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Art Leitherer

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New solid-state static frequency converters (SSC) can be used in place of motor-generator sets to produce 400-Hertz (Hz) power more efficiently. All government installations that use, repair, or build electronic components for aircraft or ships use 400-Hz power. Overall, SSCs can save 20 to 25 percent of the required input power for existing motor-generator (MG) sets used for 400-Hz power generation. In most cases, SSCs are cost effective in both new installations and in the replacement of existing MG sets.

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TechData Sheet

Naval Facilities Engineering Service Center
Port Hueneme, California 93043-4328

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Solid State Frequency Converters

New solid-state static frequency converters (SSC) can be used in place of motor-generator sets to produce 400-Hertz (Hz) power more efficiently. All government installations that use, repair, or build electronic components for aircraft or ships use 400-Hz power. Overall, SSCs can save 20 to 25 percent of the required input power for existing motor-generator (MG) sets used for 400-Hz power generation. In most cases, SSCs are cost effective in both new installations and in the replacement of existing MG sets.

MG sets consist of two main components: the **motor** and the **generator**. The conversion process starts with 60-Hz AC input power to a motor. The motor converts electrical energy to mechanical energy via the shaft, which turns a generator. The generator then converts the mechanical energy back to electrical energy but at 400 Hz; this power is finally supplied to the load. Energy losses occur in both the motor and generator due to heat, windage, and friction.

The SSC is an electronic device and has no moving parts. The main components are the **rectifier** and the **inverter**. The rectifier converts 60-Hz AC input power to DC and then the inverter delivers 400-Hz AC power to the load. This electronic design is inherently more efficient than the mechanical process used by MG sets.

Most SSCs are approximately 20 percent more efficient than equivalent MG sets. SSC full load efficiencies range from 90 percent for units rated less than 50 kVA to over 95 percent for units over 100 kVA. Synchronous MG sets have an average full load efficiency in the range of 70 to 80 percent, while induction MG sets have full load efficiencies in the 65 to 75 percent range. Like SSCs, an MG set's efficiency decreases when the percent load decreases. Figure 1 shows typical efficiency versus percent load curves for all three types of converters.

The savings from an MG set to SSC change-out can be calculated from the output power requirements and the percent load on the existing MG sets. The Naval Facilities Engineering Service Center (NFESC) has developed a spreadsheet to calculate the energy savings, the dollar savings, the savings to investment ratio (SIR) and the simple payback of an SSC retrofit. Figure 2 shows sample output from the spreadsheet using 120-kVA data.

Calculations are based on input from the user or default values in the spreadsheet. Required data includes:

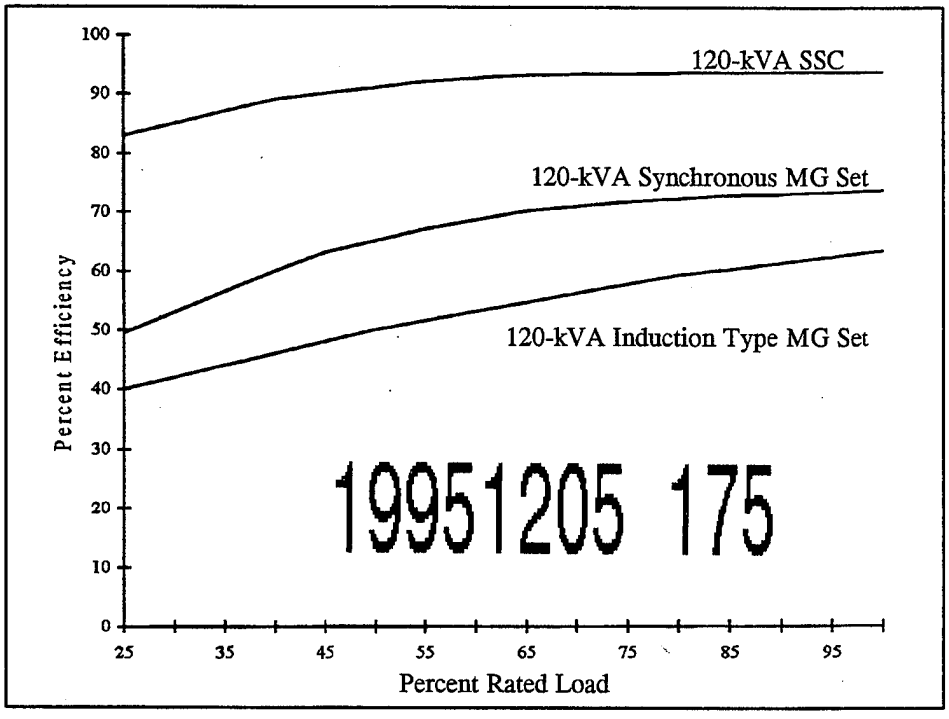

Figure 1. Efficiency versus percent load for MG sets and SSCs.

- Operating hours
- MG output size
- Converter output size
- Load efficiencies for both the MG set and the static converter
- Utility rates
- Maintenance costs
- Percent load information

A survey sheet supplied with the spreadsheet can be used to collect data while at the MG set location.

Figure 3 shows the typical payback periods for converting a 120-kVA synchronous MG set and a 120-kVA induction MG set with a 120-kVA SSC. Figure 3 was made assuming 4,160 annual operating hours (two 8-hour shifts for 52 weeks), default maintenance values, and no demand savings. For higher capacity (higher kVA units) retrofits will generally yield shorter payback periods. Figure 3 is a useful "first-run" analysis to see if you should investigate the retrofit further. Keep in mind that rebates or incentives from utility companies will lower initial costs and decrease the payback. Contact your local utility company for more information.

If after reviewing the above information you feel you have a feasible project and would like to investigate the subject further, contact the NFESC, Code ESC22, for a copy of the spreadsheet. If you choose to submit a project for funding, the NFESC can also supply a sample project submittal for converting MG sets to SSCs. If you have further questions regarding the project submission process, contact your local EFD.

More information on SSCs can also be found in NFGS-16306 and MIL-HDBK-1028/6. These specifications are particularly useful when procuring an SSC.

MG/Static Converter Replacement (V3.2) Site: Sample

	Assumptions	Detail:			Converter Costs
1	MG Output Size, KVA	120	11	Converter Size, KVA	120
2	MG Full Load Eff. %	63	12	Converter Full Load Eff. %	92
3	MG 80% Load Efficiency	60	13	Converter 80% Load Efficiency	91
4	MG 60% Load Efficiency	53	14	Converter 60% Load Efficiency	90
5	MG 40% Load Efficiency	47	15	Converter 40% Load Efficiency	88
6	MG 20% Load Efficiency	40	16	Converter 20% Load Efficiency	86
7	MG NL Losses%FLKVA	28	17	Converter NL Losses %	5
8			18	Converter Cost	$51,800
9			19	Converter Installation Cost	$3,626
10			20	Converter Engineering cost	$3,326

		MG			
21	Annual Operation Hours	4160	31	Converter Life, Years	20
22	% Time at 100% Load	5	32	SIR Evaluation, years	20
23	% Time at 80% Load	10	33	Discount rate, %	3
24	% Time at 60% Load	15	34	Electrical Energy Rate ($/KWH)	0.07
25	% Time at 40% Load	20	35	Investment UPW	0.98
26	% Time at 20% Load	25	36	Annual Savings UPW	14.88
27	% Time at 0% Load	25	37	Electrical Demand Rate ($/KW)	$8.00
28	Annual MG Maintenance ($)	$559	38	Annual Converter Maintenance ($)	$216
29			39		
30			40		

	Calculations	KWH	$$$		Summary	
41	KWH Savings @100%	12489	$874	51	Annual Energy/Demand Savings	$17,782
42	KWH Savings @80%	22674	$1,587	52	Annual Maintenance (+/-)	$343
43	KWH Savings @60%	34850	$2,439	53	Investment Cost	$58,752
44	KWH Savings @40%	39588	$2,771	54	Investment Present Worth	$57,577
45	KWH Savings @20%	33377	$2,336	55	Savings Present Worth	$269,696
46	KWH Savings @0%	28704	$2,009	56		
47	Annual SavingsTotals (KWH)	171682	$12,018	57	SIR:	4.68
48	KW Savings (KW)	60	$5,764	58	Simple Payback (Years)	3.24

Figure 2. Sample output from NFESC 400 Hz MG/Static Converter Spreadsheet Version 3.2.

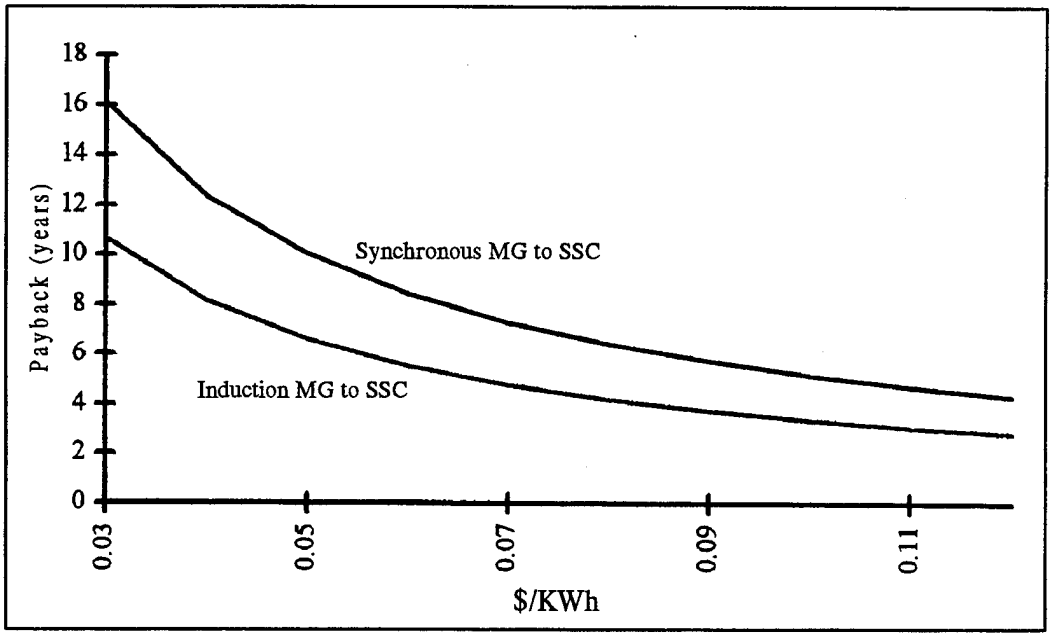

Figure 3. Payback for 120-kVA SSC retrofits.

If you have any questions regarding this technology, contact:

Mr. Art Leitherer
NFESC Code ESC22
Comm: (805) 982-9594 or DSN: 551-9594

or

Mr. Adam Bartleson
NFESC Code ESC23
Comm: (805) 982-3902 or DSN: 551-3902