

PERFORMANCE COMPARISON SPV Water Pumping Controller

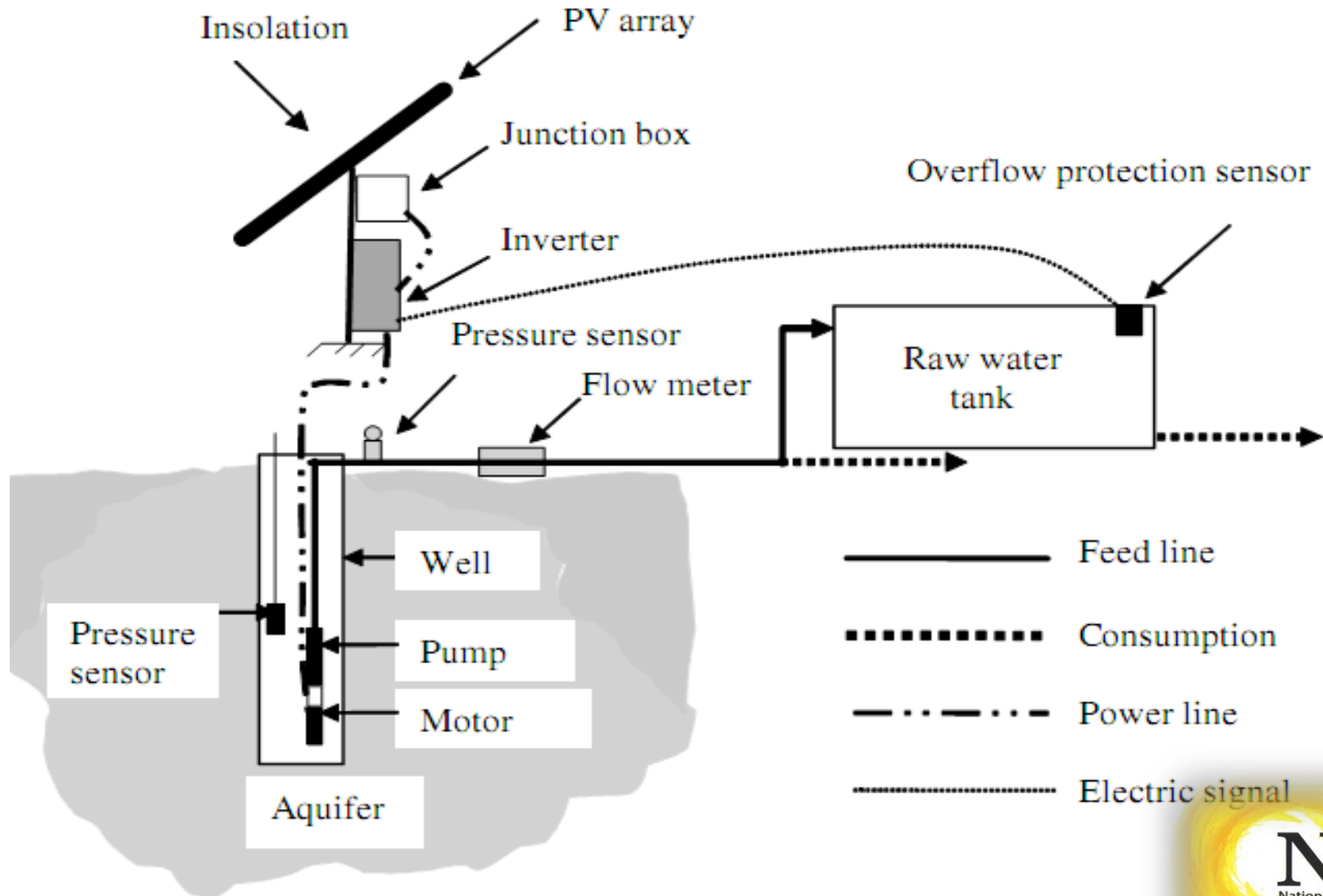


SPV Water Pumping System's components

- **PV Array** : Converts solar energy to DC electrical power .
- **Power Electronics** : MPPT/DC-DC or DC/AC converter, VFD supplies suitable power to drive the Motor and Pump.
- **Motor and Pump**: Component Convert the Power output of the Controller to hydraulic power to lift water
- **Mounting structure (s)**: For PV array can have manual as well as automatic tracking.
- **Storage and distribution system**: Delivers the water to its point of use



General SET-UP of a solar PV Pumping System



PV MODULE ARRAYS

➤ **TECHNOLOGIES:**

Mono or Multi crystalline silicon

Other Suitable PV Technologies : HIT and Maxion© SUN Power

➤ **MOTOR & PUMP CAPACITY:**

1 to 5 HP

7.5 to 10 HP (under development)

➤ **ARRAY CAPACITY:**

200Wp To 5000Wp AT STC

MINIMUM PV MODULE WATTAGE $\geq 74\text{Wp}$

➤ **QUALIFICATION REQUIREMENT(PV Modules):**

IEC 61215/ MODULE DESIGN QUALIFICATION

IEC61730 MODULE SAFETY

IEC 61701 SALT & MIST (WHEREEVER APPLICABLE)



PV MODULE MOUNTING STRUCTURES

➤ **TYPE:**

Fixed Tilt : not advised poor generation

Auto Tracking : most preferred – but technical failures in field??

Manual Tracking : Most Appropriate -3 or 5 times a daily tracking with seasonal adjustment for angle of inclination

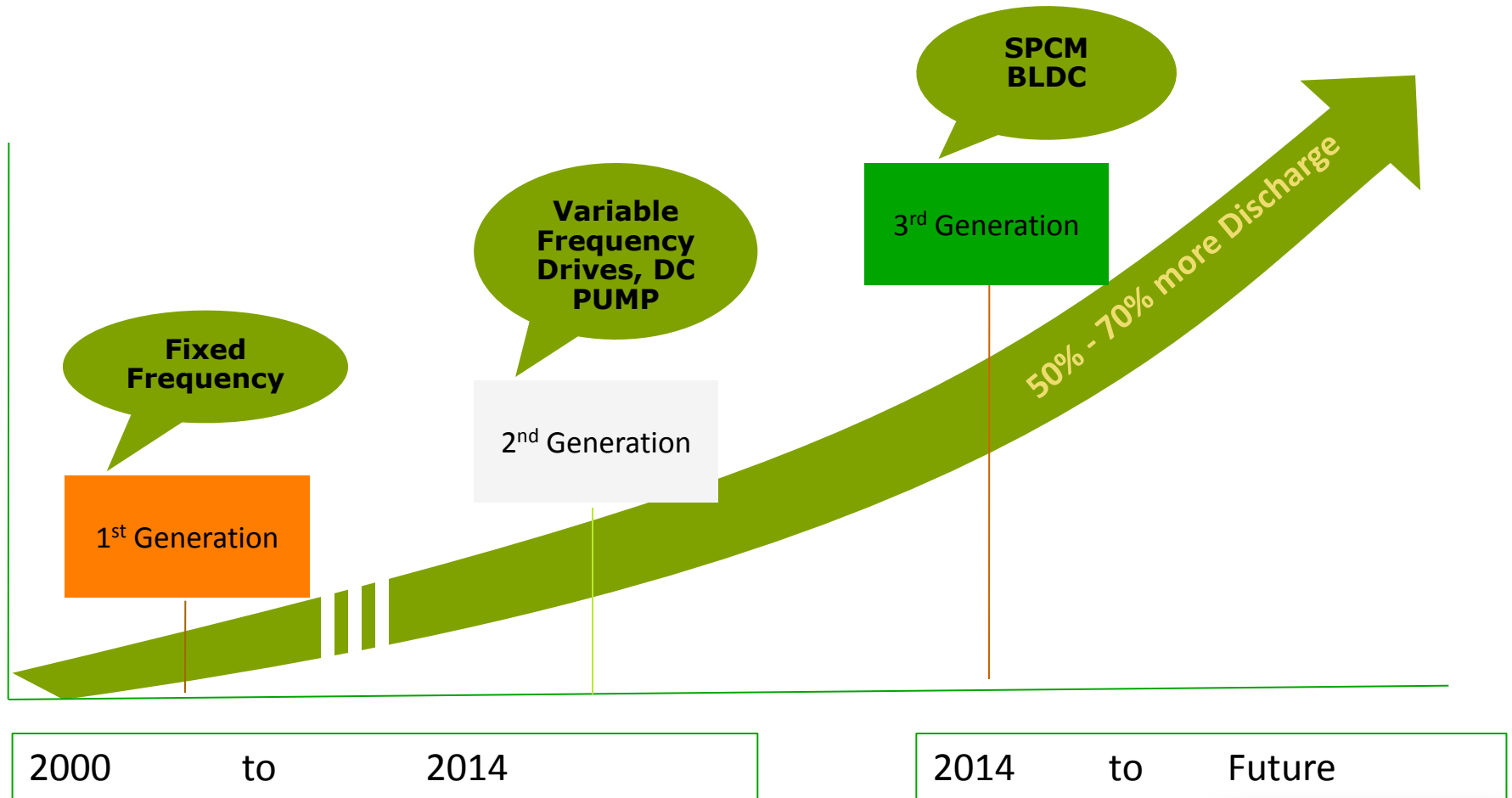
➤ **Material :**

Mild steel OR Hot Dip Galvanized Iron

Withstand wind speeds more than 150km/Hour



Pumps: History in Irrigation



Comparison

- VFD Controller Pump
- BLDC PUMP
- Sinusoidal Pump Controller with MPPT (SPCM)

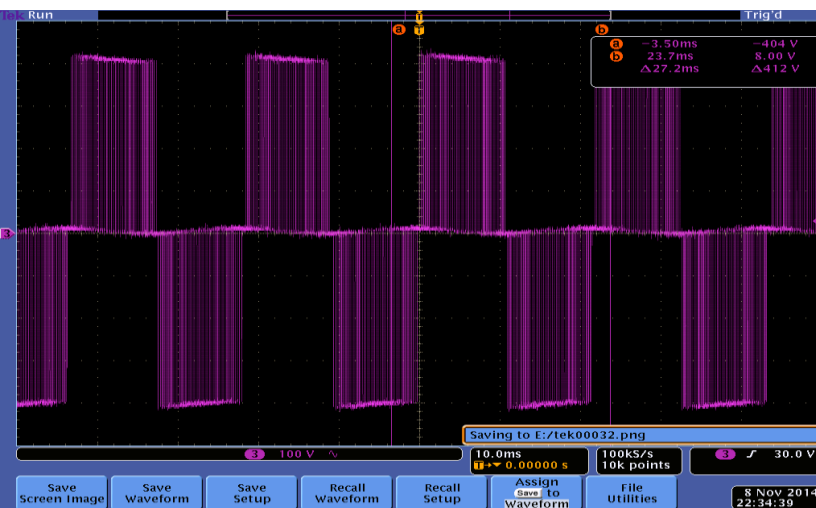


Parameters comparison

- Type of Wave form- Life of the Motor
- Power Point tracked
- Peak wattage performance
- Threshold Wattage
- Over all efficiency



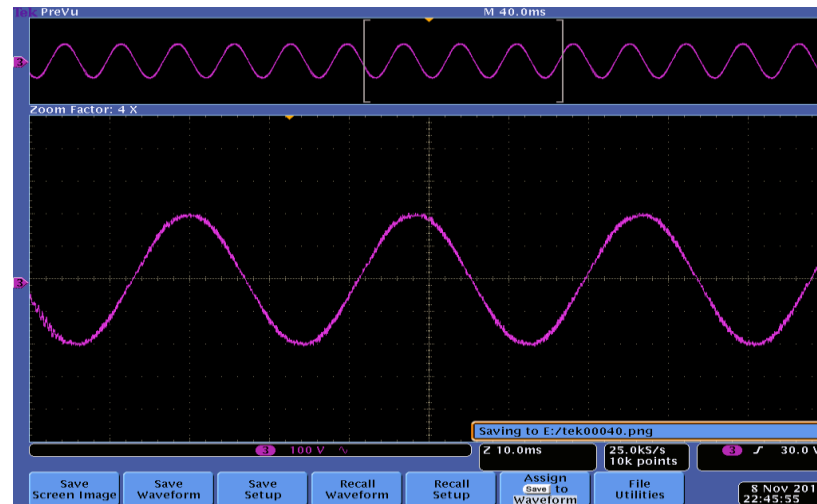
Waveforms at controller terminal (V_P)



VFD Controller
 $V_{thd} < 3\%$



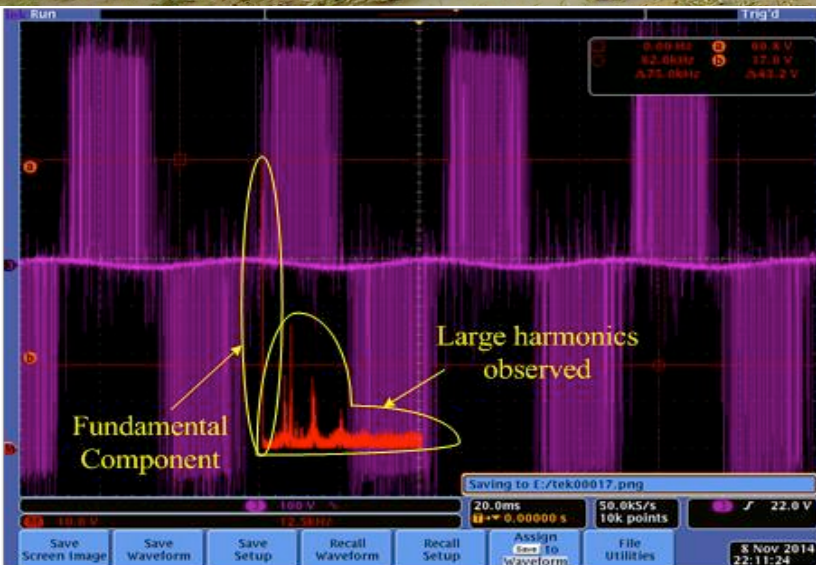
BLDC Controller
 $V_{thd} \approx 45\%$



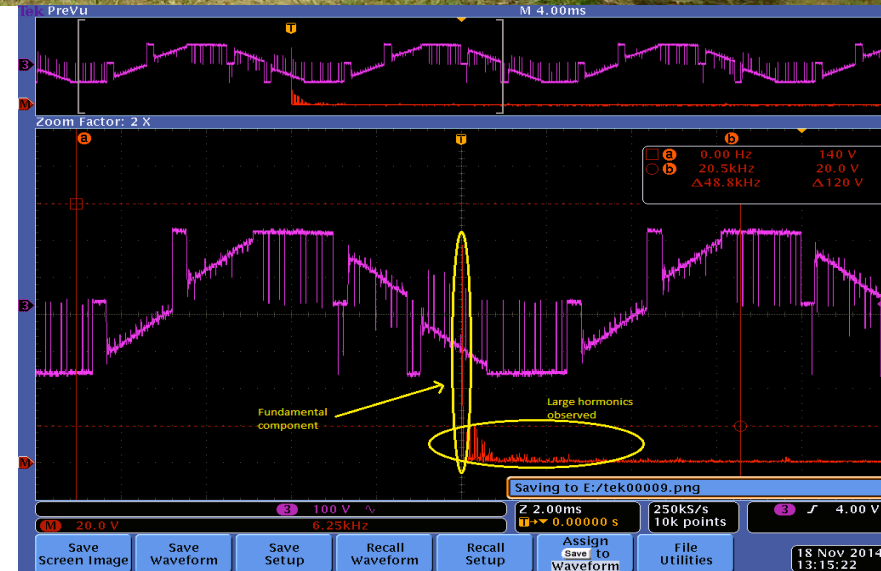
SPCM Controller $V_{thd} < 3\%$



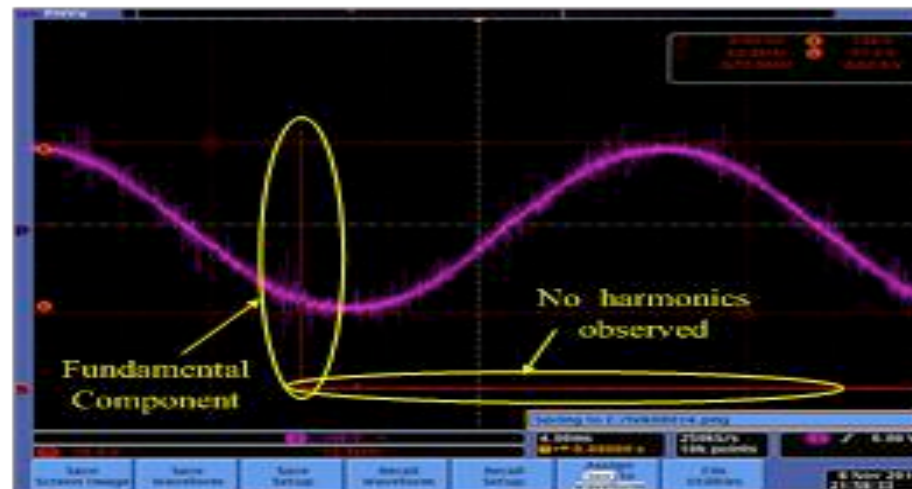
Waveform at Motor terminal, 60 meter cable Showing **fundamental** component and **Large Harmonic contents**



VFD Controller



BLDC Controller



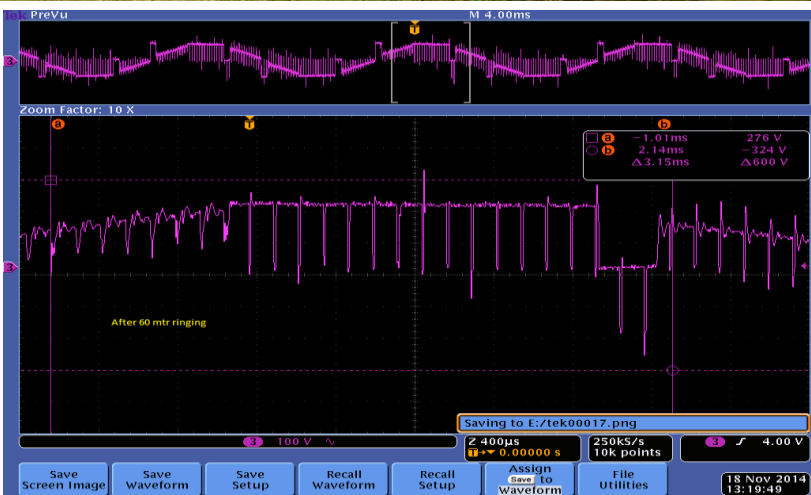
SPCM Controller



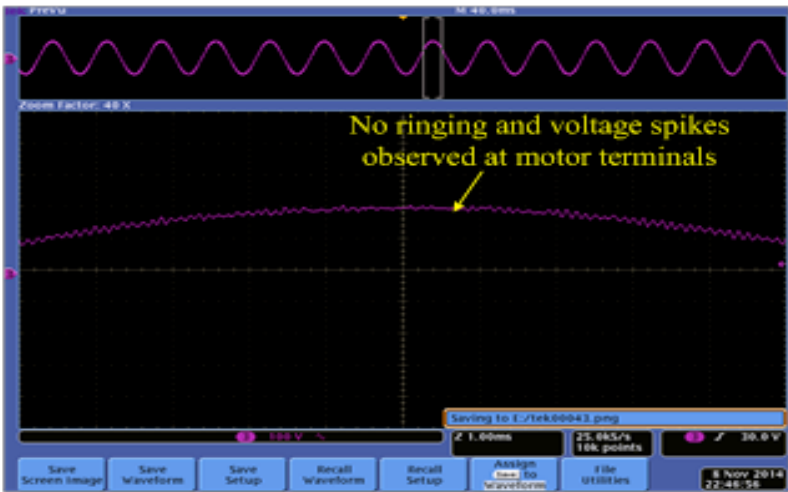
Waveform at Motor terminal, 60 meter cable Showing ringing and large voltage spikes



VFD Controller



BLDC Controller



SPCM Controller



Relation of Waveform With Life of Motor

- The carrier-frequency pulsed output voltage of a PWM VFD causes rapid rise times in these pulses, the transmission line effects of which must be considered. Since the transmission-line impedance of the cable and motor are different, pulses tend to reflect back from the motor terminals into the cable. The resulting voltages can produce overvoltages equal to twice the DC bus voltage or up to 3.1 times the rated line voltage.
- The inductance and capacitance of the cable, the motor and the output circuit of the drive may constitute a resonant circuit that can cause the edges of the voltage pulses to assume an underdamped ringing waveform. Combined with the voltage reflection phenomena, this ringing can result in voltage peaks that are significantly more than twice the bus voltage of the drive. Each voltage peak can cause a small breakdown called a partial discharge (PD) in any air-filled voids in the insulation material. Repeated PD breakdowns gradually destroy the insulation.



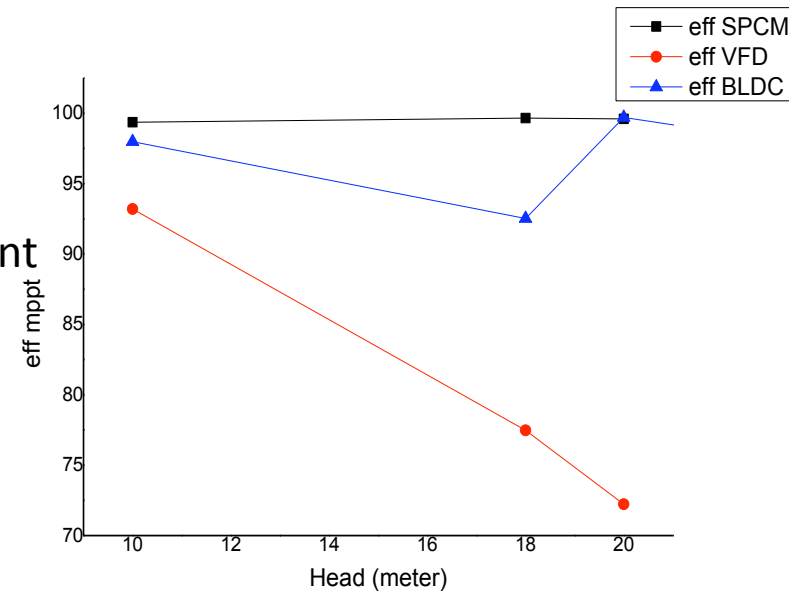
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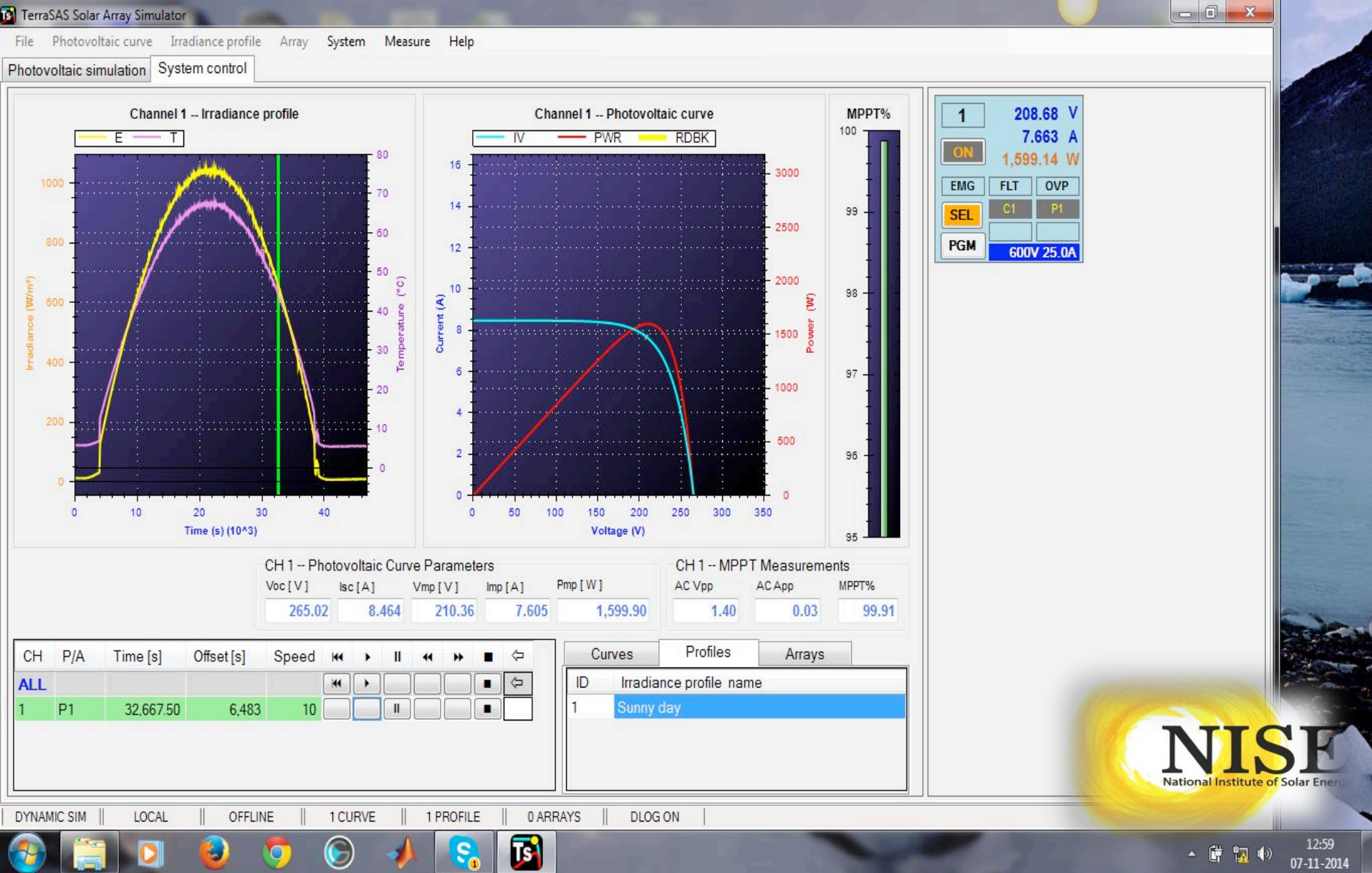
Power Point Tracking Comparison at Different Head

- VFD- with increasing Total Dynamic Head power point tracking goes away from max power Point
- BLDC- MPPT efficiency almost $\geq 97\%$
- SPCM- MPPT efficiency constantly $\geq 99\%$ at every Head



- ❖ VFD without MPPT is losing almost 30% power which is available in module
- ❖ This left 30% power causes unwanted heating in the module, raising the temperature

Tracking Performance at 20Mtr Head for SPCM



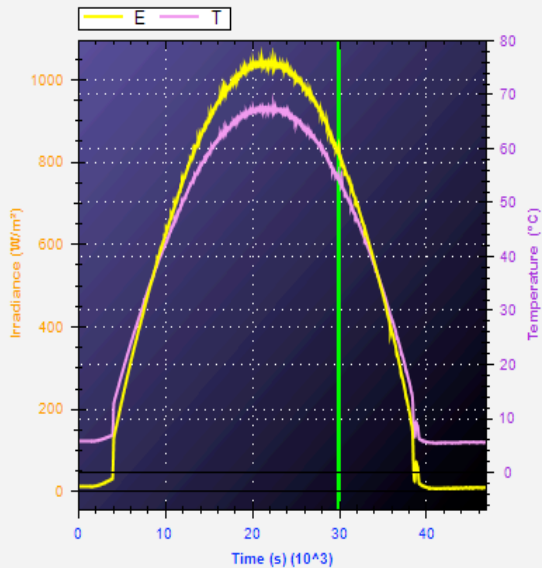
Tracking Performance at 20Mtr Head for VFD

TerraSAS Solar Array Simulator

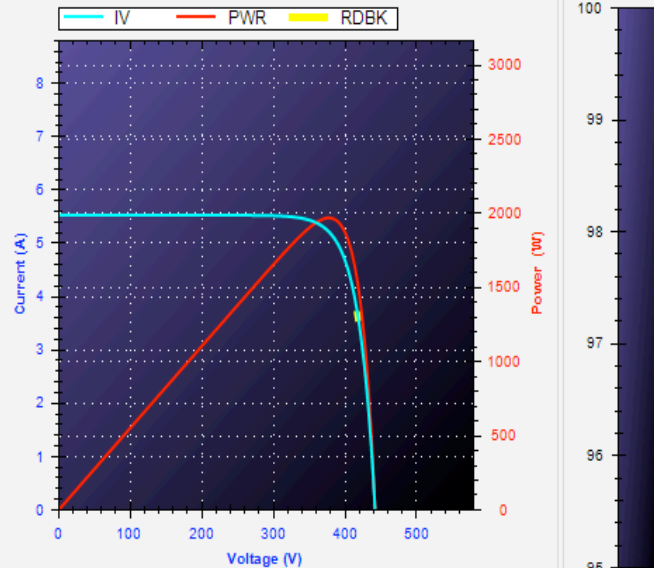
File Photovoltaic curve Irradiance profile Array System Measure Help

Photovoltaic simulation System control

Channel 1 -- Irradiance profile



Channel 1 -- Photovoltaic curve



MPPT%



1 418.24 V
ON 3.604 A
1,507.24 W
EMG FLT OVP
SEL C9 P1
PGM 600V 25.0A

CH 1 -- Photovoltaic Curve Parameters

Voc [V]	Isc [A]	Vmp [V]	Imp [A]	Pmp [W]
441.90	5.530	377.54	5.219	1,970.47

CH 1 -- MPPT Measurements

AC Vpp	AC App	MPPT%
2.79	0.16	76.49

CH	P/A	Time [s]	Offset [s]	Speed	Controls
ALL					Navigation icons
1	P1	30,071.00	5,514	10	Navigation icons

Curves

Profiles

Arrays

ID	Photovoltaic curve name
7	Curve 446V 6.8A 0.79
8	Curve 446V 6.79A 0.79
9	Curve 446V 6.77A 0.79

DYNAMIC SIM LOCAL OFFLINE 9 CURVES 1 PROFILE 0 ARRAYS LOG ON



NISE
National Institute of Solar Energy

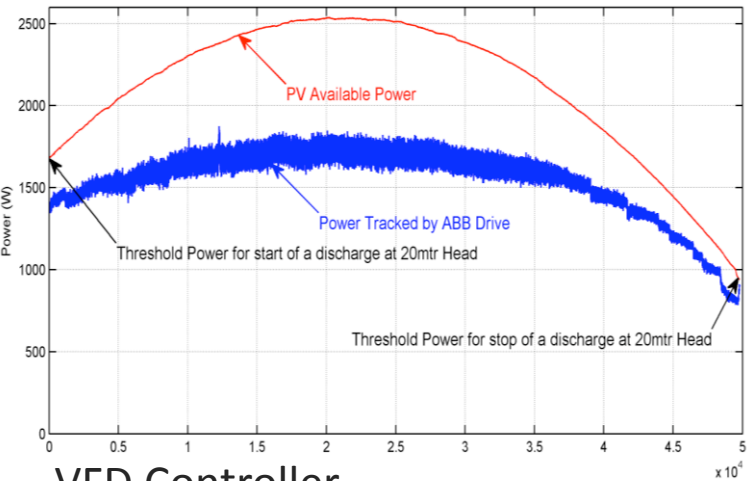
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Parameters comparison

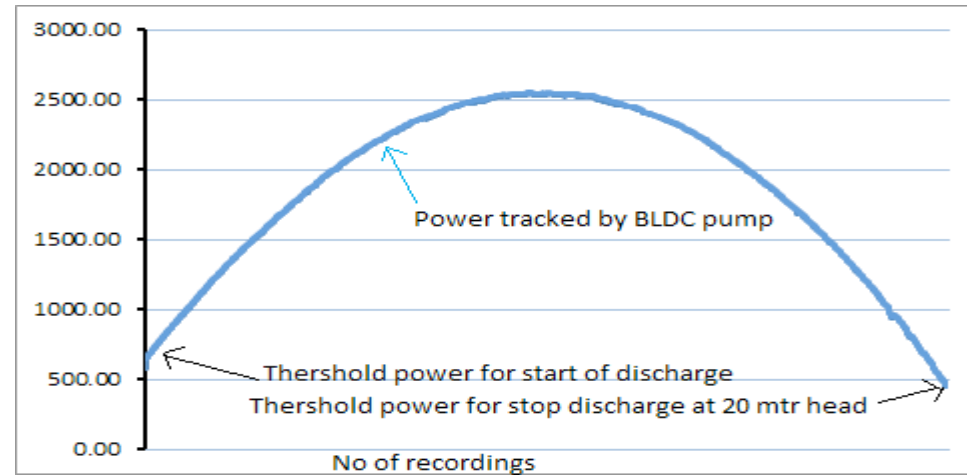
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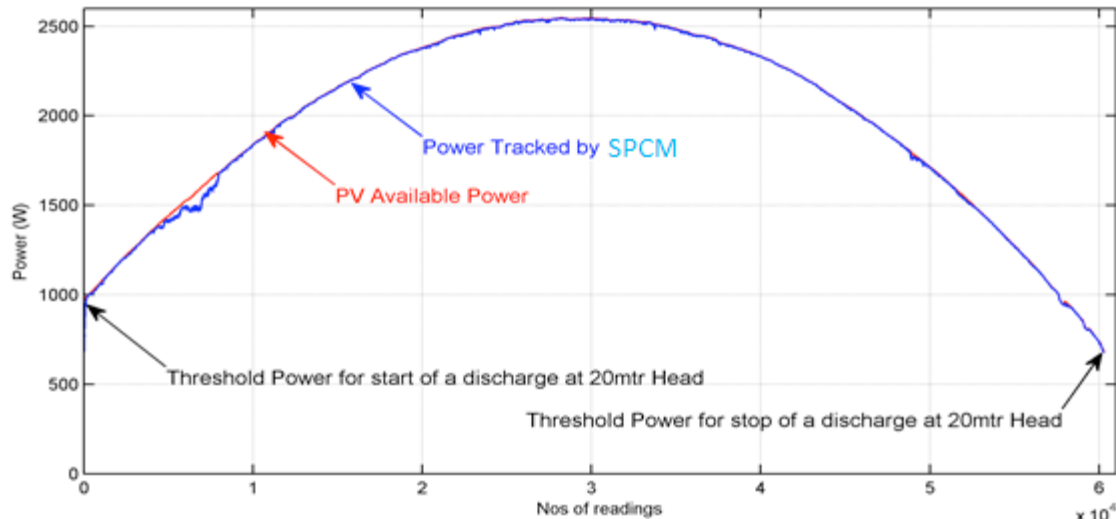
Tracking Performance at 20Mtr Head



VFD Controller



BLDC Controller



SPCM Controller



Parameters comparison

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Threshold Wattage:

HEAD mtr	VFD @ Wp		SPCM @ Wp		BLDC@ Wp	
	Start of discharge	End of discharge	Start of discharge	End of discharge	Start of discharge	End of discharge
10	1158	460	793	330	350	168
18	1178	764	968	638	543	200
20	1679	1027	989	777	647	458



Parameters comparison

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Out put comparison of SPCM and VFD

Total Volumetric Discharge						
SPCM PCU			VFD Technology			SPCM discharges higher than VFD
Initial Dial Reading	Final Dial Reading	Net Discharge	Initial Dial Reading	Final Dial Reading	Net Discharge	
2400.00 KLtr	2414.00 kLtr	14.00 kLtr	2417.04 kLtr	2425.40 kLtr	8.36 kLtr	67.46%*

*** Complete Sun profile of day is condensed to 55 min for comparison purpose**

Max. Discharge Rate in liters/minute @ Peak Power			
Head (meters)	SPCM	VFD	SPCM discharges higher than VFD
10	455	432	5%
15	420	340 (extrapolated)	24%
18	390	273	43%
20	370	235	57%



Out put comparison of BLDC and VFD

Max. Discharge Rate in liters/minute @ Peak Power			
Head (meters)	BLDC	VFD	BLDC discharges higher than VFD
10	380	432	-12%*
20	300	235	27%

NOTE:

- The BLDC is 4 stage submersible pump designed for 20 mtrs
- FOR VFD we used surface pump designed for 18 mtrs
- Studies are under progress for BLDC surface pump at 20 mtrs



Irrigation purpose pump should have...

**> 99.5%
MPPT**

- Proprietary Boost Circuit design
- Efficient MPPT Algorithm for maximum SPV power extraction

**Power
Quality**

- 3-Phase Pure Sine wave
- THD < 3%
- No Voltage Spike
- No Ringing

**V/F
Control**

- Precise V/F control
- Low and High load Power Mgmt.
- Can operate greater than 50 Hz for high throughput

**> 94%
Efficiency
&
Extended
Daytime**

- Early Morning Wake up
- Extended to late evening

Protections

- Over Current
- Over Voltage
- Motor Stall
- Short Circuit, Open Circuit
- Dry Run, Reverse Polarity
- Automatic Wake up, Safe Shutdown, etc

**Data
Logger
&
Friendly
Interface**

Data logs available for all critical power parameters useful for: a) Energy Management & Monitoring, b) Solar Mapping, etc.

Extremely Easy and Intuitive Control Panel operation



THANK YOU FOR YOUR ATTENTION!!

