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MicroSolar Learning Initiative

Galápagos Archipelago, Ecuador.

Grid Tied Photovoltaic System

I: Features

System power: 3 KW

Number of panels: 55 (Siemens SM55)

DC system voltage: 48 V

Grid Tied Inverter/Battery Charger: Outback GTFX3048

Charge controller: Outback MX60

Batteries Capacity (minimum): 100 Ah

AC input: 120 VAC

AC output: 120 VAC

II: Parts List

Component	Qty	Model
Solar Panels Main Features: Rated Power: 55 Watts Current I_{MPP}: 3.15 A Voltage V_{MPP}: 17.4 V Short Circuit current I_{SC}: 3.45 A Open Circuit Voltage V_{OC}: 21.7 V NOCT: 45 ∀ 2 ^{o}C P_{MPP} (NOCT): 40 W Temperature coefficient (α P_{MPP}): -0.45% / ^{o}C Approximate net surface area: ~24 m^2 – 258 sq ft (56 panels)	**56**	SM55 Siemens
Grid-Tied Inverter and Battery Charger Main Features: Sealed, external fan for cooling the case. 48 VDC systems (40-66 VDC range) Nominal Power: 3000 VA Nominal DC input current: 70 A (150 A max) AC input voltage range: 90 – 150 VAC	**1**	Outback GTFX 3048

Maximum AC input current: 60 A (Battery charging + Load) Maximum AC input current for battery charging: 16 A @120 VAC Maximum AC output current: 70 A @ 120 VAC (160 miliseconds) Automatic Control: Automatic transfer AC relay Anti-Islanding protection: Passive: in-Line Voltage and Frequency monitoring. UL1741 table 46.1 (see end of document)		
Charge Controller Main Features: Menu in Spanish (ES model) Maximum Power Point Track controller Battery voltage: 12, 24, 48 or 60 VDC (adjustable) PV open circuit voltage: 150 VDC Maximum DC input current: 60 A Temperature compensation (with sensor) Voltage step down capability	**1**	Outback MX-ES-60
Batteries Minimum: 100 Ah @ 48 VDC		
Control Devices MATE Device for configuration, control and display for the inverter and charge controller. Temperature sensor for batteries	**1** **1**	Outback MATE

III: Preliminary Design

a): Solar Radiation and Monthly Energy Generation

Galapagos Archipelago ~ 1^o S 90^o W

Solar radiation data from year 2005 (www.rmeter.com)

Table 1: Peak solar hours and monthly daily mean irradiation

Month	$G_{d,m}$ [kWh/m^2]	G_m [kWh/m^2]	PSH [hr per month]	E_m [kWh]
January				

February				
March				
April				
May				
June				
July				
August				
September				
October				
November				
December				

PSH = peak solar hours (equal to the length of an equivalent day with a constant irradiance of 1 kW/m^2)

$G_{d,m}$ = Monthly daily mean irradiation.

G_m = Monthly mean irradiation.

E_m = Monthly energy = $m \times PSH \times P_o$

Where m = number of days of the month

P_o = Nominal array power = 3080 W

Table 2: Power rate compensated by temperature

Month	T_a [^oC]	T_c [^oC]	I_{MPP}* [A]	V_{MPP}* [V]	P_o* [W]	E_m* [kWh]
January						
February						
March						
April						
May						
June						
July						
August						
September						
October						
November						
December						

Ta = ambient temperature (monthly average)

T_c = cell temperature = $T_a + \frac{NOCT - 20}{800} G_{d,m}$

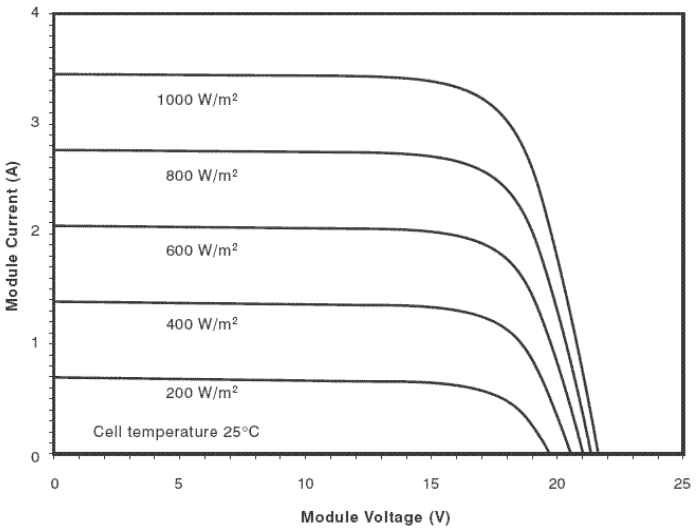
NOTC = 45 ^oC

I_{MPP}* = Estimated from graph 1

V_{MPP}* = Estimated from graph 1

P_o* = { (I_{MPP}*)(V_{MPP}*) - (0.0045 P_{MPP}*)(T_c – 25) } × 56

Graph 1: Solar Module performance at different irradiance levels:



b): Orientation

Two main factors are considered in the tilt angle of the photovoltaic panels:

i: Holiday season is January through March so there is little use of the system.

ii: According to table 1, the tilted is optimized for the worst radiation months.

The tilt suggested for any location is:

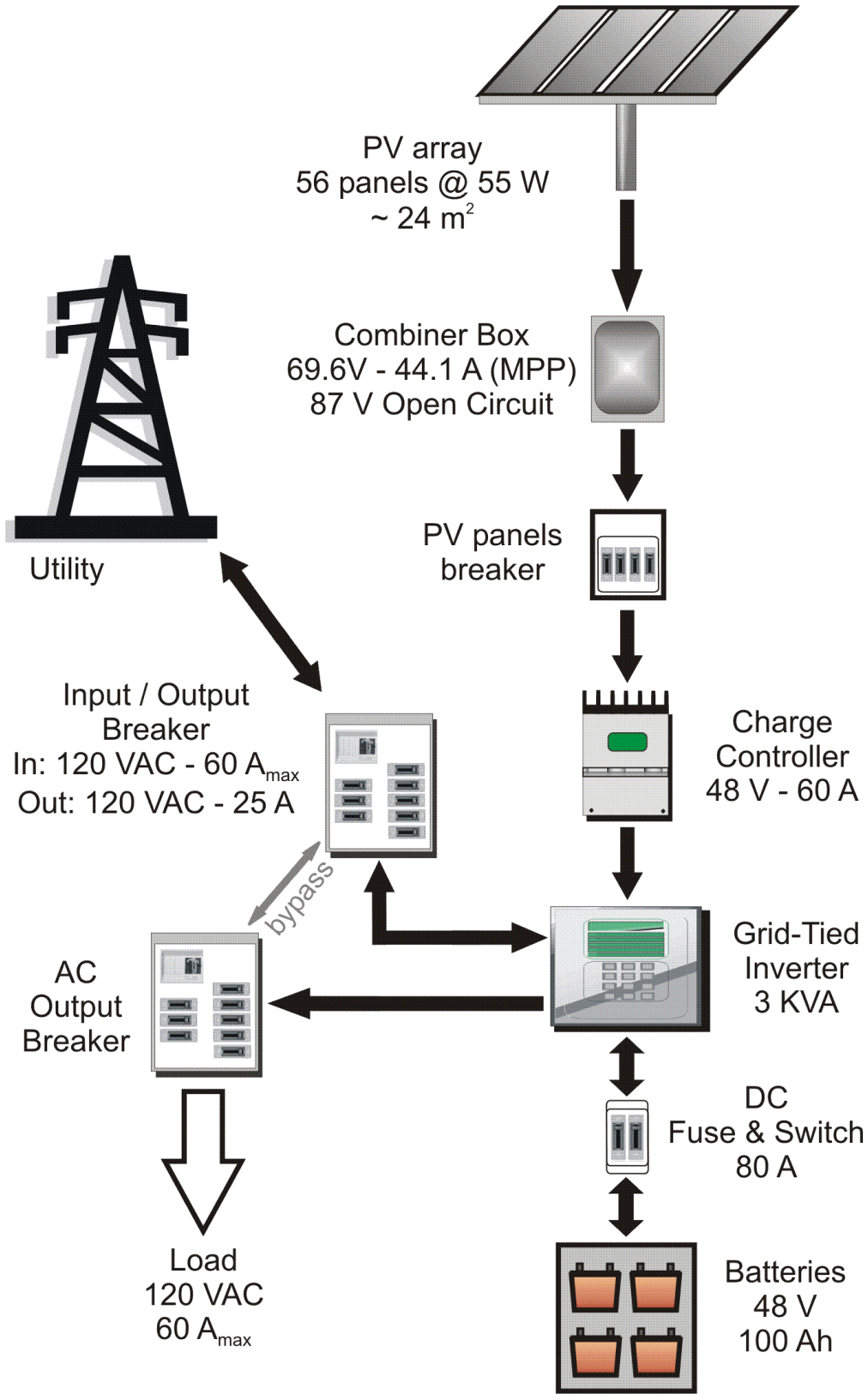
c): Connection

Series – Parallel connections: 14 arrays in parallel. Each array is 4 panels series connected.

Voltage per array at Maximum Power Point (STC): 69.6 V (STC)

Total current at Maximum Power Point (STC): 44.1 A

IV: Schematic



V: Electric Diagram

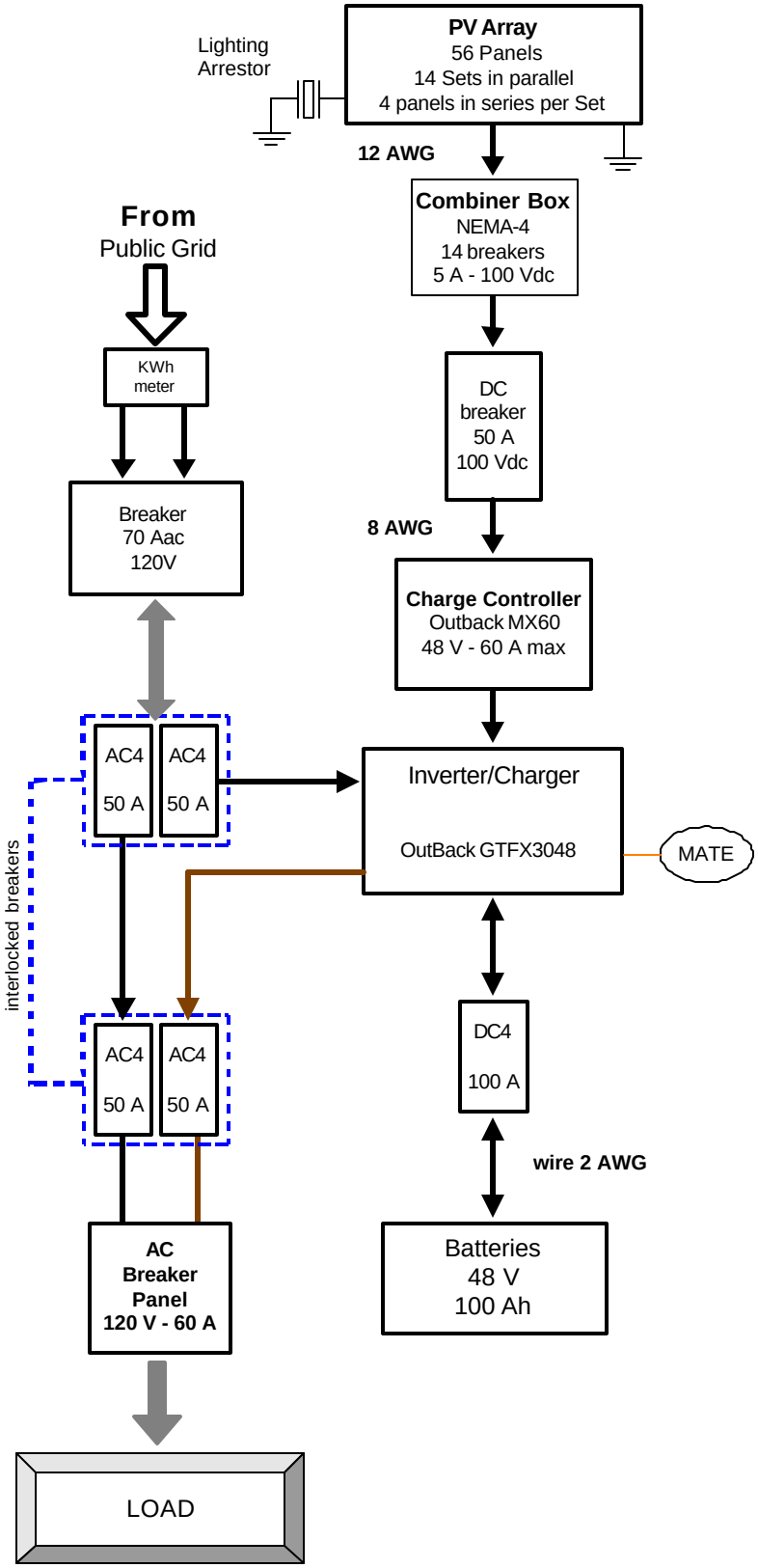


Table 46.1

Condition	Voltage V	Frequency Hz	Max time seconds	(cycles)
A	0.5Vnor (b)	rated	0.1	(6)
B	0.5Vnor<V<0.88Vnor	rated	2	(120)
C	0.88Vnor<Vnor<1.1Vnor	rated	(c)	(c)
D	1.1Vnor<V<1.37Vnor	rated	2	(120)
E	1.37Vnor<Vnor<V	rated	2/60	(2)
F	rated	f<rated-0.7 (d)	0.1	(6)
G	rated	f<rated+0.5 (d)	0.1	(6)

(b) Vnor is the nominal output voltage rating.
(c) Normal operating range, no cessation required.
(d) The rate of change in frequency shall be less than 0.5 Hz per second.