Photovoltaic (PV) System Acceptance Test Report

The PV system acceptance test is conducted by Eternax Solar, based on the guidelines from the California Energy Commission (CEC). The purpose of the test is to verify an efficient and complete installation and proper system performance.

1. System Summary:

System description:	355kW (DC) Ground-mounted PV system with 1-axis Tracker
System location:	Cochise College, 4190 W. Hwy. 80, Douglas, AZ 85607
System coordinates:	31° 22', -109° 41'
System size:	355.320 KW [DC, STC rated], 312.088kW [AC, CEC rated]
PV modules:	1512 Sharp NU-U235F1 235W modules, single crystalline
PV array:	Bi-polarity array, 14 modules per string, 108 strings in parallel, with 54 strings for each polarity
PV inverter:	1 Advanced Energy Solaron 333kW inverter [480VAC]
PV tracker:	TTI Sunseeker single–axis tracker
Step up/down transformer:	Cooper B-line 336kVA transformers, 480 to 12,470 V
PV monitoring:	Energy Recommerce meters and weather station

2. Testing Equipment

   The testing equipment is a Solar 300 PV tester from Hukseflux, USA, equipped with pyranometer and temperature sensors to measure solar irradiance and solar module and environmental temperatures.

3. System Performance Test:

   a. Weather condition during testing: Sunny, cloudless

   b. Solar module parameters (Sharp NU-U235F1)

Maximum Power (Pmax)*	235 W
Open Circuit Voltage (Voc)	37.0 V
Maximum Power Voltage (Vpm)	30.0 V
Short Circuit Current (Isc)	8.60 A
Maximum Power Current (Ipm)	7.84 A
Module Efficiency (%)	14.4%
Maximum System (DC) Voltage	600 V
Series Fuse Rating	15 A
NOCT	47.5°C

Temperature Coefficient (Pmax) -0.485%/°C
Temperature Coefficient (Voc) -0.351%/°C
Temperature Coefficient (lsc) 0.053%/°C
*Measured at (STC) Standard Test Conditions: 25°C, 1 kW/m2 insolation, AM 1.5

c. Environmental parameters measurement at solar field

Solar irradiance	(Irr)	986	W/m^2
PV module Temp	(TC)	52.9	°C
Environment Temp	(TE)	34.4	°C

d. PV string performance test

String nominal power (Pnom)	3290 W
String power loss due to Temp	(52.9-25)*-0.485% = -13.53%
Expected DC string power output	2805.03 W
Expected string efficiency	86.47%
Measured average string current (Istring)	7.76 A
Measured average string voltage (Vstring)	352.35 V
Average string DC power output (Pstring)	2733.26 W
Measured string efficiency	84.26%

The string voltage was actually measured at PV re-combiner box. Therefore, the measured value will be slightly lower than the actual value, due to the DC voltage drop over copper cable runs from DC disconnect/combiner boxes to re-combiner boxes. This is why the measured string power is less than the expected value. Estimated power loss over DC cable runs is about 71.77 W, which accounts for 2.21% efficiency loss.

e. PV array (DC) performance test
There are a total of 6 output channels of PV bi-polarity array, 3 outputs per polarity.

System nominal power	Pnom	355.32	kW
Positive array:			
DC output voltage1	Vdc1	351.4	V
DC output current1	Idc1	131.8	A
DC output power1	Pdc1	46.3	kW
DC output voltage2	Vdc2	352.8	V
DC output current2	Idc2	147.5	A
DC output power2	Pdc2	52.1	kW
DC output voltage3	Vdc3	352.7	V
DC output current3	Idc3	132.7	A
DC output power3	Pdc3	46.9	kW
Subtotal	Pdc,+	145.3	kW
Negative array:			
DC output voltage1	Vdc1	352.5	V

DC output current1	Idc1	144	A
DC output power1	Pdc1	50.7	kW
DC output voltage2	Vdc2	352.1	V
DC output current2	Idc2	132	A
DC output power2	Pdc2	46.6	kW
DC output voltage3	Vdc3	352.6	V
DC output current3	Idc3	133.7	A
DC output power3	Pdc3	47.1	kW
Subtotal	Pdc,-	144.4	kW
Total DC power	Pdc	289.7	kW
Total DC efficiency = Pdc/(Pnom*Irr/1000)		82.69	%

f. PV inverter performance test

System nominal power	Pnom	355.32	kW
AC power measurement	Pac	282.2	kW
AC current phase1	Iac1	328.7	A
AC voltage phase1-2	Vac1-2	495.3	V
AC current phase2	Iac2	332.4	A
AC voltage phase2-3	Vac2-3	490.5	V
AC current phase3	Iac3	329	A
AC voltage phase3-1	Vac3-1	494.9	V
Power factor	pf	1.000	
Total PV field efficiency = Pac/(Pnom*Irr/1000)		80.55	%
AC inverter efficiency = Pac/Pdc		97.41	%

g. Energy Recommerce meter reading
AC power generation was recorded by Energy Recommerce meter after step up/down transformers. The distance between transformers is around 1424 ft.

Meter AC power reading	Pac-meter	274	kW
Power loss between PV field and meter		2.91	%
Total PV system Efficiency = Pac-meter/(Pnom*Irr/1000)		78.21	%

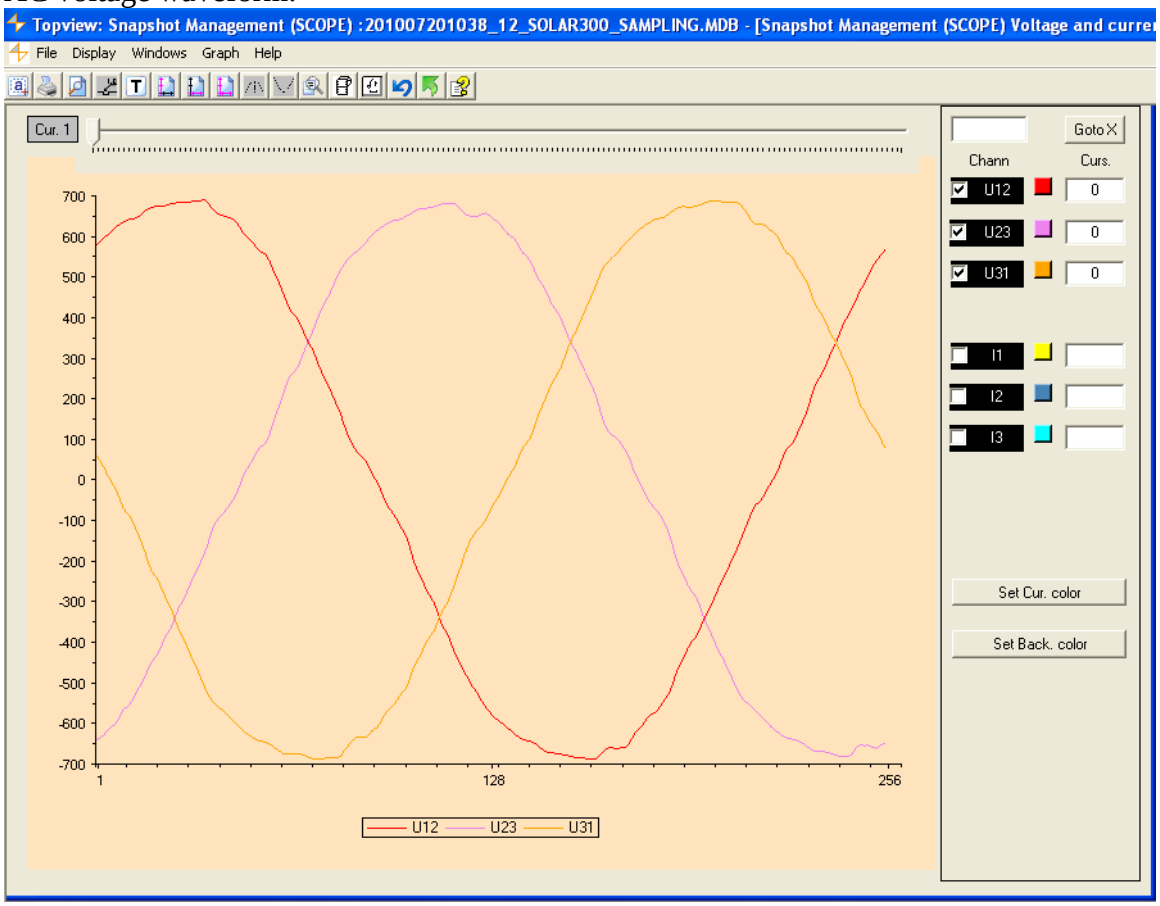
h. Inverter AC output quality measurement:
The quality parameters of AC output of inverter, such as power factor (PF) and total harmonic distortions (THD), were measured. Test results are shown below:

AC output of each phase:

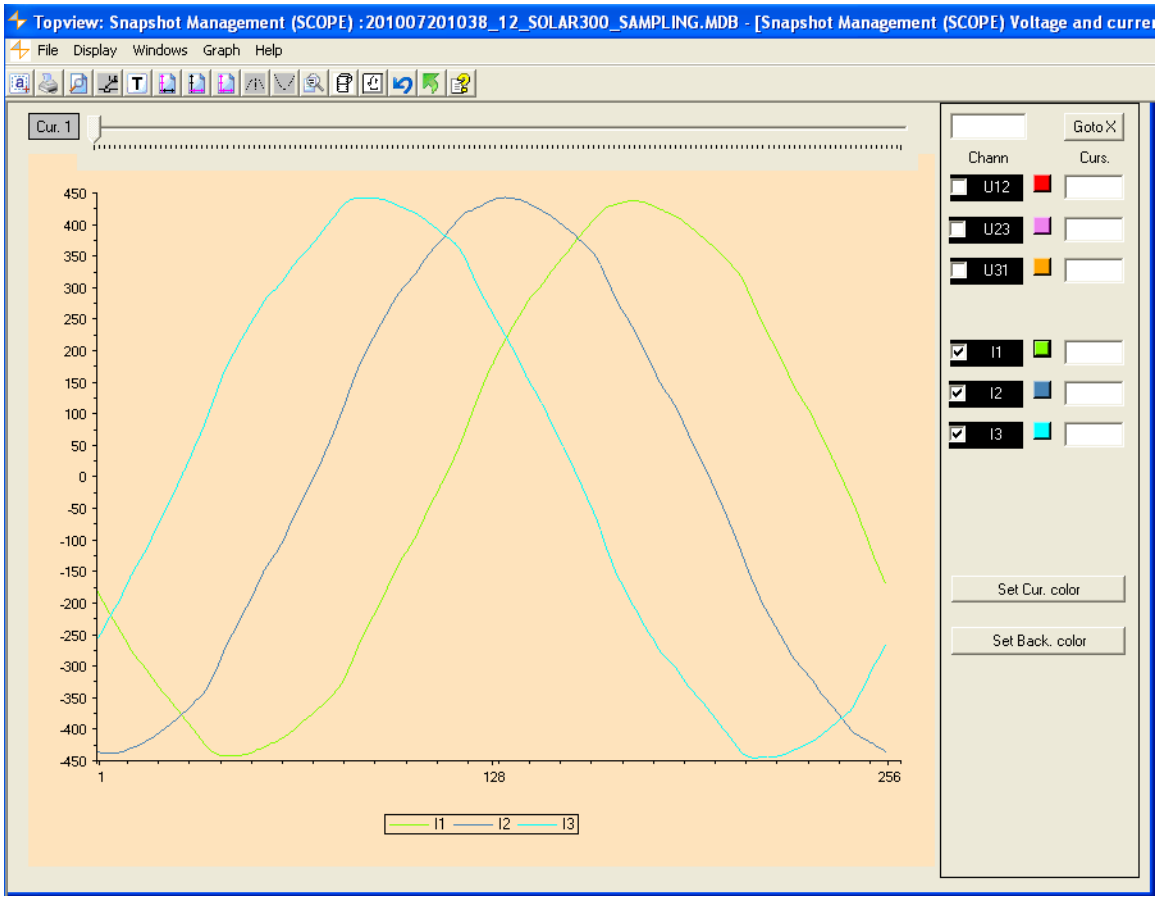
V1_PE	(V)	285.20

V2_PE	(V)	282.53
V3_PE	(V)	282.38
V1_2	(V)	492.65
V2_3	(V)	487.58
V3_1	(V)	492.25
Freq	(Hz)	59.98
I1	(A)	308.98
I2	(A)	311.05
I3	(A)	310.08
PF1		1.00
PF2		1.00
PF3		1.00

AC voltage waveform:

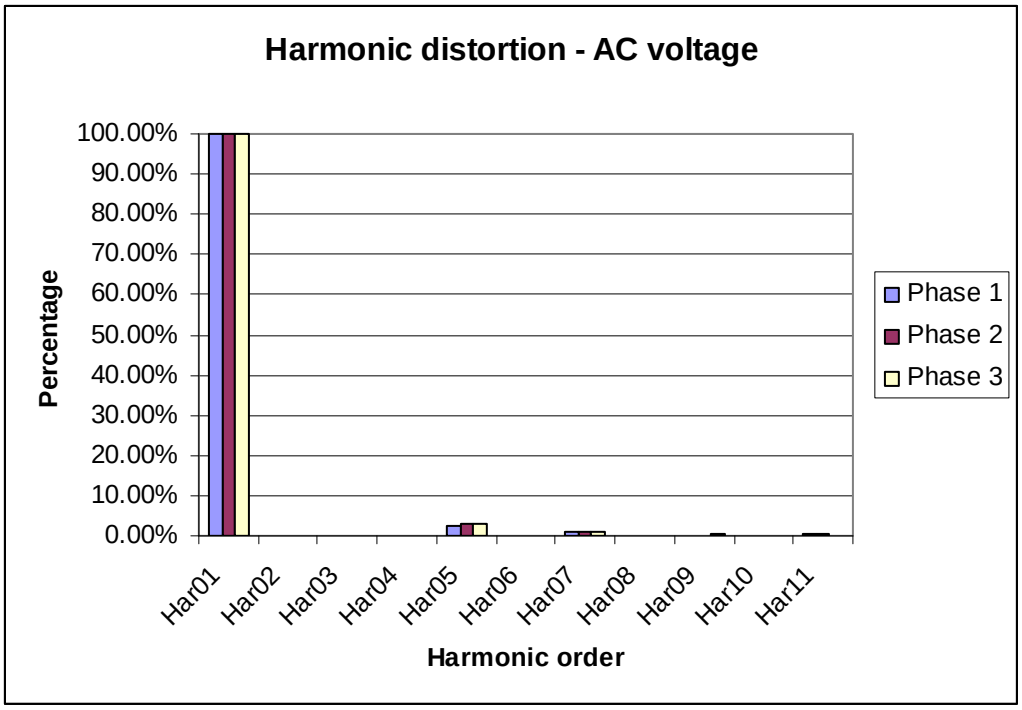


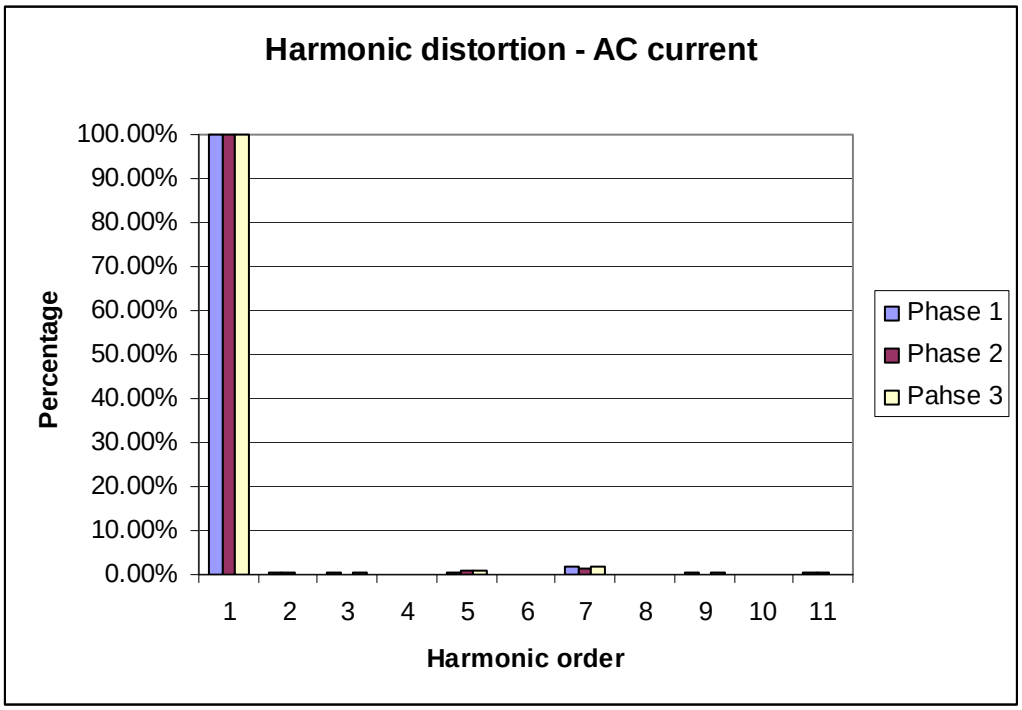
AC current waveform:



Total harmonic distortion (THD) measurement:

	Voltage THD [%]
Phase 1	2.95
Phase 2	3.26
Phase 3	3.24
	Current THD [%}
Phase 1	2.10
Phase 2	1.92
Phase 3	2.38





From the two diagrams above, the majority of the total harmonic distortion is generated at the 5^{th} order for the AC voltage signal and the 7^{th} order for the AC current signal.