Current Renewables Engineering

01-31-2023

Enphase Energy Inc

47281 Bayside Parkway

Attn.: To Whom It May Concern

re job: Damon Mosby

510 Rolling Pines Dr, Spring Lake, NC 28390, USA

The following calculations are for the structural engineering design of the photovoltaic panels and are valid only for the structural info referenced in the stamped plan set. The verification of such info is the responsibility of others.

I certify that the roof structure has sufficient structural capacity for the applied PV loads.

All mounting equipment shall be designed and installed per manufacturer's approved installation specifications.

Design Criteria:

Code: 2018 NCSBC, IBC 2018, ASCE 7-16,
Live Load: 20 psf
Ult Wind Speed: 118 mph
Exposure Cat: C
Ground Snow: 10 psf
Min Snow Roof: N/A

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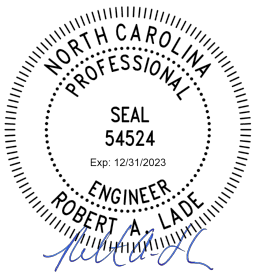

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Roof Properties:

	Roof 1	Roof 2	Roof 3	Roof 4
Roof Type =	Shingle	Shingle	Shingle	Shingle
Roof Pitch (deg) =	29.0	34.0	32.0	33.0
Mean Root Height (ft) =	13.0	13.0	13.0	13.0
Attachment Trib Width (ft) =	3.25	3.25	3.25	3.25
Attachment Spacing (ft) =	4.0	4.0	4.0	4.0
Framing Type =	Truss	Truss	Truss	Truss
Framing Size =	2x4	2x4	2x4	2x4
Framing OC Spacing (in.) =	24.0	24.0	24.0	24.0
Section Thickness, b (in) =	1.5	1.5	1.5	1.5
Section Depth, d (in) =	3.5	3.5	3.5	3.5
Section Modulus, Sx (in^3) =	3.062	3.062	3.062	3.062
Moment of Inertia, Ix (in) =	5.359	5.359	5.359	5.359
Unsupported Span (ft) =	9.0	7.5	7.5	9.5
Upper Chord Length (ft) =	18.0	15.0	15.0	19.0
Deflection Limit D+L (in) =	3.6	3.0	3.0	3.8
Deflection Limit S or W (in) =	2.4	2.0	2.0	2.533
Attachments Pattern =	Fully Staggered	Fully Staggered	Fully Staggered	Fully Staggered
Framing Upgrade =	No	No	No	No
Sister Size =	NA	NA	NA	NA
Wood Species =	DF	DF	DF	DF
Wood Fb (psi) =	900.0	900.0	900.0	900.0
Wood Fv (psi) =	180.0	180.0	180.0	180.0
Wood E (psi) =	1600000.0	1600000.0	1600000.0	1600000.0
C_D (wind) =	1.6	1.6	1.6	1.6
C_d (snow) =	1.15	1.15	1.15	1.15
C_{LS} =	1.0	1.0	1.0	1.0
$C_M = C_t = C_L = C_i$ =	1.0	1.0	1.0	1.0
C_F =	1.5	1.5	1.5	1.5
C_{fu} =	1.0	1.0	1.0	1.0
C_r =	1.15	1.15	1.15	1.15
F'b wind (psi) =	2484.0	2484.0	2484.0	2484.0
F'b snow (psi) =	1785.37	1785.37	1785.37	1785.37
F'v wind (psi) =	288.0	288.0	288.0	288.0
F'v snow (psi) =	207.0	207.0	207.0	207.0
M allowable wind (lb-ft) =	633.94	633.94	633.94	633.94
M allowable snow (lb-ft) =	455.64	455.64	455.64	455.64
V allowable wind (lbs) =	1008.0	1008.0	1008.0	1008.0
V allowable snow (lbs) =	724.5	724.5	724.5	724.5
E' (psi) =	1600000.0	1600000.0	1600000.0	1600000.0

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Load Calculation:

Dead Load Calculations:

	Roof 1	Roof 2	Roof 3	Roof 4
Panels Dead Load (psf) =	3.0	3.0	3.0	3.0
Roofing Weight (psf) =	3.0	3.0	3.0	3.0
Decking Weight (psf) =	2.0	2.0	2.0	2.0
Framing Weight (psf) =	0.602	0.602	0.602	0.602
Misc. Additional Weight (psf) =	1.0	1.0	1.0	1.0
Existing Dead Load (psf) =	6.602	6.602	6.602	6.602
Total Dead Load (psf) =	9.602	9.602	9.602	9.602

Wind Load Calculations:

Ultimate Wind Speed (mph) =	118.05	118.05	118.05	118.05
Directionality Facto r, kd =	0.85	0.85	0.85	0.85
Topographic Factor, kzt =	1.0	1.0	1.0	1.0
Velocity Press Exp Factor, kz =	0.849	0.849	0.849	0.849
Velocity Pressure, qz (psf) =	25.742	25.742	25.742	25.742
External Pressure Up, GCp_1 =	-1.499	-1.499	-1.499	-1.499
External Pressure Up, GCp_2 =	-1.769	-1.769	-1.769	-1.769
External Pressure Up, GCp_3 =	-2.189	-2.189	-2.189	-2.189
External Pressure Down, GCp =	0.78	0.78	0.78	0.78
Design Pressure Up, p_1 (psf) =	-26.624	-26.624	-26.624	-26.624
Design Pressure Up, p_2 (psf) =	-31.414	-31.414	-31.414	-31.414
Design Pressure Up, p_3 (psf) =	-38.881	-38.881	-38.881	-38.881
Design Pressure Down, p (psf) =	16.0	16.0	16.0	16.0

Snow Load Calculations:

Ground Snow Load, pg (psf) =	10.0	10.0	10.0	10.0
Min Flat Snow, pf_min (psf) =	0.0	0.0	0.0	0.0
Sloped Snow, ps_min (psf) =	0.0	0.0	0.0	0.0
Snow Importance Factor, Ic =	1.0	1.0	1.0	1.0
Exposure Factor, Ce =	0.9	0.9	0.9	0.9
Thermal Factor, Ct =	1.1	1.1	1.1	1.1
Flat Roof Snow, pf (psf) =	6.93	6.93	6.93	6.93
Slope Factor, Cs =	1.0	1.0	1.0	1.0
Sloped Roof Snow, ps (psf) =	6.93	6.93	6.93	6.93

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Lag Screw Checks:

	Roof 1	Roof 2	Roof 3	Roof 4
Ref. Withdrawal Value, W (lb/in) =	266.0	266.0	266.0	266.0
(C_m = C_t = C_{eg} = 1.0) CD =	1.6	1.6	1.6	1.6
Adjusted Withdrawal Value, W' (lb/in) =	425.6	425.6	425.6	425.6
Lag Penetration, p (in.) =	2.5	2.5	2.5	2.5
Allowable Withdrawal Force, W'p (lbs) =	1064.0	1064.0	1064.0	1064.0
Applied Uplift Force (lbs) =	-159.149	-160.215	-159.77	-192.301
Uplift DCR =	0.15	0.151	0.15	0.181
Ref. Lateral Value, Z (lbs) =	266.0	266.0	266.0	266.0
(C_m = C_t = C_Δ = C_{eg} = 1.0) CD =	1.15	1.15	1.15	1.15
Adjusted Lateral Value, Z' (lbs) =	310.5	310.5	310.5	310.5
Applied Lateral Force (lbs) =	62.584	72.186	68.407	70.307
Angle of Resultant Force, α (deg) =	1.196	1.147	1.166	1.22
Adjusted Interaction Lateral Value, Z'α (lbs) =	803.013	754.876	773.283	827.283
Lateral DCR =	0.078	0.096	0.088	0.085

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Roof Framing Checks:

Force Checks:

LC1: D+S

	Roof 1	Roof 2	Roof 3	Roof 4
Applied Moment (lb-ft) =	335.0	232.0	232.0	373.0
Applied Shear (lbs) =	185.0	154.0	154.0	195.0
Allowable Moment (lb-ft) =	456.0	456.0	456.0	456.0
Allowable Shear (lbs) =	724.0	724.0	724.0	724.0
Moment DCR =	0.735	0.51	0.51	0.819
Shear DCR =	0.255	0.212	0.212	0.269

LC2: D+0.6W

Applied Moment (lb-ft) =	389.0	270.0	270.0	433.0
Applied Shear (lbs) =	214.0	178.0	178.0	226.0
Allowable Moment (lb-ft) =	634.0	634.0	634.0	634.0
Allowable Shear (lbs) =	1008.0	1008.0	1008.0	1008.0
Moment DCR =	0.613	0.426	0.426	0.683
Shear DCR =	0.213	0.177	0.177	0.225

LC3: D+0.75(S+0.6W)

Applied Moment (lb-ft) =	445.0	309.0	309.0	496.0
Applied Shear (lbs) =	246.0	204.0	204.0	259.0
Allowable Moment (lb-ft) =	634.0	634.0	634.0	634.0
Allowable Shear (lbs) =	1008.0	1008.0	1008.0	1008.0
Moment DCR =	0.703	0.488	0.488	0.783
Shear DCR =	0.244	0.203	0.203	0.257

LC4: 0.6D+0.6W

Applied Moment (lb-ft) =	311.0	216.0	216.0	347.0
Applied Shear (lbs) =	172.0	143.0	143.0	181.0
Allowable Moment (lb-ft) =	634.0	634.0	634.0	634.0
Allowable Shear (lbs) =	1008.0	1008.0	1008.0	1008.0
Moment DCR =	0.491	0.341	0.341	0.547
Shear DCR =	0.17	0.142	0.142	0.18

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Deflection Checks (Service Level):

LC1: D+L

Deflection (in.) =	0.514	0.233	0.239	0.608
Deflection Limit (in.) =	3.6	3.0	3.0	3.8
Deflection DCR =	0.143	0.078	0.08	0.16

LC2: S

Deflection (in.) =	0.099	0.048	0.048	0.123
Deflection Limit (in.) =	2.4	2.0	2.0	2.533
Deflection DCR =	0.041	0.024	0.024	0.049

LC3: W (Down)

Deflection (in.) =	0.096	0.046	0.046	0.119
Deflection Limit (in.) =	2.4	2.0	2.0	2.533
Deflection DCR =	0.04	0.023	0.023	0.047

LC4: W (Up)

Deflection (in.) =	0.16	0.077	0.077	0.199
Deflection Limit (in.) =	2.4	2.0	2.0	2.533
Deflection DCR =	0.067	0.039	0.039	0.078

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Seismic Check:

Existing Weight:

Wall Weight (psf) =	17.0
Tributary Wall Area (ft^2) =	1120.0
Total Wall Weight (lbs) =	19040.0
Roof Weight (psf) =	6.602
Roof Area (ft^2) =	3132.0
Total Roof Weight (lbs) =	20676.094
Total Existing Weight (lbs) =	39716.094

Total Additional PV Weight (lbs) = 1994.85

Weight Increase:

(Existing W + Additional W)/(Existing W) = 1.05

The increase in weight as a result of the solar system is less than 10% of the existing structure and therefore no further seismic analysis is required.

Limits of Scope of Work and Liability:

Existing structure is assumed to have been designed and constructed following appropriate codes at time of erection, and assumed to have appropriate permits. The calculations produced are only for the roof framing supporting the proposed PV installation referenced in the stamped planset and were completed according to generally recognized structural analysis standards and procedures, professional engineering and design experience, opinions and judgements. Existing deficiencies which are unknown or were not observable during time of inspection are not included in this scope of work. All PV modules, racking, and mounting equipment shall be designed and installed per manufacturer's approved installation specifications. The Engineer of Record and the engineering consulting firm assume no responsibility for misuse or improper installation. This analysis is not stamped for water leakage. Framing was determined based on information in provided plans and/or photos, along with engineering judgement. Prior to commencement of work, the contractor shall verify the framing sizes, spacings, and spans noted in the stamped plans, calculations, and cert letter (where applicable) and notify the Engineer of Record of any discrepancies prior to starting construction. Contractor shall also verify that there is no damaged framing that was not addressed in stamped plans, calculations, and cert letter (where applicable) and notify the Engineer of Record of any concerns prior to starting construction.