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Study Of The Reliability Of Static Converter For Photovoltaic Application

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Abstract

The study of the reliability of PV systems, although they are answered in the world, is rare. In Algeria we have recorded any university research laboratory on the subject, despite the government gives great importance to the development of PV systems from us. It is therefore important to know the reliability, availability and sustainability of these systems. This will help to objectively determine the lifetime of a PV system before the costs become more important than the gains from the system.
The objective of this work is to calculate the reliability of the MPPT of PV system and simulate the combination of a photovoltaic panel with a DC / DC converter controlled by the technical Disrupts & Regards. Two choppers are available for study parallel (three conduction modes and three powers), and the chopper Cuk (for the same power).

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Key words: photovoltaic systems; MPPT; reliability of the MPPT; DC/DC converter

1. Introduction

An important characteristic of the solar panels is that the maximum available power is provided by only a single operating point defined by a voltage and a known current, called the maximum power point. Furthermore, the position of this point is not fixed but moves according to the temperature of irradiation and solar cells as well as the filler used. Because of the relatively expensive cost of this type of energy, we must:

Study the various causes of failure in order to avoid them in the future to have a good use of this type of power source, consequently, the study of the reliability of these systems.

2. Photovoltaic System

A photovoltaic system is a system that uses one or more solar panels to convert solar energy into electricity. It contains several components, comprising the photovoltaic modules, electrical and mechanical connections, and means for setting (or not) to change the output power (AC or DC). We have grouped these components into 4 parts by function [1]:

- PV generator unit of production of electrical energy in the form of direct current.
- Static Converters (choppers, Inverters).
- Storage system of electric energy.
- The load.

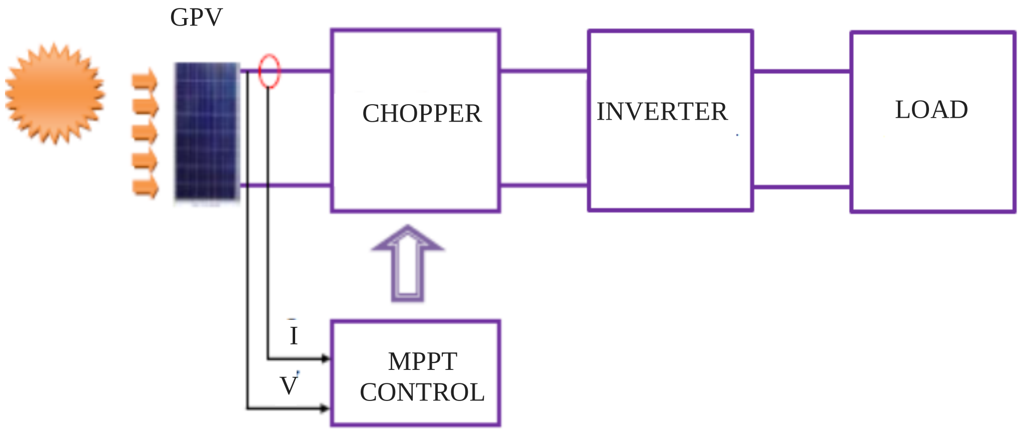


Fig. 1 PV conversion of elemental chain controlled by an MPPT

2.1. Simulation graphs

A. For P1=9,156 KW

1. CCM Mode

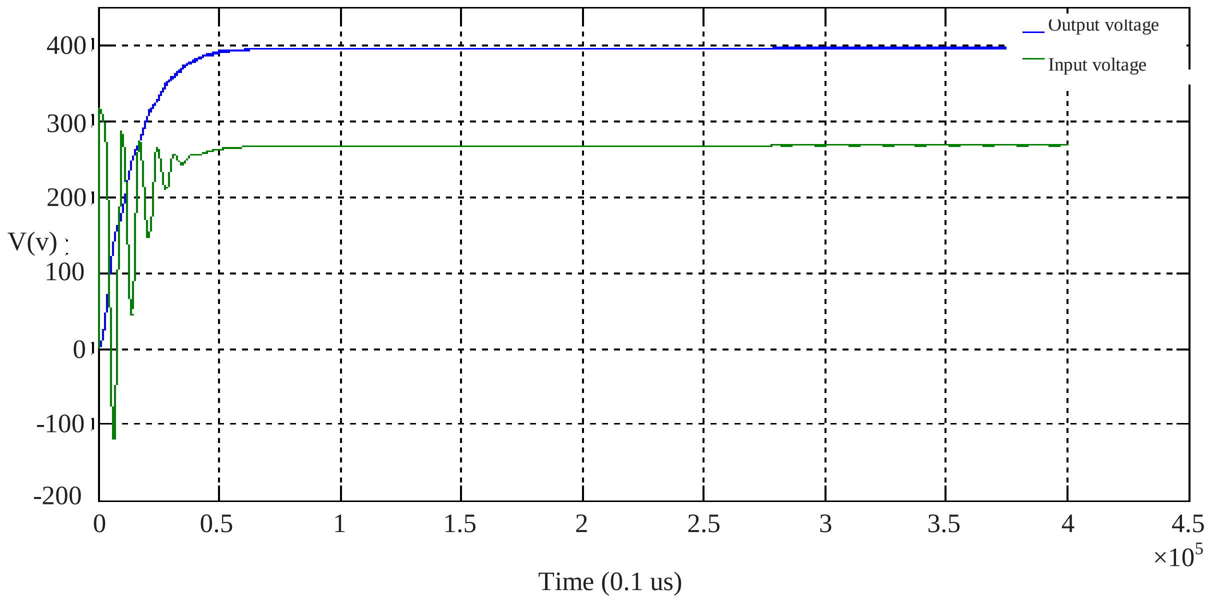


Fig .2 the voltages (output and input)

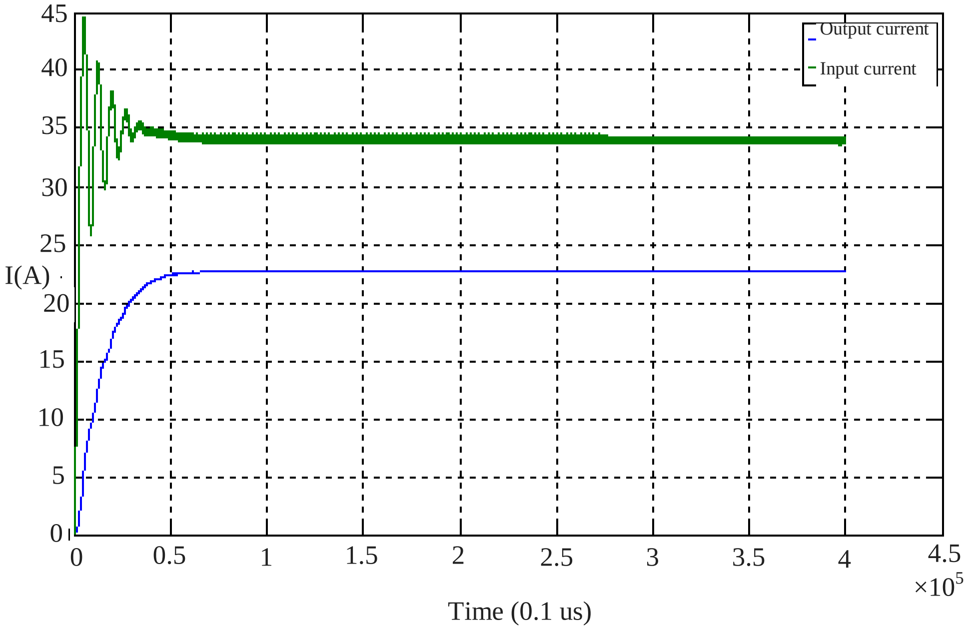


Fig .3 currents (output and input)

2. En mode CRM :

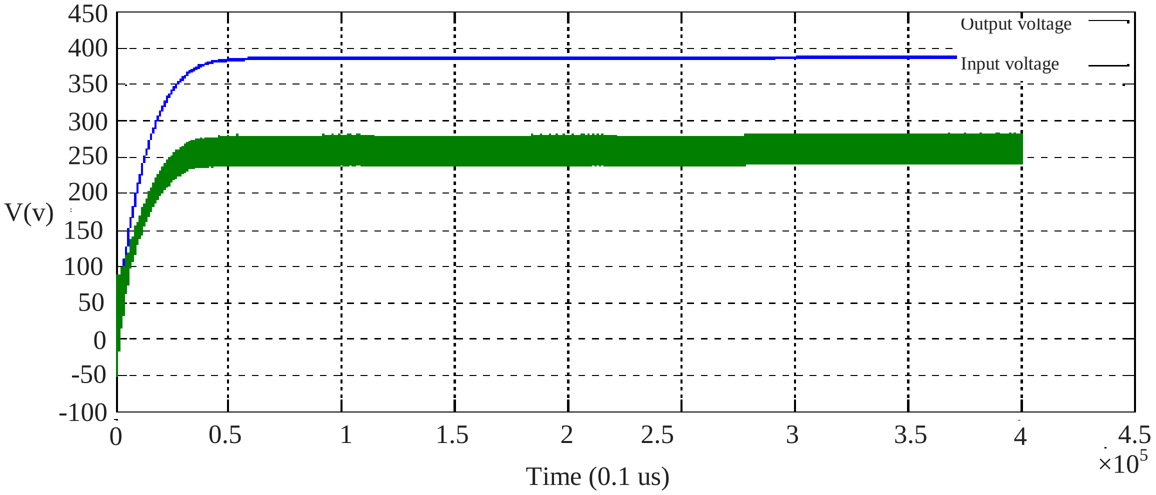


Fig .4 the voltages (output and input)

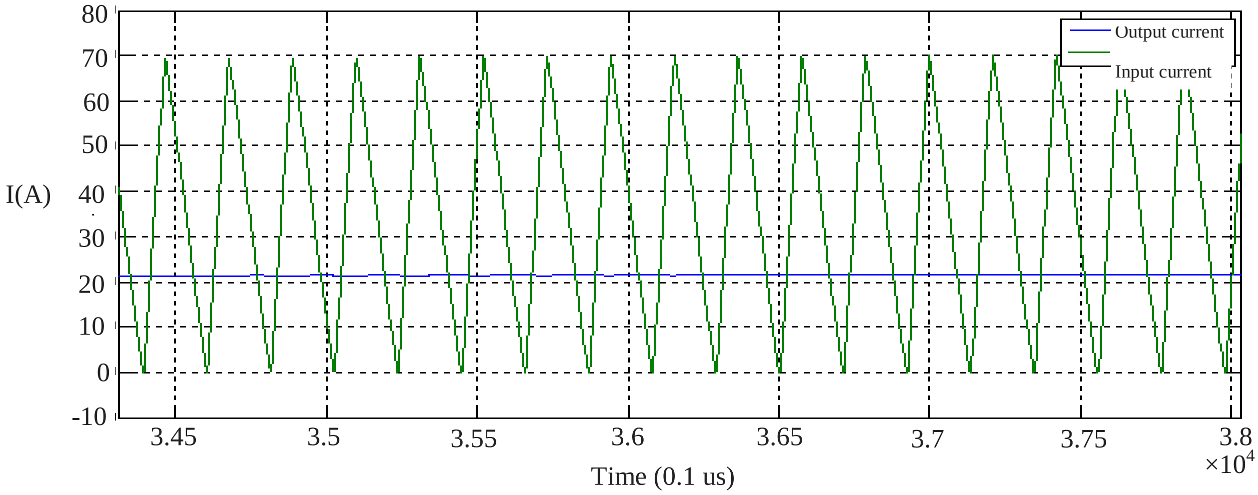


Fig.5currents (output and input)

3. En mode DCM

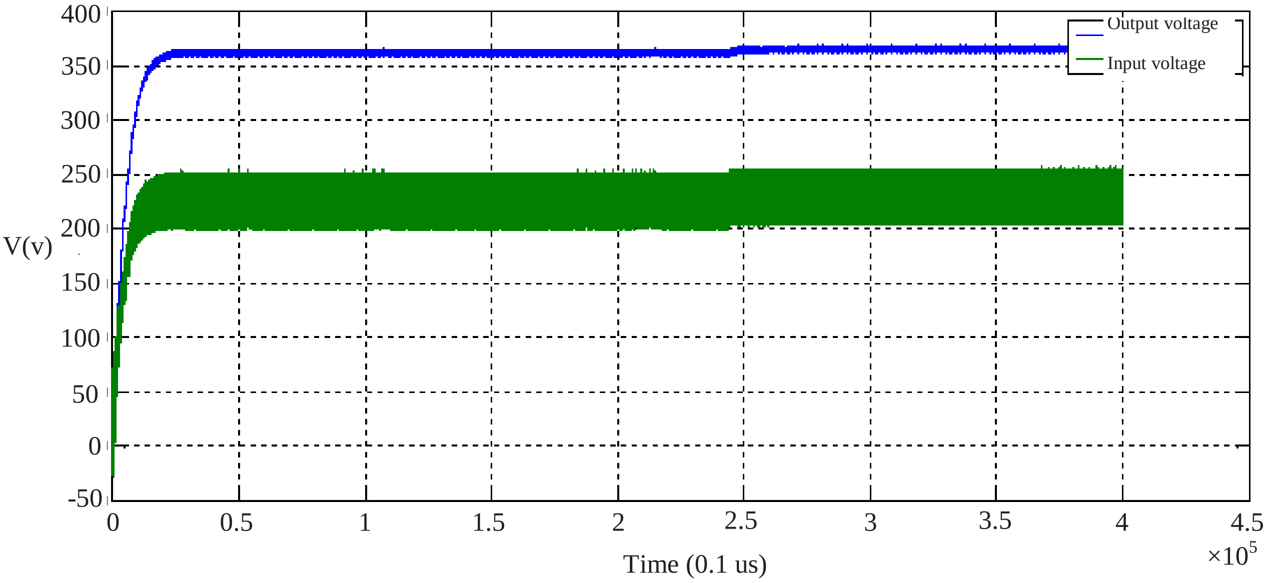


Fig .6 the voltages (output and input)

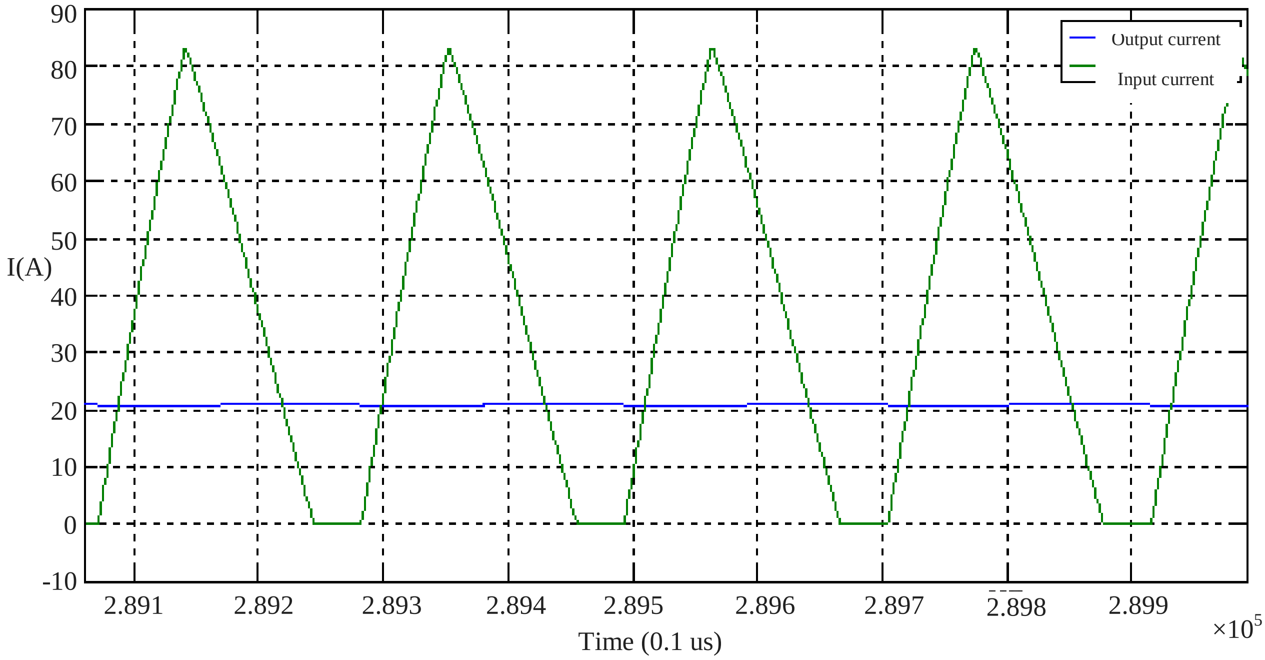


Fig.7 currents (output and input)

According to the simulation graphs DCM guide (figure 6), we see that the output voltage has fallen more, and that the current peaks are higher.

3. Converters

The converter group's role is to extract the maximum power from the PV generator and power the load. To fulfill this role, this group of converters consists of a floor chopper (DC-DC converter) followed by an inverter stage (DC-AC converter) .Three conduction modes for parallel chopper and the chopper series, the continuous conduction mode "TLC" review mode "CRM" conduction and conduction mode interrupted "DCM" to see the effect of conduction mode on ingredients chopper especially MOSFET and LED. [2]; [3]

4. The parallel converter « Boost »

Figure 2 illustrates a parallel chopper (boost); it consists of a source voltage Vs (voltage) inductor L, K controllable switch, diode D, capacitor C to the filter output and to the resistive load R. [4]

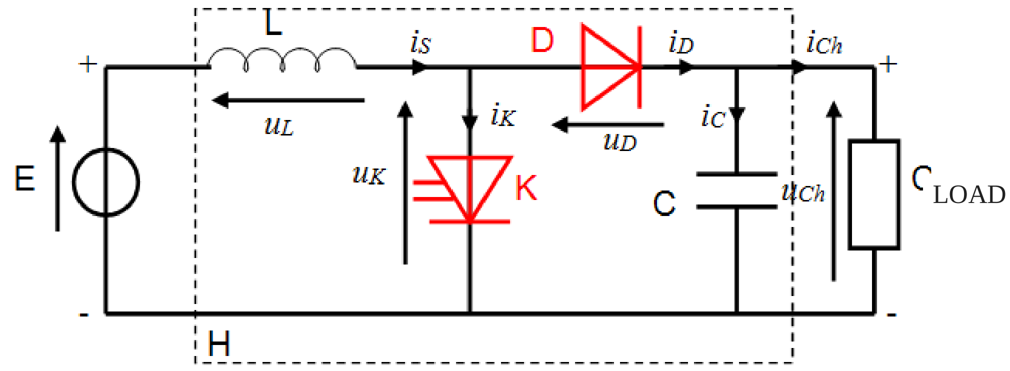


Fig8 . Schematic diagram of the parallel chopper

4.1. Data Reliability

The use of MIL HDBK-217 F involves the use of several factors to calculate the reliability of a system in power electronics, each element has its calculated by formulas specified factors, that's why it is necessary that we present the reasons for choosing these formulas. [5]

4.3. Reliability calculation

The component failure rate is given in the following general form:

$$\lambda = \lambda_{base-element} \prod \pi_i \; failure/10e-6hours$$

Where:

$\lambda = \lambda_{base-element}$: Is the rate of failure often introduced by a basic model of the electrical linking influences and effects of temperature on the component?

π_i : Factors affect the rate of failure

a. *Le mode CCM*

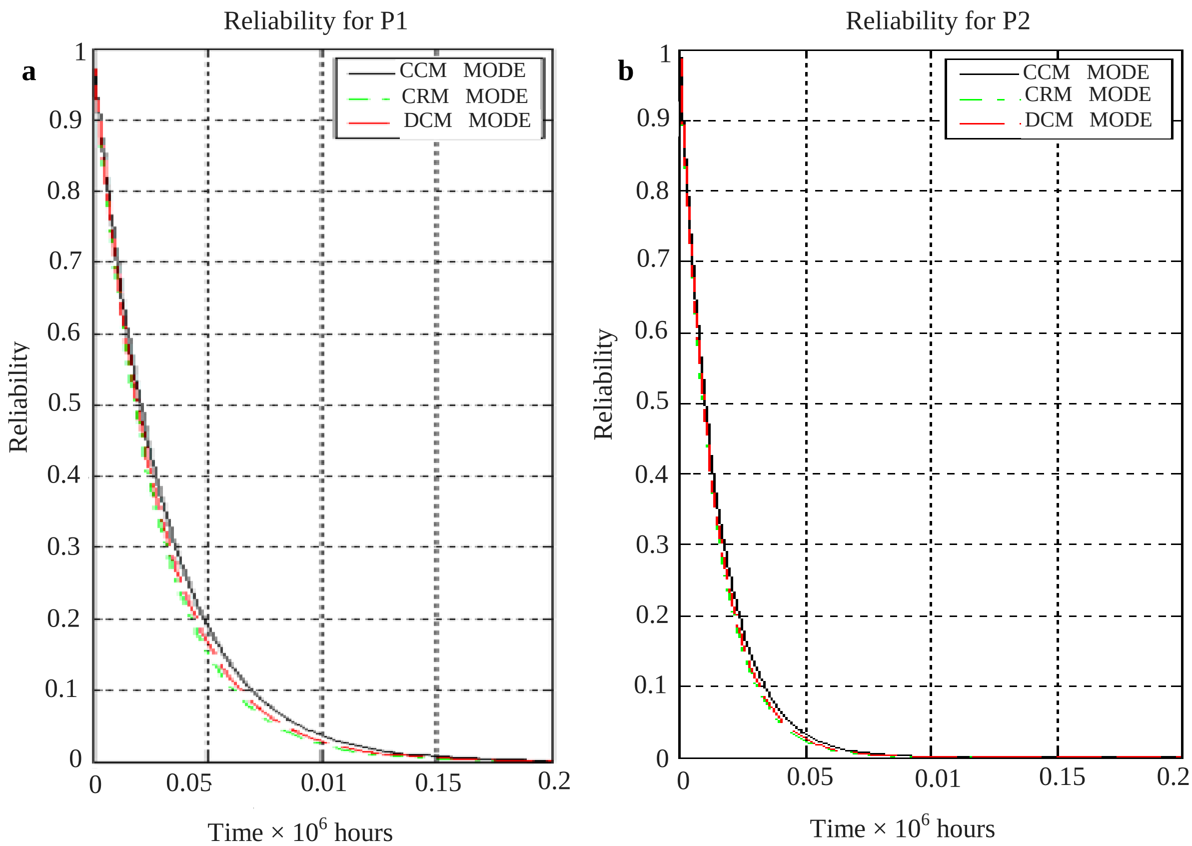
Table1.calculation of reliability for the user parallel converter CCM

Ta [°C]	**27**											
ΔT	10											
component	Power [W]	λ_b	π_A	π_Q	π_E	T_c	T_j	π_T	π_s	π_c	π_{cv}	λ_p [fail/10E6 H]
Mosfet	9156.78	0.012	10	5.5	6	125.95	155.63	7.16				28.359
	12209.04	0.012	10	5.5	6	195.16	245.61	15.61				61.815
	15261.3	0.012	10	5.5	6	282.50	359.15	30.40				120.399
Diode	9156.78	0.069		5.5	6	72.78	109.41	4.16	0.37	1		3.538
	12209.04	0.069		5.5	6	88.05	136.88	5.83	0.37	1		4.957
	15261.3	0.069		5.5	6	103.31	164.35	7.83	0.37	1		6.658
Capacitor	9156.78	0.0306148		30	2						0.63	1.153
	12209.04	0.0306148		30	2						0.64	1.179
	15261.3	0.0306148		30	2						0.65	1.199
Inductance		0.0005077		20	4					1		0.041

B.failure rate of the system

Table 2 .comparison between the three modes and 3 powers at the reliability of the parallel converter

Power	**P1=9 .156 KW**				**P2=12.209 KW**			**P3=15.261 KW**	
the mode conduction	**CCM**	**CRM**	**DCM**	**the mode conduction**	**CCM**	**CRM**	**DCM**	**the mode conduction**	**CCM**
$\lambda_{p\,(Mosfet)}$	28.358	35.523	29.580	$\lambda_{p\,(Mosfet)}$	28.358	35.523	29.580	$\lambda_{p\,(Mosfet)}$	28.358
$\lambda_{p\,(Diode)}$	3.537	8.636	4.957	$\lambda_{p\,(Diode)}$	3.537	8.636	4.957	$\lambda_{p\,(Diode)}$	3.537
$\lambda_{p\,(Condensateur)}$	1.153	1.153	1.087	$\lambda_{p\,(Condensateur)}$	1.153	1.153	1.087	$\lambda_{p\,(Condensateur)}$	1.153
$\lambda_{p\,(inductance)}$	0.041	0.041	0.041	$\lambda_{p\,(inductance)}$	0.041	0.041	0.041	$\lambda_{p\,(inductance)}$	0.041
λ_p total	33.084	37.418	35.664	λ_p total	33.084	37.418	35.664	λ_p total	33.084
MTBF	302261.85	267250.095	292016.798	MTBF	302261.85	267250.095	292016.798	MTBF	302261.85



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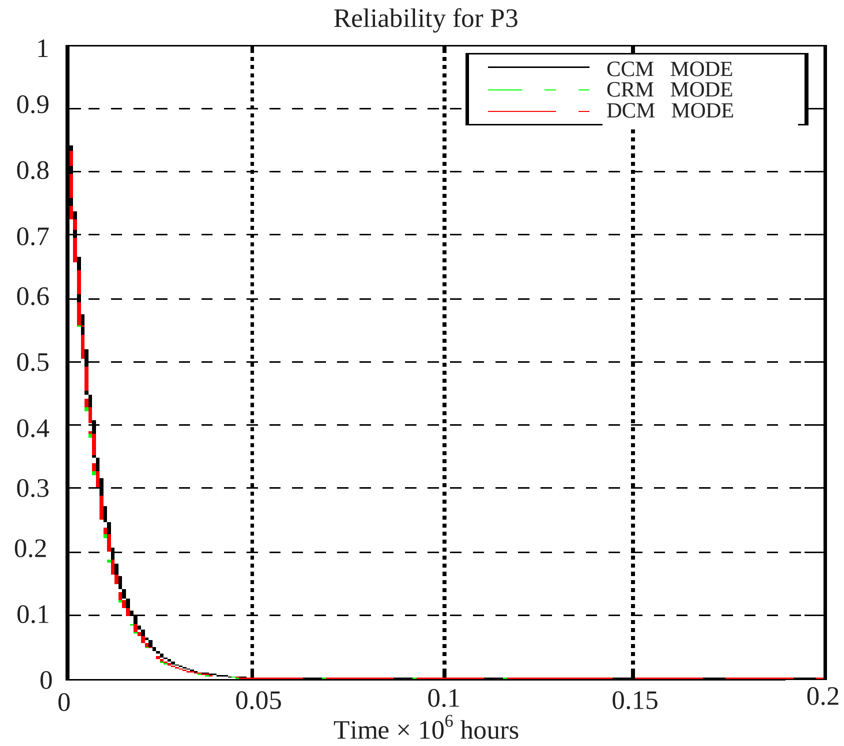

Fig9. Reliability curves parallel chopper for the three powers and the three firing modes (a) For P1; (b) for P2; (c) for P3.

4.3. Analysis of results

The graphs in Figure 9 show the reliability of the three modes in three powers

From the results shown in Table 4, we observe the following:

- The parallel converter "Boost" has the best reliability for continuous conduction mode "CCM" by comparing with batch modes "DCM" and critical "CRM".
- Most of the failure rate for the three firing modes is presented at the switches, the MOSFET and the diode. Then, we must give the more interesting.
- The reliability of the two modes "CRM" and "DCM" resembles that of "CC :" mode when the power increases,
- Reliability decreases with increasing power, but the "CCM" mode still has the best reliability in comparison with the other two modes "CRM" and "DCM".
- The temperature factor has a major responsibility to increase the failure rate for all modes of conduction.

We can explain the observations noted above by:

- The decrease in the reliability of the three modes by increasing power is due to increased losses from conduction and because of the switching of the boost current.

Low failure rate of capacitors and inductor are due to the absence of the series resistors, which can cause significant losses and increase the temperature around the components

5. The converter Cúk

The block diagram of Cuk converter illustrated in figure 10 [6].

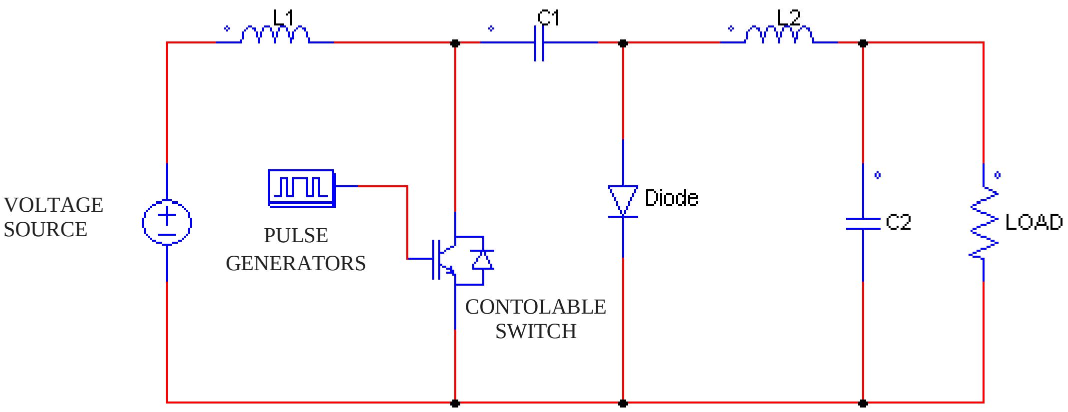

Fig10. The converter Cuk

5.1 Calculating the reliability

We'll have the same characteristics as those of the parallel chopper. Except that, it is necessary to use a MOSFET that supports not only the output voltage but the sum of the two voltages of the input and the output, and also for the storage capacitor must also be capable of withstanding the sum the two voltages. As the diode

Table 3. Reliability calculation converter Cúk

Ta °C]	27											
ΔT	10											
component	power [W]	λ_b	π_A	π_Q	π_E	T_c	T_j	π_T	π_s	π_c	π_{cv}	λ_p [fail/10E6 H]
MOSFET	9156.78	0.012	10	5.5	6	861.34	1119.98	160.42				635.267
	12209.04	0.012	10	5.5	6	1512.47	1972.97	271.14				1073.719
	15261.3	0.012	10	5.5	6	2334.70	3050.09	357.97				1417.563
Diode	9156.78	0.069		5.5	6	167.93	294.77	21.53	0.07	1		3.395
	12209.04	0.069		5.5	6	214.91	384.02	34.12	0.07	1		5.382
	15261.3	0.069		5.5	6	261.88	473.28	48.44	0.07	1		7.640
Capacitor Cs	9156.78	0.0306		30	2						0.407	0.748
	12209.04	0.0306		30	2						0.417	0.765
	15261.3	0.0306		30	2						0.424	0.778
Capacitor C1	9156.78	0.0452		30	2						0.597	1.618
	12209.04	0.0452		30	2						0.610	1.654
	15261.3	0.0452		30	2						0.620	1.683
Inductance L1		0.0005		20	4					1		0.0406
Inductance L2		0.0005		20	4					1		0.0406

The overall failure rate of the system:

Table4. Comparison 3 at powers of the reliability of the converter Cúk

power	P1=9 .156 KW	P2=12.209 KW	P3=15.261 KW
$\lambda_{F(Mosfet)}$	635.267	1073.719	1417.564
$\lambda_{F(Diode)}$	3.396	5.382	7.641
$\lambda_{F(CapacitorC1)}$	1.618	1.655	1.683
$\lambda_{F(Capacitor\ C2)}$	0.748	0.765	0.779
$\lambda_{F(inductance\ L1)}$	0.041	0.041	0.041
$\lambda_{F(inductance\ L1)}$	0.041	0.041	0.041
λ_F total	641.111	1081.602	1427.748
MTBF (heures)	15597.927	9245.543	7004.039

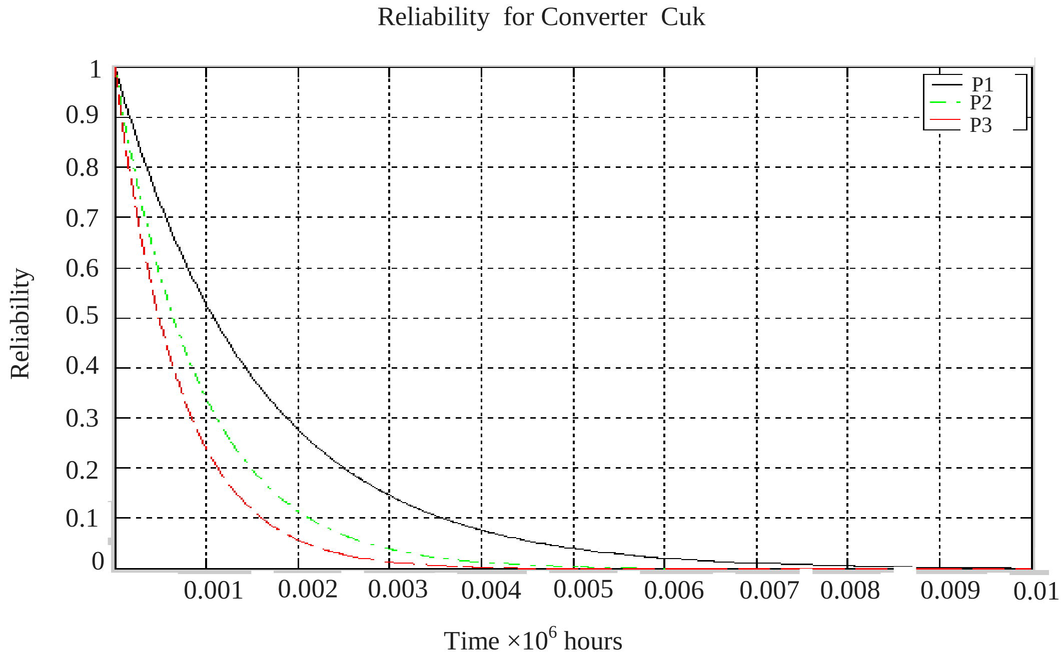

Fig11. Curves reliability chopper for three powers CuK

5.2 Analysis of results

According to Figure 11 we see that the reliability of the converter decreases with increasing power, and from Table 4, the rate of failure is the major MOSFET, this increase in failure rate up to switching losses and at conduction MOSFET subjected to the sum of the input and output currents which causes extremely high losses.

6. Comparaison between the two choppers

We will make a comparison between the two choppers, to see which type is more reliable for the same powers. As shown in Figure 12, the chopper has the best reliability parallel with respect to the chopper Cuk, but the degradation in reliability of the power function is slower for the chopper CuK that parallel chopper.

This difference in reliability up to the complexity of the configuration of the chopper by Cuk against the parallel chopper is very simple and does not include many elements; the complexity decreases the reliability of the system, because the complexity increases the likelihood of breaking down. And although the chopper can operate as CUK or lift-down voltage, and it serves to isolate the input of the output using the capacitive storage to transfer electrical energy to the load, but it causes losses at significant power MOSFET and the diode.

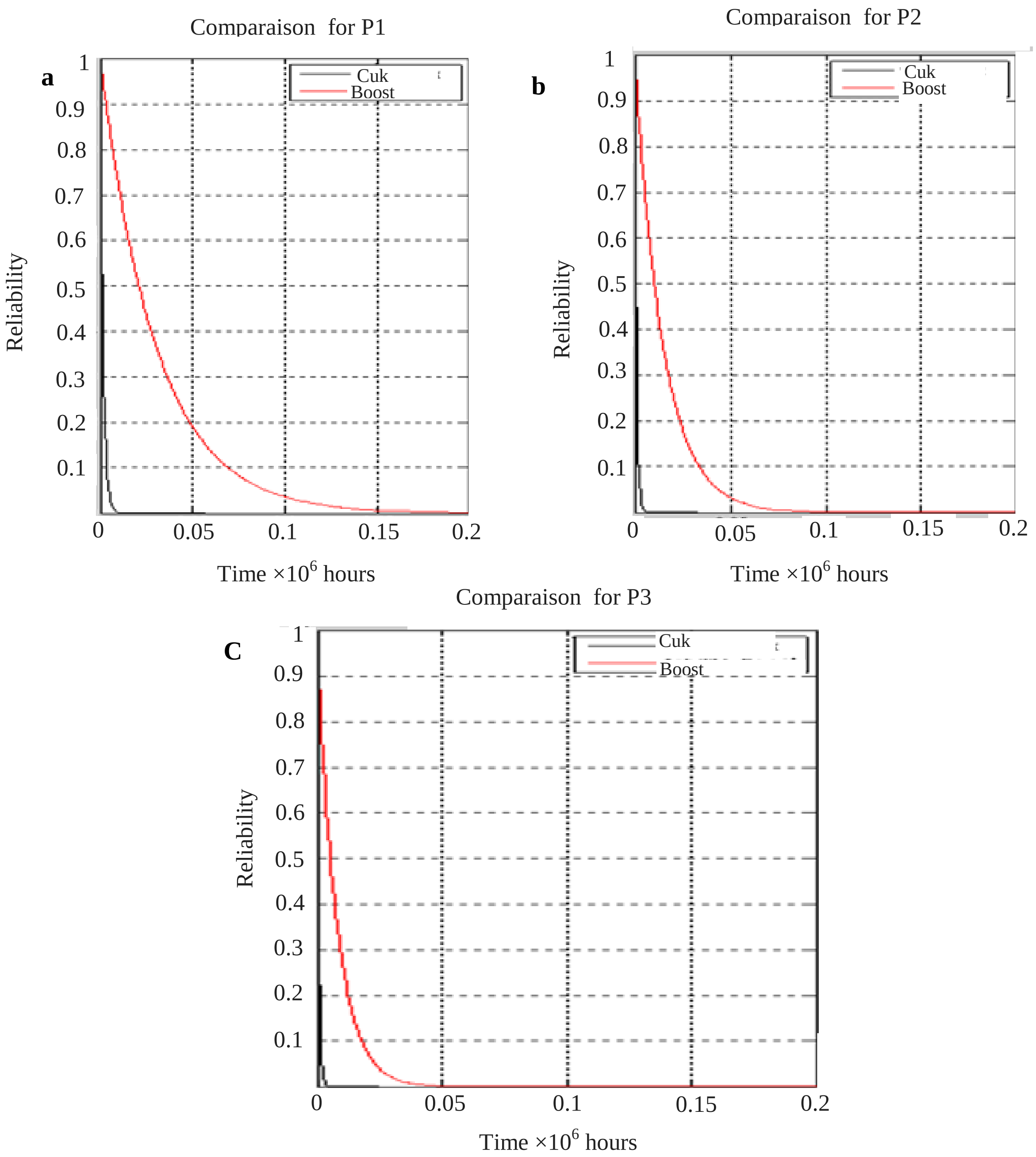

Fig12. Comparison of the reliability of the parallel chopper "Boost" and the chopper Cuk. (a) For P1; (b) For P2; (c) For P3

7. Conclusion

We calculated the reliability of the two choppers, parallel and Cuk, using MIL-HDBK-217-F, to show what kind of chopper has the best reliability for operation as MPPT.

From what has been obtained by calculations, we can say that the use of the chopper in the Cuk Photovoltaic field operated as MPPT, or we try to extract the maximum power from the PV modules is not recommended due to the presence of significant losses in the switching and conduction, to its composition and also increasing the probability of breaking down and, consequently, reduce reliability, As against the parallel chopper "Boost" has good reliability, as it uses a simple configuration, and also, less switching losses and conduction by comparing the chopper Cuk.

The use of parallel chopper CCM mode is recommended, and the other two firing modes (DCM and CRM) remain for special purposes, but not to function as a MPPT.

References:

[1] Stéphane VIGHETTI. Systèmes photovoltaïques raccordés au réseau : Choix et dimensionnement des étages de conversion. L'Institut polytechnique de Grenoble 2010.

[2] Jie Liu, Norbert Henze. Reliability consideration of low-power grid-tied inverter for photovoltaic application. Fraunhofer Institut für Windenergie und Energiesystemtechnik IWES Königstor 59, D-34119, Kassel, Germany 2010

[3]- Keng C. Wu « Switch-Mode Power Converters Design and Analysis », ELSEVIER presse académique 2006.

[4] Michel Pinard .CONVERTISSEURS ET ÉLECTRONIQUE DE PUISSANCE. Dunod, Paris, 2007.

[5] MLI-hdbk 217F

[6] S. Cuk, R. D. Middlebrook "A New Optimum Topology Switching DC-TO-DC " , IEEE Power Electronics Splist Conference June 14-16,1977, Palo Alto CA.