0.05
10	1.12	23	0.07

Based on the above data, then analyzed using ETAP 7.0 software help to determine the value of the bus voltage THD, current TDD, and conductor power factor in the distribution network of industrial and residential customers on a number of installation strategies of PV generator. Analysis of three parameters shown in Table V, VI, and VII.

TABLE V. COMPARATION OF VOLTAGE QUALITY USING DIFFERENT STRATEGY OF PV INSTALATION ON INDUSTRIAL COSTUMER

Strategies	Bus	V(pu)	V_{THD} (%)	V_{THD} Std (%)
Without PV	1	0.998	0.01	5
	2	0.988	0.01	5
	3	0.985	0.00	5
	4	0.985	0.00	5
	5	0.989	0.01	5
	6	0.989	0.01	5
	7	1.000	0.00	5
	8	0.989	0.01	5
PV1	1	0.998	0.07	5
	2	0.981	0.18	5
	3	0.986	0.13	5
	4	0.986	0.13	5
	5	0.991	0.13	5
	6	0.991	0.13	5
	7	1.000	0.00	5
	8	0.998	0.13	5
PV1 + PV2	1	0.999	0.15	5
	2	0.989	0.32	5
	3	0.987	0.27	5

	4	0.986	0.27	5
	5	0.991	0.31	5
	6	0.991	0.27	5
	7	1.000	1.00	5
	8	0.991	0.27	5
PV1 + PV2+ PV3	1	0.999	0.22	5
	2	0.991	0.45	5
	3	0.988	0.40	5
	4	0.987	0.40	5
	5	0.992	0.44	5
	6	0.993	0.44	5
	7	1.000	0.00	5
	8	0.998	0.40	5

TABLE VI. COMPARATION OF VOLTAGE QUALITY USING DIFFERENT STRATEGY OF PV INSTALATION ON RESIDENTIAL COSTUMER

Strategies	Bus	V(pu)	V_{THD} (%)	V_{THD} Std (%)
Without PV	1	0.997	0.01	5
	2	0.986	0.00	5
	3	0.987	0.00	5
	4	0.986	0.01	5
	5	0.997	0.00	5
	6	0.998	0.00	5
	7	0.986	0.02	5
	8	0.986	0.01	5
	9	0.988	0.00	5
	10	1.000	0.00	5
PV	1	0.998	0.07	5
	2	0.987	0.13	5
	3	0.988	0.13	5
	4	0.987	0.13	5
	5	0.998	0.13	5
	6	0.990	0.17	5
	7	0.987	0.13	5
	8	0.987	0.13	5
	9	0.989	0.13	5
	10	1.000	0.00	5

Table V dan VI shows that bus voltage THD value on distribution network of industrial and residential customers ranged between 0 through 0.45%. This value is still below limit of voltage THD recommended by IEEE 519-1992 by 5%. The addition of PV generator in both distribution network generates increasing of voltage THD value. On industrial customer network without PV, maximum bus voltage THD value is 0.01%, while network using three PV maximum bus voltage THD value increased to 0.45%. The maximum bus voltage THD value on residential customer networks without PV of 0.02% and if using PV maximum bus voltage THD value increased to 0.17%.

Figure 9 and 10 show that on industrial and residential customers network, the more the number of PV generator installed then value of current harmonics (TDD) at PCC bus will be even greater. This is because in addition to functioning PV generator supplying power to the distribution network, is also generating harmonics due to presence of inverter as a media to convert DC to AC voltage.

Table VII shows that the value of conductor currents TDD in the industrial customers distribution network has already meet current TDD recommended by IEEE 519-1992 except on conductor 2, 5, and 6. Current TDD value on conductor 2 has a minimum because value of the power factor is 1.0. Improvement of TDD current only can be done on conductor 5 and 6 for the condition of P1 + PV1 and PV1+ PV2 + PV3 connected to the grid by increasing power factor of both conductor becomes 1.0. By using the power triangular method, we will obtain reactive power compensation value to get value of C, L, and R is based on the most dominant-order harmonics with a single passive filters tuned using Equation 4 to 7. The most dominant-order harmonics are 3^{rd}, 5^{th}, 7^{th}, 11^{th}, and 14^{th}. By using the same procedure, migitation of current TDD can be done on conductor 6 in the residential distribution network for PV installed to the grid. Table VIII shows designed single tuned passive filters, current TDD without and with filter. From Table VII, we can see that nominal current TDD on conductor 5 and 6 in the industrial costumer distribution network before using single tuned passive filters are 224.9 and 39.4. After using 3^{rd} order single tuned passive filter, as shown in Table VIII, the value of current TDD for both conductor has reduced to 154.68 and 28.26. Improvement of current TDD using filter also happens on conductor 6 in the residential distribution network for PV installed to the grid. Figure 11 and 12 show harmonic current spectrum of conductor 6 for PV1 + PV 2 + PV 3 connected to grid on industrial costumer network before and after installed single tuned passive filter.

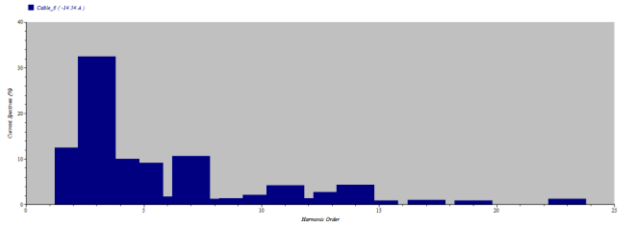


Figure 11. Harmonic current spectrum of conductor 6 for PV1 + PV 2 + PV 3 connected to grid on industrial costumer network without filter

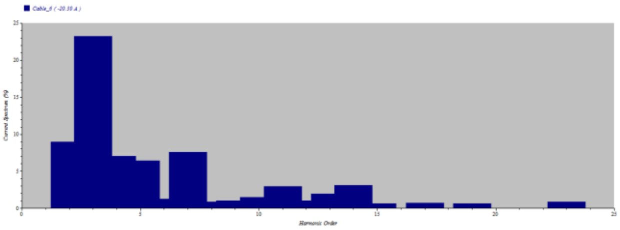


Figure 12. Harmonic current spectrum of conductor 6 for PV1 + PV 2 + PV 3 connected to grid on industrial costumer network with filter

Table VII also shows that the addition of PV generator in two models distribution network produce conductor current TDD value is increasing. The most value of conductor current TDD average generated by conductor that is connected directly to the PV generator bus.

V. CONCLUSION

The simulation results show that the THD value on the bus voltage distribution network of industrial and residential customers are still under voltage THD limit recommended by the IEEE 519-1992 by 5%. The majority of the value of TDD conductor in two models of the distribution network is under the limit conductor current TDD recommeded by IEEE 519-1992. In industrial and residential customer networks, the more the number of PV generator installed, then the value of current TDD at PCC bus will be even greater. This is because in addition to functioning PV plants supplying power to the distribution network, is also generates harmonics due to the presence of the inverter as a medium to transform DC into AC voltage. Using of single tuned passive filter 3rd order give better solution to improve current TDD. The value of power factor in the distribution network of industrial and residential customers on average already meet minimum requirements set PLN limits by 85%.

VI. ACKNOWLEDGMENT

The authors would like to acknowledge to Directorate General of Human Recource for Science, Technology, and Higher Education Indonesia for financial support by BPP-DN Scholarships to pursue Doktoral Program in Electrical Engineering, Sepuluh Nopember Institute of Technology (ITS) Surabaya.

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APPENDIXS:

TABLE I. IEEE 519-1992 HARMONIC VOLTAGE LIMIT

Bus Voltage on PCC	Individual Voltage Distortion (%)	Total Voltage Distortion THD (%)
69 kV and below	3,0	5,0
69,001 kV through 161 kV	1,5	2,5
161,001 kV and above	1,0	1,5

Tabel II. IEEE 519-1992 HARMONIC CURRENT LIMIT

Maximum Harmonic Current Distortion in Percent of I_L						
Individual Harmonic Order (Odd Harmonics)						
I_{sc}/I_L	<11	11≤h<17	17≤h<23	23≤h<35	35≤h	TDD
<20*	4	2	1,5	0,6	0,3	5
20 s/d 50	7	3,5	2,5	1	0,5	8
50 s/d 100	10	4,5	4	1,5	0,7	12
100 s/d 1000	12	5,5	5	2	1	15
>1000	15	7	6	2,5	1,4	20

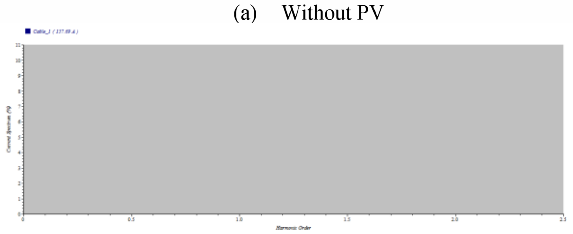
TABLE III. DISTRIBUTION NETWORK DATA OF INDUSTRIAL AND RESIDENTIAL COSTUMERS

Network models	Generator and Transformers	Conductors	Loads
Industrial costumer	External grid 9000 MVAsc (Swing) Transformer 1000 kVA, 11/0.4 kV, Δ/Y PV 1 (Bus 2) 150 kW (Mvar Control) PV 2 (Bus 5) 150 kW (Mvar Control) PV 3 (Bus 6) 150 kW (Mvar Control) Frekuensi 50 Hz	Bus 1-8, Al 3/C 120 mm^2 Bus 8-2, CU 3/C 35 mm^2 Bus 8-3, CU 3/C 35 mm^2 Bus 8-4, CU 3/C 35 mm^2 Bus 8-5, CU 3/C 35 mm^2 Bus 8-6, CU 3/C 35 mm^2	Bus 2, 25 kW cos φ = 0.980 Bus 3, 35 kW cos φ = 0.970 Bus 4, 35 kW cos φ = 1.000
Residential costumer	External grid 9000 MVAsc (Swing) Transformer 400 kVA, 11/0.4 kV, Δ/Y PV (Bus 6) 150 kW (Mvar Control) Frequency 60 Hz	Bus 1-9, Al 3/C 120 mm^2 Bus 9-2, CU 3/C 35 mm^2 Bus 9-3, CU 3/C 35 mm^2 Bus 9-4, CU 3/C 35 mm^2 Bus 9-5, CU 3/C 35 mm^2 Bus 9-6, CU 3/C 35 mm^2 Bus 9-7, CU 3/C 35 mm^2 Bus 9-8, CU 3/C 35 mm^2	Bus 2, 23 kW cos φ = 0.960 Bus 3, 10 kW cos φ = 0.780 Bus 4, 27 kW cos φ = 0.910 Bus 5, 25 kW cos φ = 0.975 Bus 7, 20 kW cos φ = 0.945 Bus 8, 35 kW cos φ = 0.970

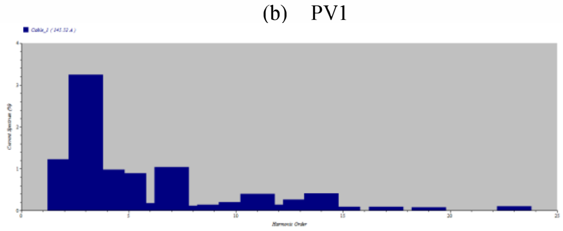
TABLE VII. COMPARATION OF CURRENT QUALITY ON A NUMBER PV INSTALLATION STRATEGY

Network Models	Strategies	Conductors	PF (%)	Isc (A)	IL (A)	Isc/IL	TDD (%)	TDD Std (%)
Industrial Costumer	Without PV	1	99.2	13900	157.7	88.1420	0.000	12
		2	98.1	8100	36.30	223.141	0.000	15
		3	97.1	6700	51.20	130.860	0.000	15
		4	100.0	7300	71.10	102.673	0.000	15
		5	0.0	8960	0.000	N/A	0.000	20
		6	0.0	9040	0.000	N/A	0.000	20
	PV1	1	99.6	13860	145.5	95.2580	3.920	12
		2	100.0	8083	24.00	336.792	23.87	15
		3	97.2	6900	51.30	134.503	0.090	15
		4	100.0	7600	71.10	106.892	0.000	15
		5	0.0	9390	0.000	N/A	0.000	20
		6	0.0	9480	0.000	N/A	0.000	20
	PV1 + PV2	1	99.7	13860	143.3	96.7200	7.970	12
		2	100	8441	24.00	351.709	23.83	15
		3	97.2	7150	51.30	100.422	0.180	15
		4	100	7890	71.20	110.815	0.180	15
		5	85.7	9390	6.300	1490.48	224.5	20
		6	0.0	9930	0.000	N/A	0.000	20
	PV 1 + PV2 + PV3	1	100.0	13860	130.7	106.045	13.10	15
		2	100.0	8800	24.10	365.146	23.74	15
		3	97.2	7400	51.40	143.968	0.260	15
		4	100.0	8190	71.20	115.029	0.270	15
		5	85.8	9840	6.300	1561.91	224.9	20
		6	85.1	9930	15.60	636.539	39.54	20
Residential costumer	Without PV	1	93.6	13860	165.0	84.0000	0.000	12
		2	96.1	7300	34.00	214.710	0.000	15
		3	77.3	6430	18.40	349.460	0.000	15
		4	91.0	7450	41.60	179.090	0.000	15
		5	97.5	6810	17.50	389.143	0.000	15
		6	0.0	9040	0.000	N/A	0.000	20
		7	94.5	7210	30.00	240.334	0.000	20
		8	97.0	6230	24.90	250.201	0.000	20
	PV	1	94.3	13860	150.9	91.8900	3.780	12
		2	96.1	7590	34.10	222.581	0.090	15
		3	77.3	6600	18.50	356.757	0.070	15
		4	91.3	7750	41.60	186.298	0.080	15
		5	97.5	7070	17.50	404.000	0.090	15
		6	85.0	9040	14.60	619.178	39.44	15
		7	94.5	7500	30.00	250.000	0.130	15
		8	97.0	6450	24.90	259.036	0.130	15

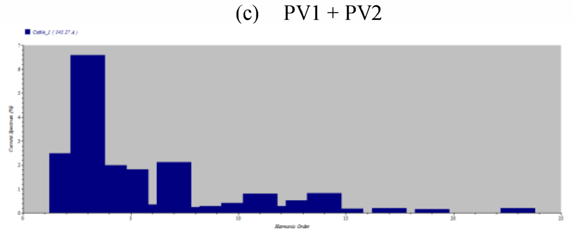
(a) Without PV



(b) PV1



(c) PV1 + PV2



(d) PV1 + PV2 + PV3

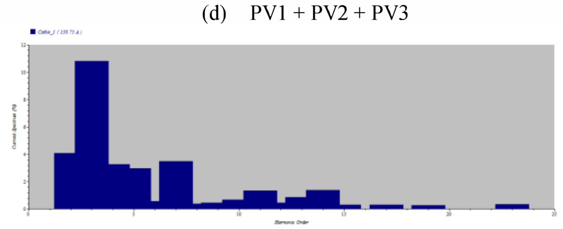


Figure 9. Harmonic current spectrum in the number of PV installation strategies on industrial costumer network at PCC

(a) Without PV (b) PV

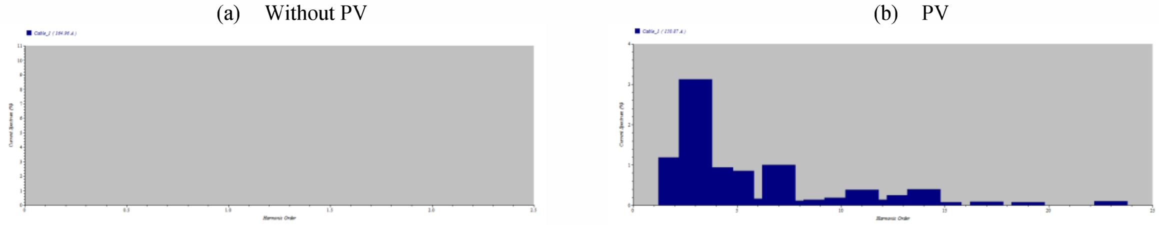


Figure 10. Harmonic current spectrum in the number of PV installation strategies on residential costumer network at PCC

TABLE VIII. DESIGN SINGLE TUNED PASSIVE FILTERS AND TOTAL DEMAND DISTORTION

Strategies	**Conductors**	**Tuned Filter**	**C (µF)**	**L (mH)**	**R (Ω)**	**TDD**	
						Without Filter	**With Filter**
Industrial Costomer							
PV 1 + PV2	5	3rd	17.4690	44.7459	0.5062	224.50	154.65
		5th	17.4690	16.1113	0.3037	224.50	157.08
		7th	17.4690	8.22000	0.2167	224.50	156.65
		11th	17.4690	3.3288	0.1381	224.50	160.06
		14th	17.4690	2.0055	0.1059	224.50	163.06
PV 1 + PV2 + PV3	5	3rd	17.4690	44.746	0.5062	224.90	154.68
		5th	17.4690	16.111	0.3037	224.90	156.97
		7th	17.4690	8.2200	0.2167	224.90	156.47
		11th	17.4690	3.3288	0.1381	224.90	159.91
		14th	17.4690	5.0055	0.1059	224.90	161.10
	6	3rd	87.3713	8.9480	0.1012	39.540	28.260
		5th	87.3713	3.2213	0.0608	39.540	28.540
		7th	87.3713	1.6435	0.0434	39.540	28.880
		11th	87.3713	0.6656	0.0276	39.540	29.490
		14th	87.3713	0.4109	0.0217	39.540	30.190
Residential Costumer							
PV	6	3rd	87.3713	8.9480	0.1012	39.440	28.270
		5th	87.3713	3.2213	0.0608	39.440	28.480
		7th	87.3713	1.6435	0.0434	39.440	28.280
		11th	87.3713	0.6656	0.0276	39.440	29.160
		14th	87.3713	0.4109	0.0217	39.440	29.280