Timing Requirements for Grid Integrated Solar Photovoltaic (PV) DC to AC Power Inverters

A Leading Provider of Smart, Connected and Secure Embedded Control Solutions

Gregg Watson

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Agenda

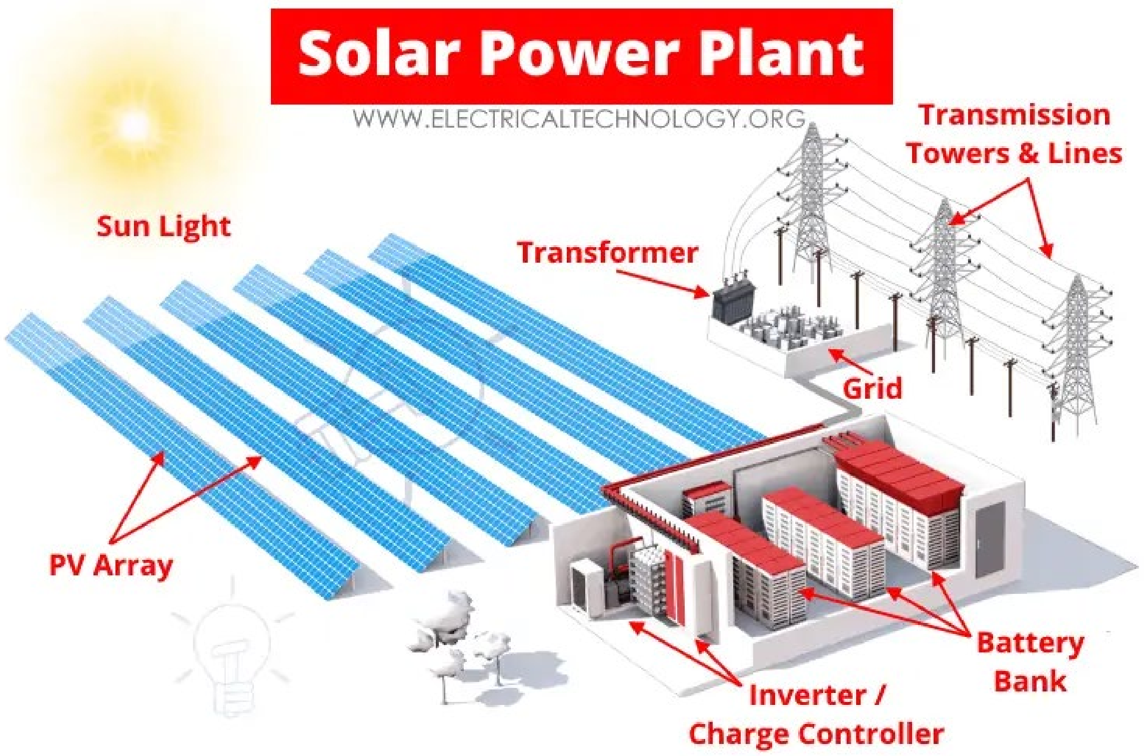
- **The Rise of the Mega Solar Power Grid**
- **Components of a Solar Power System**
  - DC/AC Inverters
  - System Balance Components
- **How Does Timing Apply to This?**
- **The Need for Standardization and IEEE 1547-2018**

Rise of the Mega Solar Power Grid

- **Solar Power is being heavily invested in within the Public and Private Sector as new clean energy.**
  - In 2002, the global solar networks supplied 2 Gigawatts
  - In 2018, the networks grew to supply 500 Gigawatts
  - In 2022, the networks doubled to supply 1000 Gigawatts/ 1 Terawatts

MICROCHIP

How to Supply Solar Power to the Network



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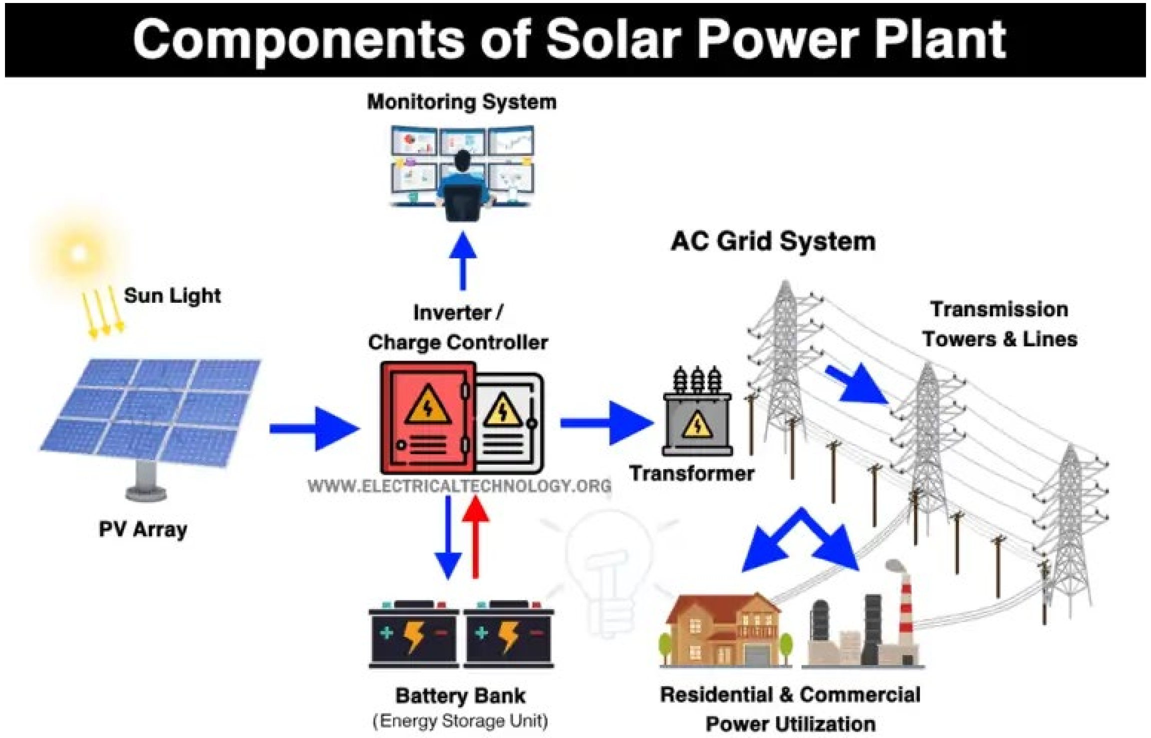

The 2 main components –

- DC/AC Inverter
- System balancing component

DC/AC Inverters

- **Inverters are a key element required in all solar energy systems**
- **Convert direct current (DC) electricity, which is what a solar panel generates, to alternating current (AC) electricity**
- **DC is constant voltage in one direction. AC voltage rapidly changes from positive to negative and flows in both directions**
- **Inverters produce a repeating sine wave that can be injected into the power grid**
- **The inverter supplies its stored energy via a transformer which is connected to a protection relay**

System Balance Components

- To control, protect and distribute the stored power within the system
- The most important condition is that the system must match the output frequency and voltage to the electrical grid (50 Hz in USA & 60Hz in Europe)
- This is where the importance of timing and frequency for the system and the electricity grid need to be aligned
- For the stored power to be released accurately and safely to protect systems from over voltage and oscillating voltage damage

How Does Timing Apply to This

- In order for both the national electrical grid and the private networks to work together, they have to both have the same common timing and frequency

- With the use of NTP, which provides timestamps for the monitoring results, it is also provides the common time frame for the inverter to release its stored energy at the precise time, to the transformer to release onto the electrical grid

The Need for Standardisation

- **The power utility grid needs the privately owned solar farms to adhere to standardisation in order ensure the power they supply doesn't trip their network upon its release**

- **IEEE 1547-2018 focuses on technical specifications for interconnection between the DER (Distributed Energy Resources) and the BPS (Bulk Power System)**

- **BPS Perspectives and Recommendations**
  - With increased DER penetrations, the ability of DERs to ride through large changes in voltage phase angle becomes increasingly important for reliable operation of the BPS
  - Large changes in voltage phase angle can occur during normally cleared fault events or line switching on the BPS
  - Widespread DER tripping during these events could cause adverse impacts to BPS reliability. Therefore, from the BPS perspective, voltage phase angle ride-through capability and performance is strongly recommended for all DERs

IEEE 1547-2018 Technical Specifications

Standards for DER		Listing/Certification			Interconnection Standards			State/PUC/Utility Rules	
								CA	HI/HECO
Function Set	**Advanced Functions Capability**	**UL 1741**	**UL 1741(SA) 2016**	**IEEE 1547.1 -201?***	**IEEE 1547-2003**	**IEEE 1547a-2014**	**IEEE 1547-2018**	**Rule 21 (Phases)**	**Rule 14H & UL SRDv1.1**
All	Adjustability in Ranges of Allowable Settings			Δ		√	‡		
Monitoring & Control	Ramp Rate Control		Δ					‡ (P1)	‡
	Communication Interface			Δ			‡	‡ (P2)	‡
	Disable Permit Service (Remote Shut-Off, Remote Disconnect/Reconnect)			Δ			‡	‡ (P3)	‡
	Limit Active Power			Δ			‡	‡ (P3)	
	Monitor Key DER Data			Δ			‡	‡ (P3)	
Scheduling	Set Active Power							[‡ (P3)]	
	Scheduling Power Values and Models							‡ (P3)	
Reactive Power & Voltage Support	Constant Power Factor	√	Δ	Δ	√	√	‡	‡ (P1)	X
	Voltage-Reactive Power (Volt-Var)		Δ	Δ	X	√	‡	‡ (P1)	‡
	Autonomously Adjustable Voltage Reference			Δ			‡	!!!	!!!
	Active Power-Reactive Power (Watt-Var)			Δ	X		‡		‡
	Constant Reactive Power	√		Δ	√	√	‡		
	Voltage-Active Power (Volt-Watt)		Δ	Δ	X	√	‡	‡ (P3)	‡
	Dynamic Voltage Support during VRT						√	[‡ (P3)]	
Bulk System Reliability & Frequency Support	Frequency Ride-Through (FRT)		Δ	Δ			‡	‡ (P1)	‡
	Rate-of-Change-of-Frequency Ride-Through			Δ			‡	!!!	!!!
	Voltage Ride-Through (VRT)		Δ	Δ			‡	‡ (P1)	‡
	Voltage Phase Angle Jump Ride-Through			Δ			‡	!!!	!!!
	Frequency-Watt		Δ	Δ	X	√	‡	‡ (P3)	‡
Other Advanced DER Functions	Anti-Islanding Detection and Trip			Δ			‡	‡ (P1)	‡
	Transient Overvoltage						‡		‡
	Remote Configurability						‡	‡ (P2)	‡
	Return to Service (Enter Service)						‡	‡ (P1)	‡

Legend: X Prohibited, √ Allowed by Mutual Agreement, ‡ Capability Required, Δ Test and Verification Defined
[…] Subject to clarification of the technical requirements and use cases, !!! Important Gap

Source: EPRI

- **IEEE 1547-2018 focuses on technical specifications for interconnection between the DER and the Bulk Power System (BPS)**
- **Two of the more progressive states in the U.S. where IEEE 1547-2018 is adopted and implemented include California and Hawaii**

https://www.nerc.com/comm/PC_Reliability_Guidelines_DL/Guideline_IEEE_1547-2018_BPS_Perspectives.pdf

Thank You!