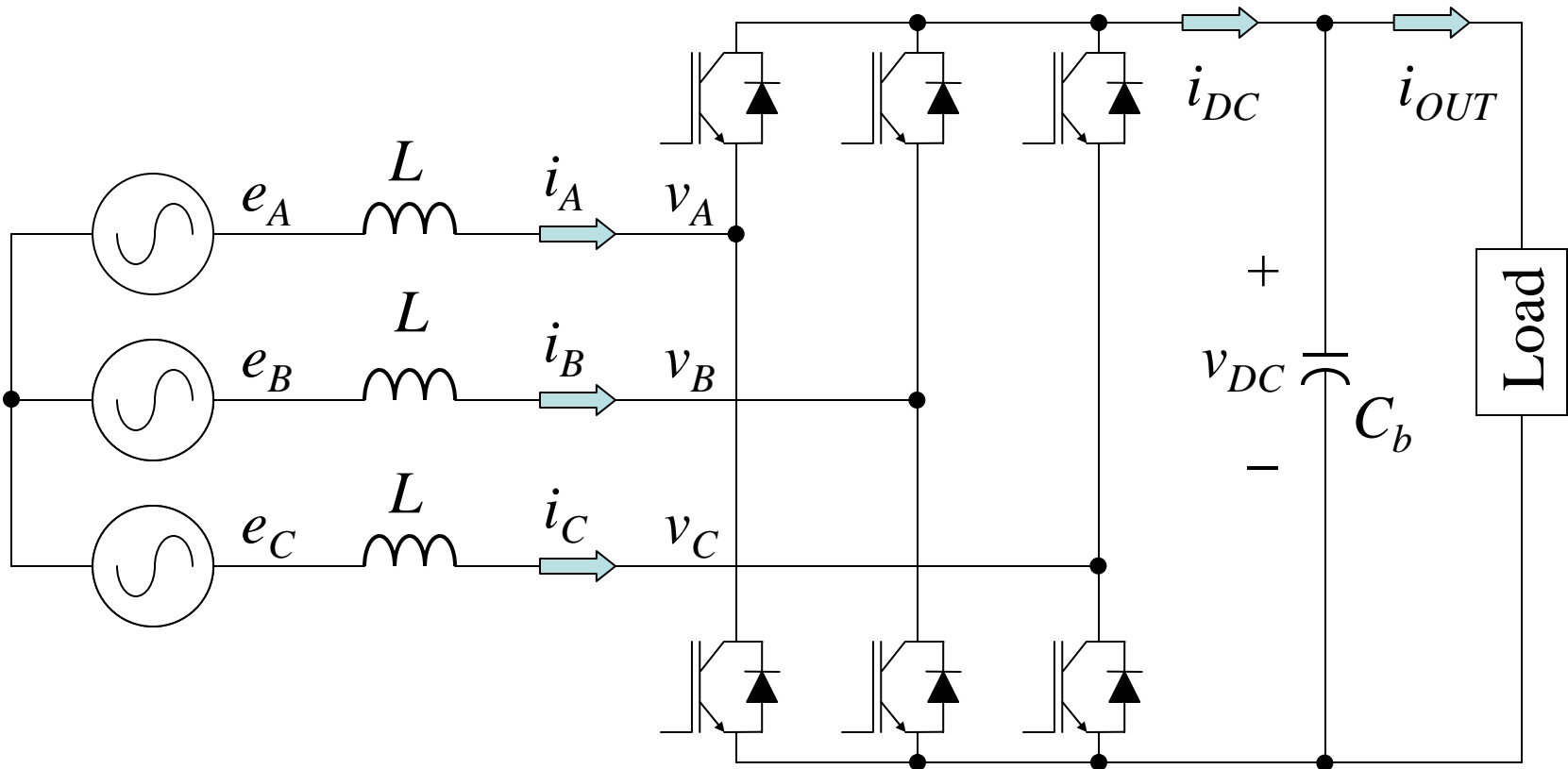


Design Characteristics of High Power Grid-Tie PV Inverters

Eric Seymour
Director of Engineering
Solar Inverters



Inverter / Active Rectifier





SYSTEM

VIEW

TIME PLOT

EVENT

STATUS

CH1, 2, 3

CH 4

60Hz

INTERNAL MEMORY

SETTING

3P3W3 600V 500A

OFF 150V 500A

PLL: U1

PC CARD MEMORY

RECORDING

Real Time View

f : 59.990Hz

ANALYZING

U x1

I x5

2cycle

WAVE

VOLT/CURR

VOLTAGE

CURRENT

VECTOR

VECTOR

DMM

POWER

VOLTAGE

CURRENT

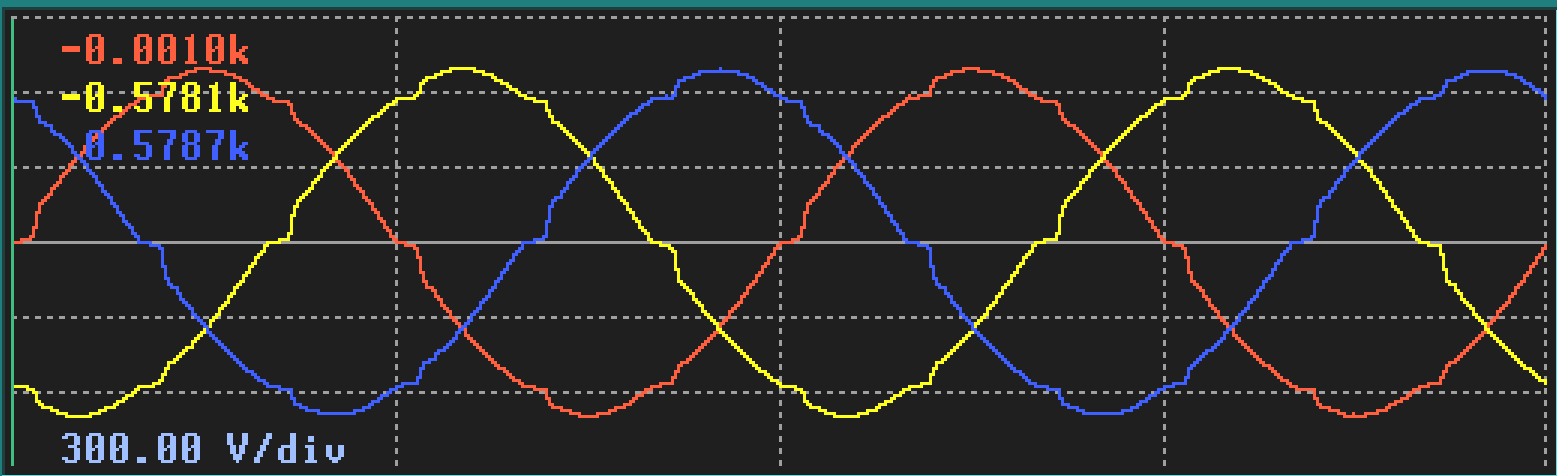
HARMONICS

GRAPH

LIST

2005/09/06

14:49:43



SELECT

CURSOR

SCROLL



Old Inverter Design Characteristics

Product

- Monopolar – (600V)
- Transformer Required
 - ratio changing
 - galvanic isolation

Engine

- Air-Cooled
 - physically large
 - high parasitics – large voltage margin required
- Hard Switched (2-8kHz)
- Snubberless
- Components
 - high parts count
 - electrolytic caps
 - large, expensive IGBT modules

Filter(s)

- Resonant point – completely undamped
- Large delta caps – high harmonic draw

Controls

- Barrowed in many cases
- Id or Pac control modes



New Inverter Design Characteristics

Product

- Bipolar – double voltage (1200)
- Transformerless

Engine

- Liquid-Cooled
 - compact (triple power density)
 - low parasitics
- Soft Switched
- High Frequency (more than doubled)
- Snubber-based
- Components
 - film caps
 - common, inexpensive IGBT modules

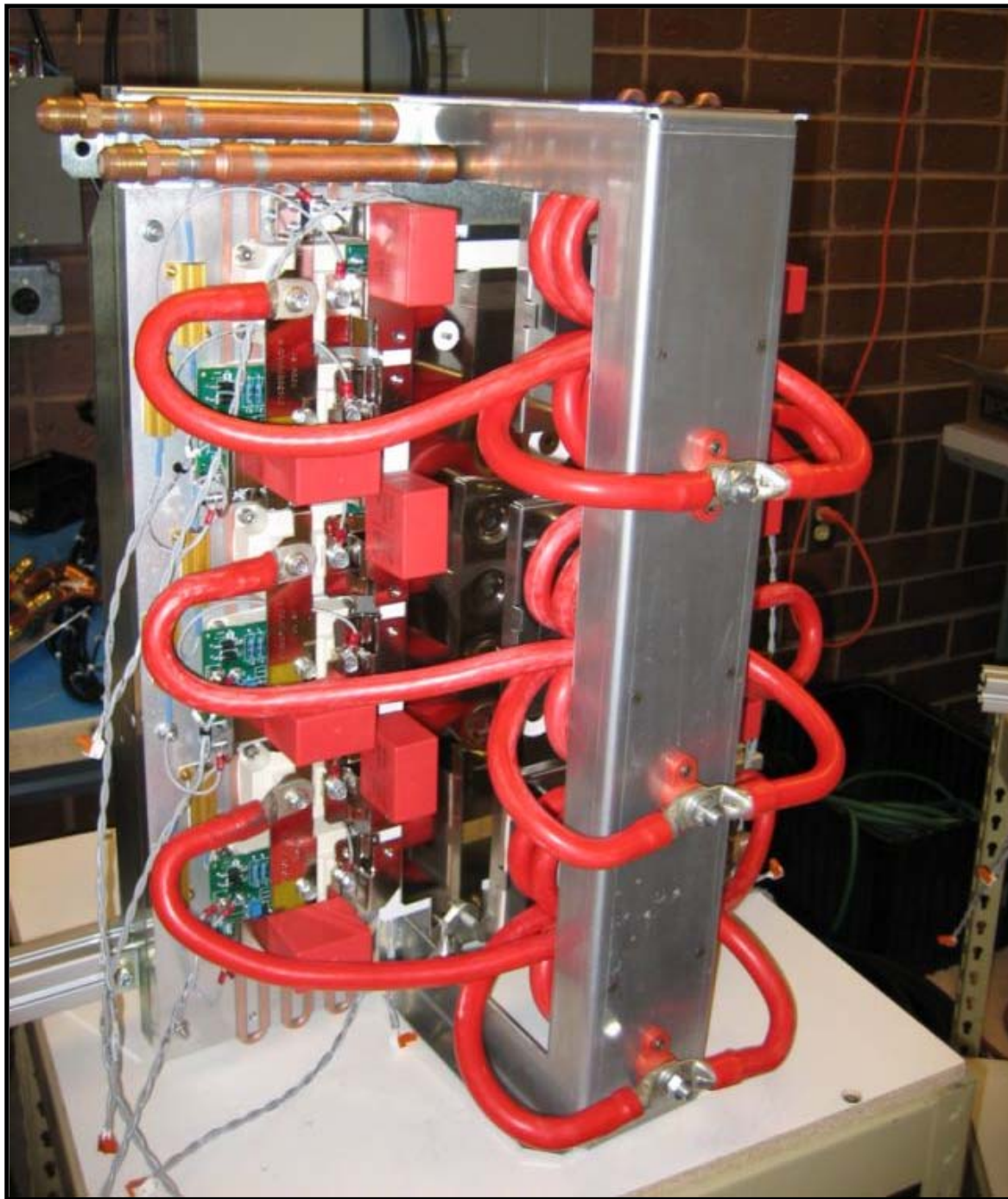
Filter(s)

- Resonant point – critically damped
- Small delta caps – low harmonic draw

Controls

- Specifically developed for Solar Industry
- Full synchronous DQ-space control set
- High speed Vdc control





Manufacturer: Advanced Energy Industries, INC.

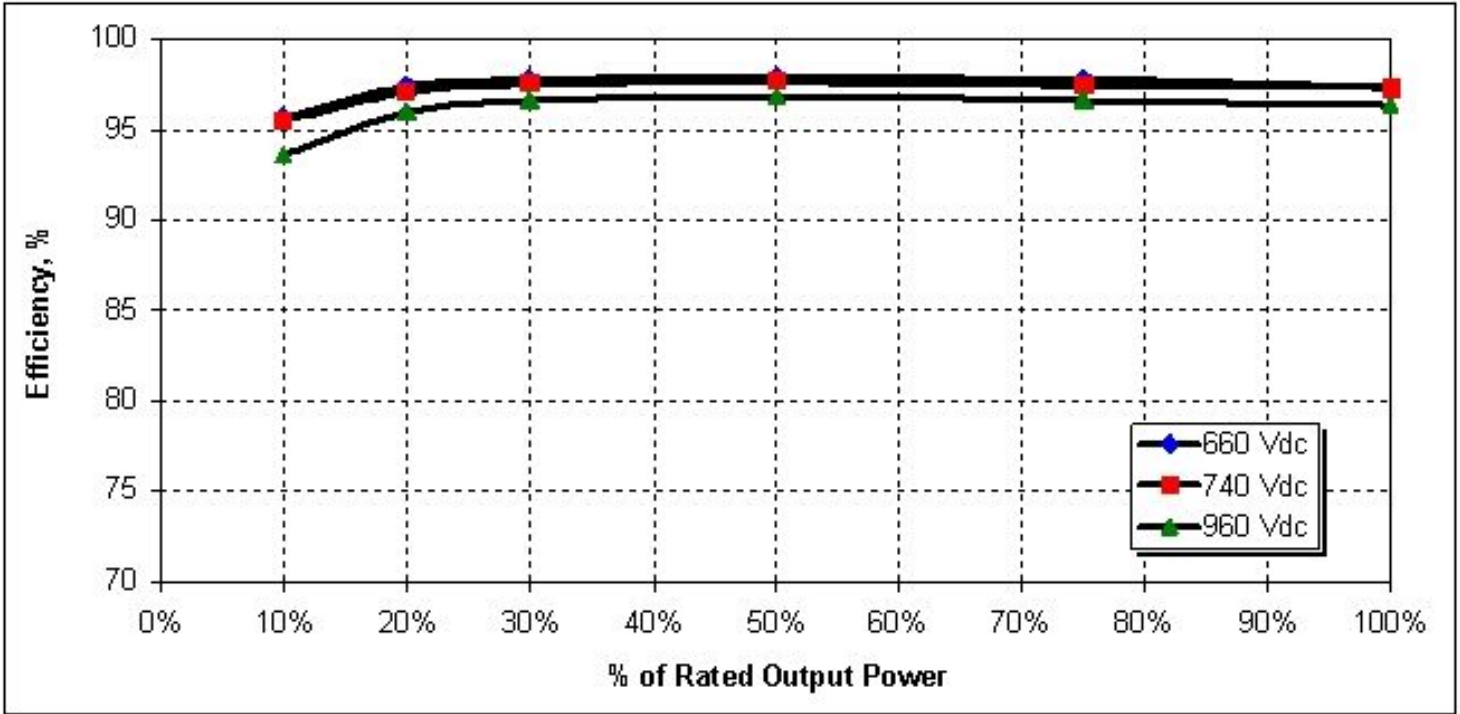
Model #: 3159000-104

Rated Maximum Continuous Output Power: 333.00 kW Night Tare Loss: 89.58 W

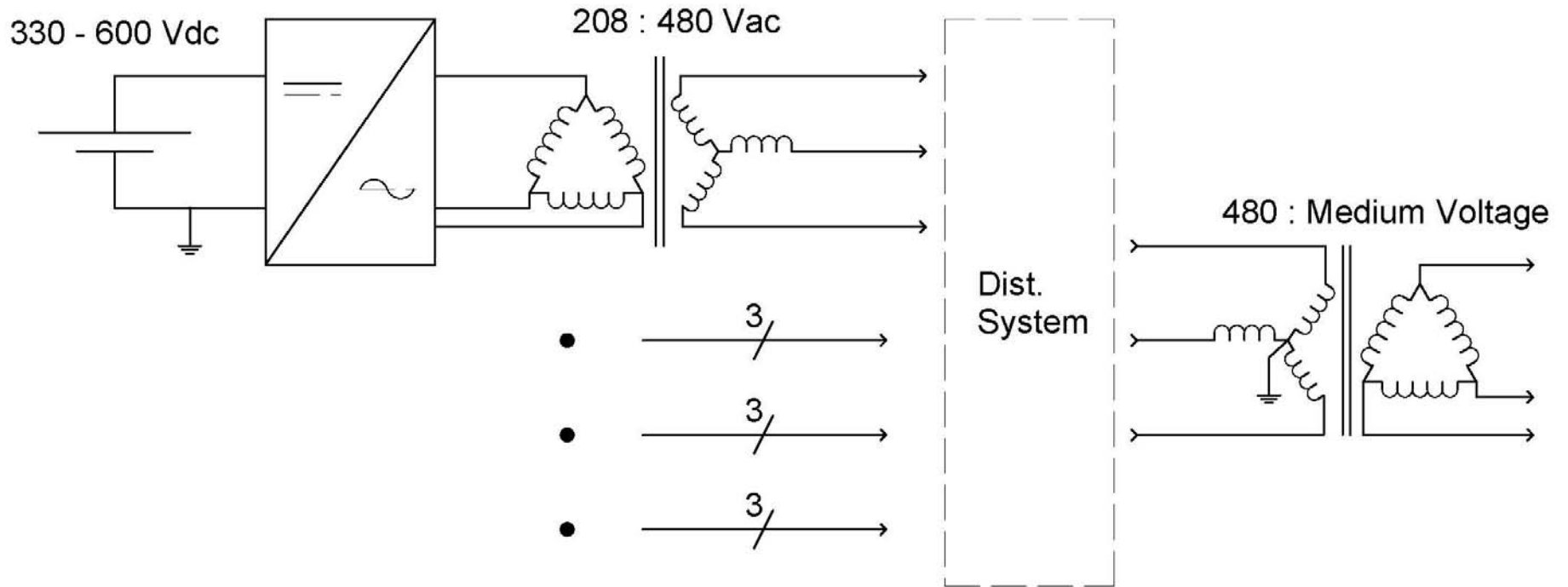
Vmin: 660 Vdc Vnom: 740 Vdc Vmax: 960 Vdc

		Power Level (%; kW)						Wtd
		10%	20%	30%	50%	75%	100%	
Input Voltage (Vdc)		33.30	66.60	99.90	166.50	249.75	333.00	
Vmin	660	95.6	97.4	97.8	97.9	97.7	97.2	97.7
Vnom	740	95.5	97.0	97.5	97.6	97.4	97.2	97.4
Vmax	960	93.6	95.9	96.6	96.8	96.6	96.3	96.5

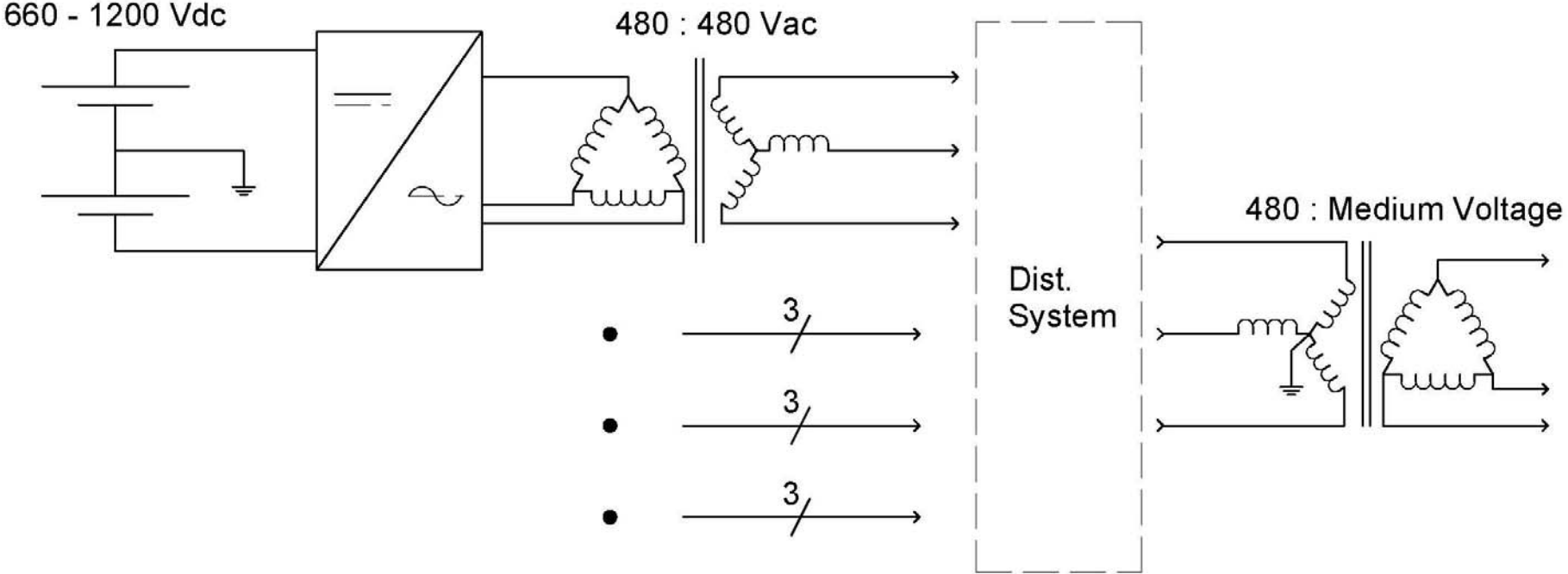
CEC Efficiency = 97.0%



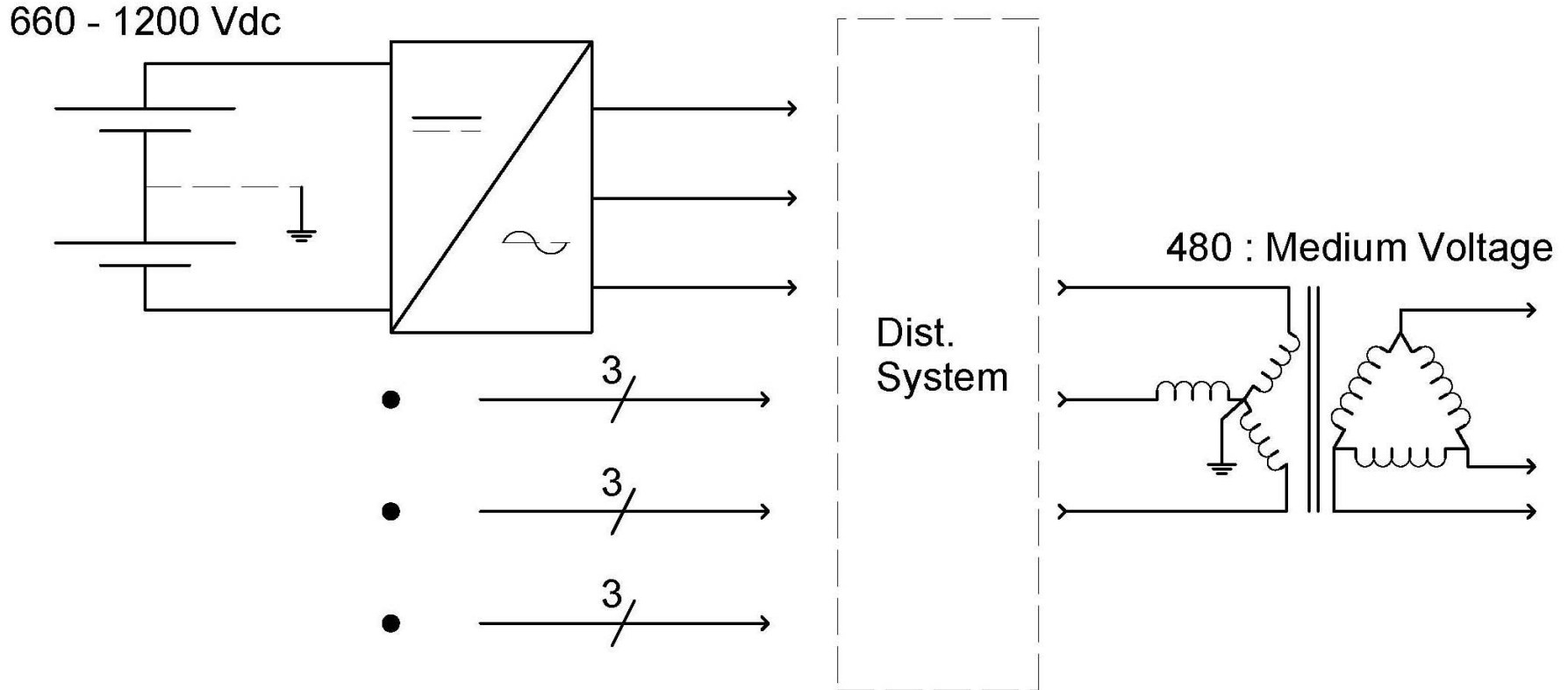
Traditional Unipolar PV



BiPolar PV with Transformer

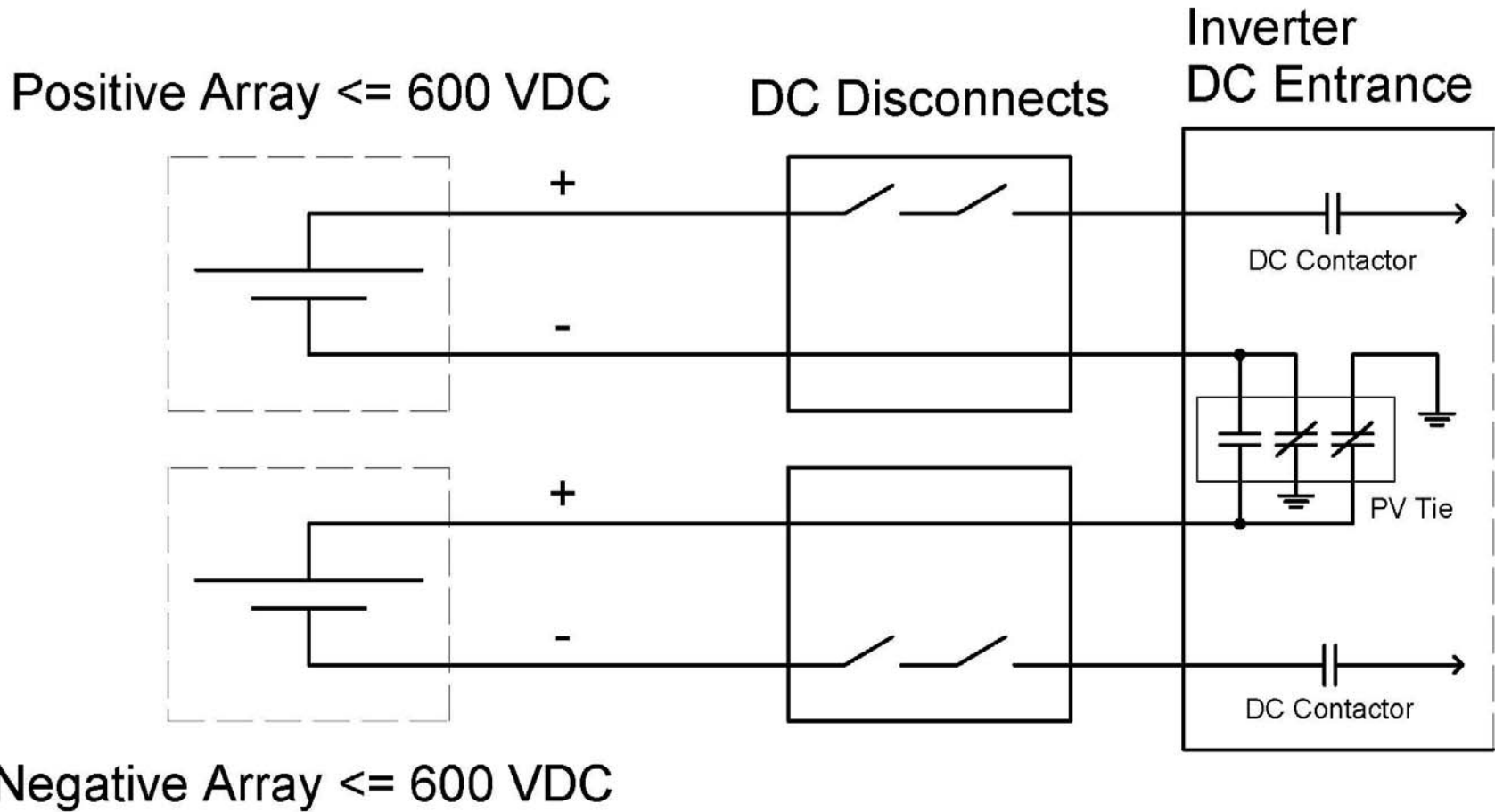


BiPolar PV without Transformer



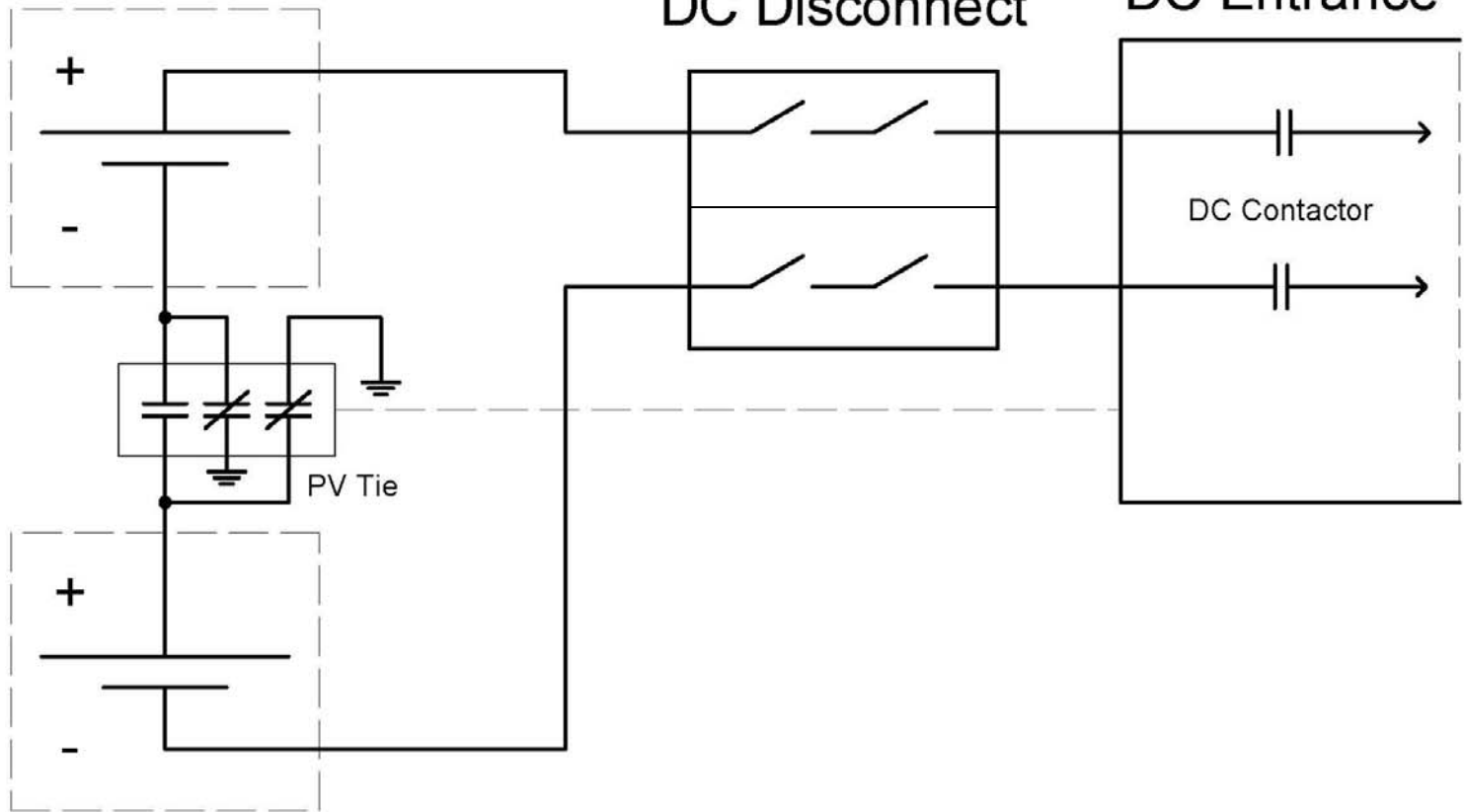
- PV Tie point held near ground even for ground-currents far in excess of inst. GFI trip (9.5 Arms for 333kW System) for NEC LV Compliance
- High Frequency blocked from entering both AC and DC sides
- DC injection to Power System kept well below 0.5% 1547 Limit

Array Wiring 1



Array Wiring 2

Positive Array ≤ 600 VDC



Negative Array ≤ 600 VDC



Loop

VQ I

0 Unit Address

ON

OFF

RESET

AC

-279. kW

0.0 kVAR

333 Irms

Freq

785 Vdc

-367 Idc

1.5 Ens

Timers

0:00 Reconnect

0:00 AutoReset

0:00 Shutdown

0:00 Charge

0:00 Wake-Up

Setpoints / Limits

782 VDC

0.0 Q

-333.0 Pac Lim

450 Iac Limit

-500 Idc Limit

1100 Vdc High

700 Vdc Low

AutoStart

On Off

Tracking Mode

On Off

PV-VDC

783

dq Synchronous

	E	I*	I
d	395	-456.	-471.
q	0.2	-1.6	-0.6

Decoupling Angle -137.0

Phase Sequencing: Pos

Freq 59.99

VCMave 2.8

VCMrms 32.0

VCM60 1.9

Igd 0.8

Iharm 8.0

PTrip -338

Temperatures

28.7 Ambient 37.6 Coolant 43.3 Cabinet 72.6 Reactor

MOV OK