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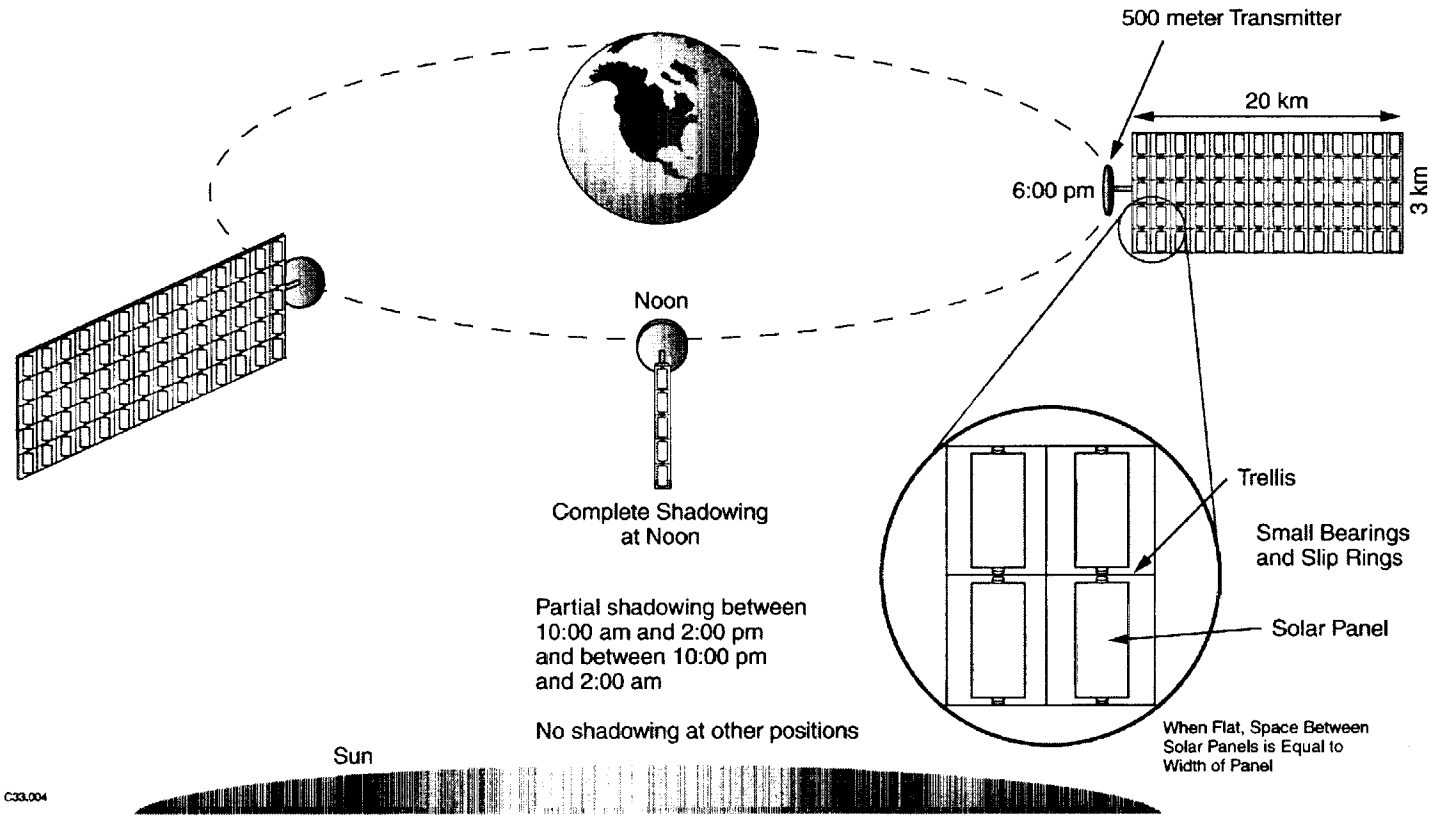
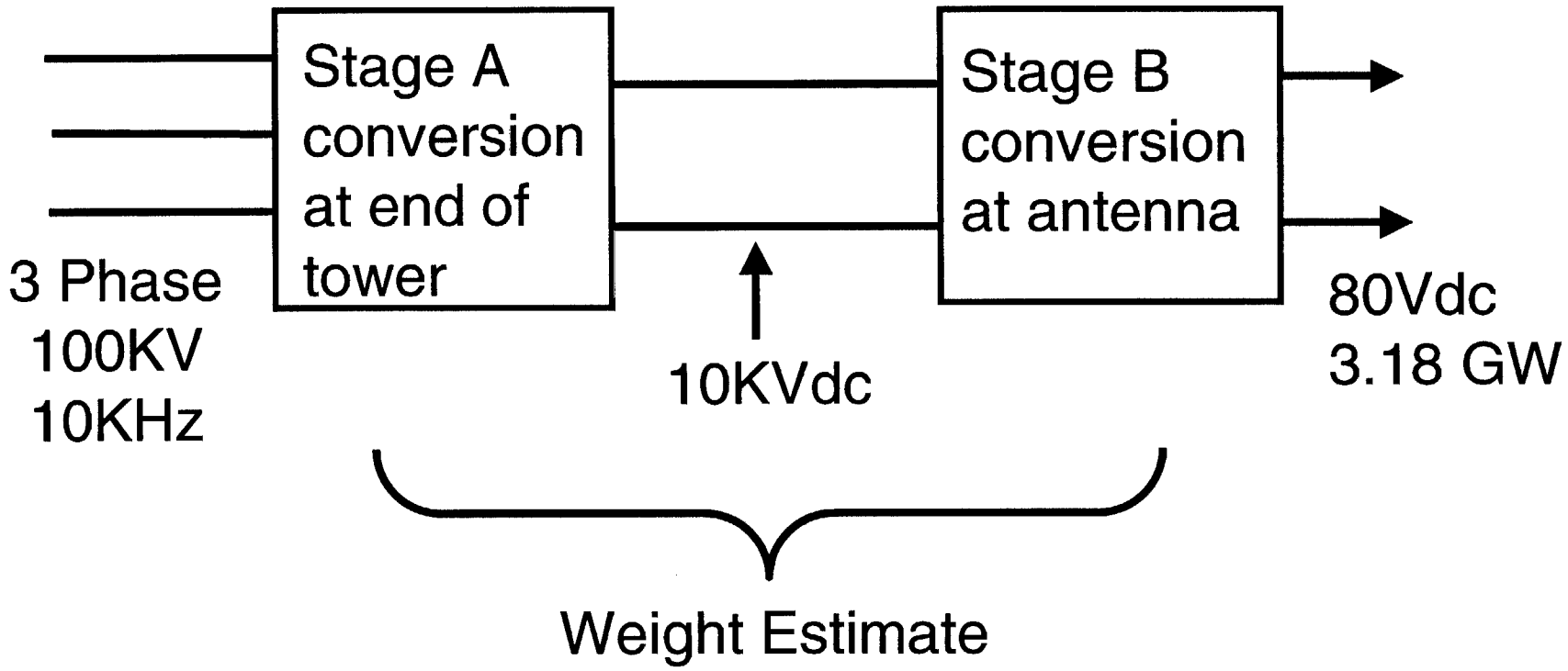
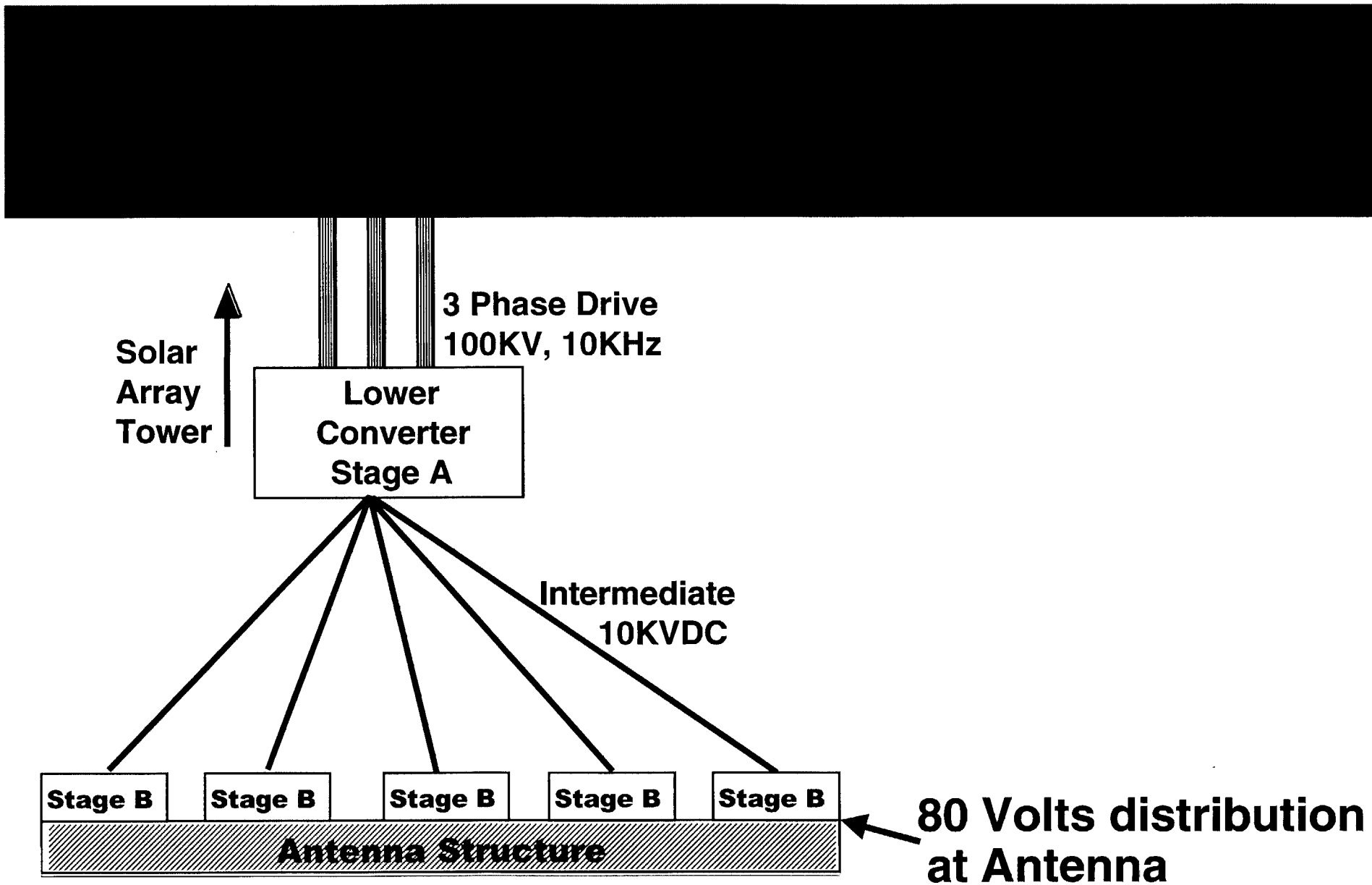
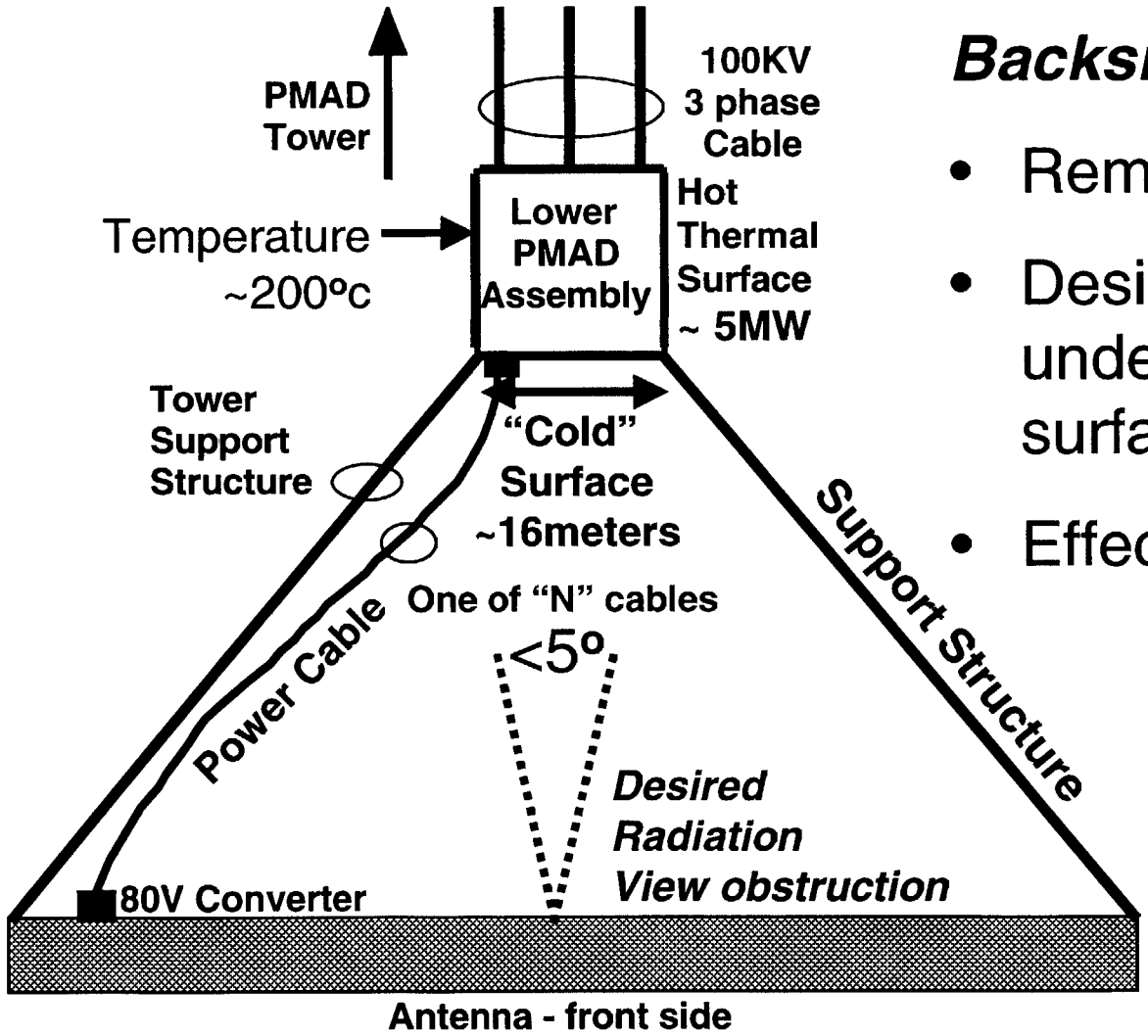
- Architecture
- Backside Thermal View
- Solar Array Interface
- Transformer design & risks
- Twelve phase rectifier
- Antenna(80V) Converters
- Distribution Cables
- Weight analysis
- Summary & Conclusions

- Transmitter always faces Earth
- Trellis framework fixed to transmitter
- Individual panels rotate to face Sun



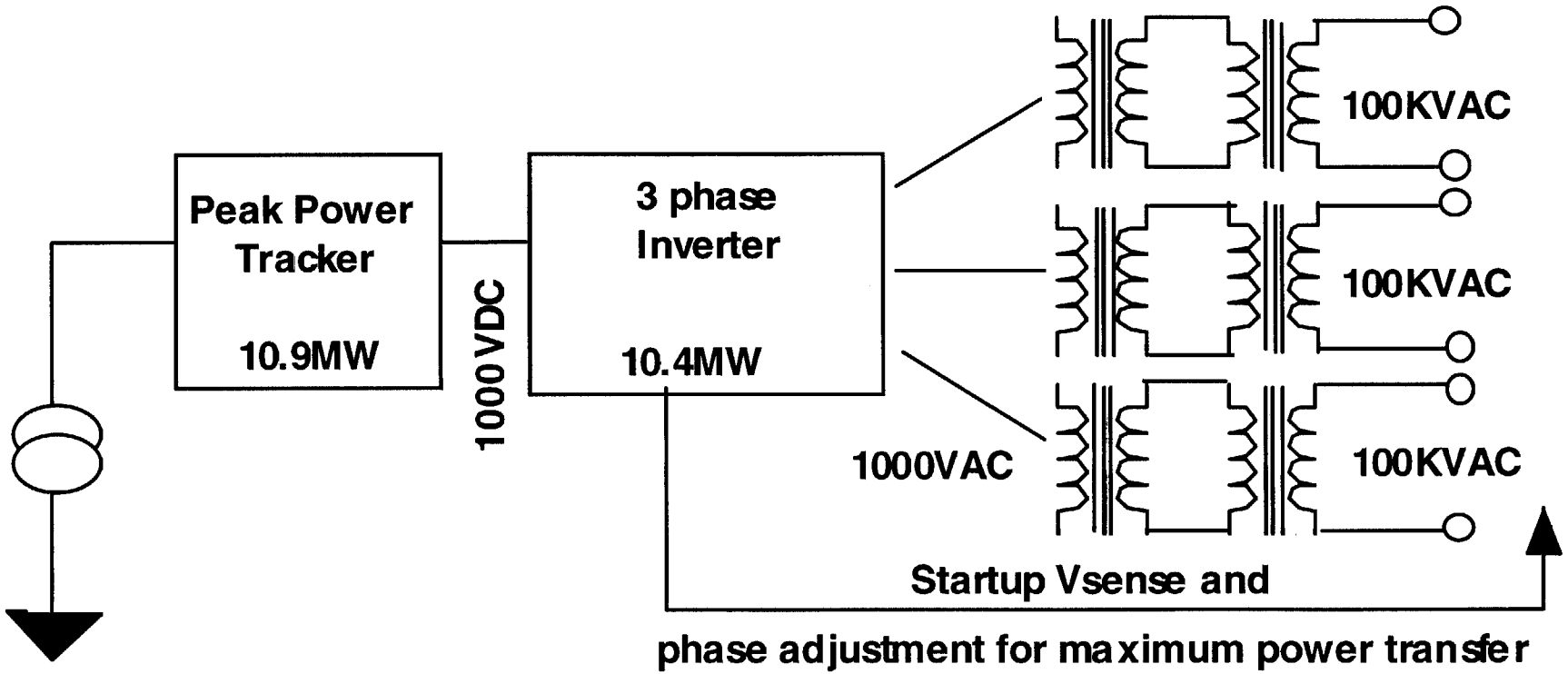

Stage A
conversion
at end of
tower
Stage B
conversion
at antenna
3 Phase
100KV
10KHz
10KVdc
80Vdc
3.18 GW
Weight Estimate


3 Phase Drive
100KV, 10KHz
Solar
Array
Tower
Lower
Converter
Stage A
Intermediate
10KVDC
Stage B
Stage B
Stage B
Stage B
Stage B
Antenna Structure
80 Volts distribution
at Antenna



Backside thermal view

- Remote locate PMAD
- Design for cold underside PMAD surface
- Effect of cable heating?


Peak Power Tracker
10.9MW
1000VDC
3 phase Inverter
10.4MW
1000VAC
100KVAC
100KVAC
100KVAC
Startup Vsense and
phase adjustment for maximum power transfer

Transformer analysis

RF at Antenna	2.86E+09 watts
Antenna efficiency	90.0%
DC to Antenna	3.18E+09 watts

$$N_p = \frac{E \times 10^8}{4.44 f B_m A_e}$$

Stage1	Conversion to 10KV
Primary Voltage	100000 Vrms
Primary Current	93.5 Arms
Secondary Voltage	10000 Vrms
Secondary Current	934.6 Arms
Frequency	10000 Hz
Bmax	5000 gauss
Area of core	50 cm^2
Stacking Factor	80% (1 mil tape)
Effective core area	63 cm^2
Core dimension	7.9 (sq core)
Core Length	557 cm
Core volume	27835 cm^3
Steel weight	0.0161 lbs/cm^3
Core weight	359 lbs

	Primary	Secondary
Turns	901	90
Wire Size	4	8 "O"s
Wire Area	0.2105	2.1
Insulation fill factor	80%	80%
Winding Area	948	954
Window Fill Factor	0.5	
Window area	3805	
Window side length	61.7	
Wire weight	0.0203	
Winding length	23.72	
wire volume	9024	
Wire Weight	183	
Transformer Weight	542	
Transformer Volume	788,316	
Core Loss, W	35,900	

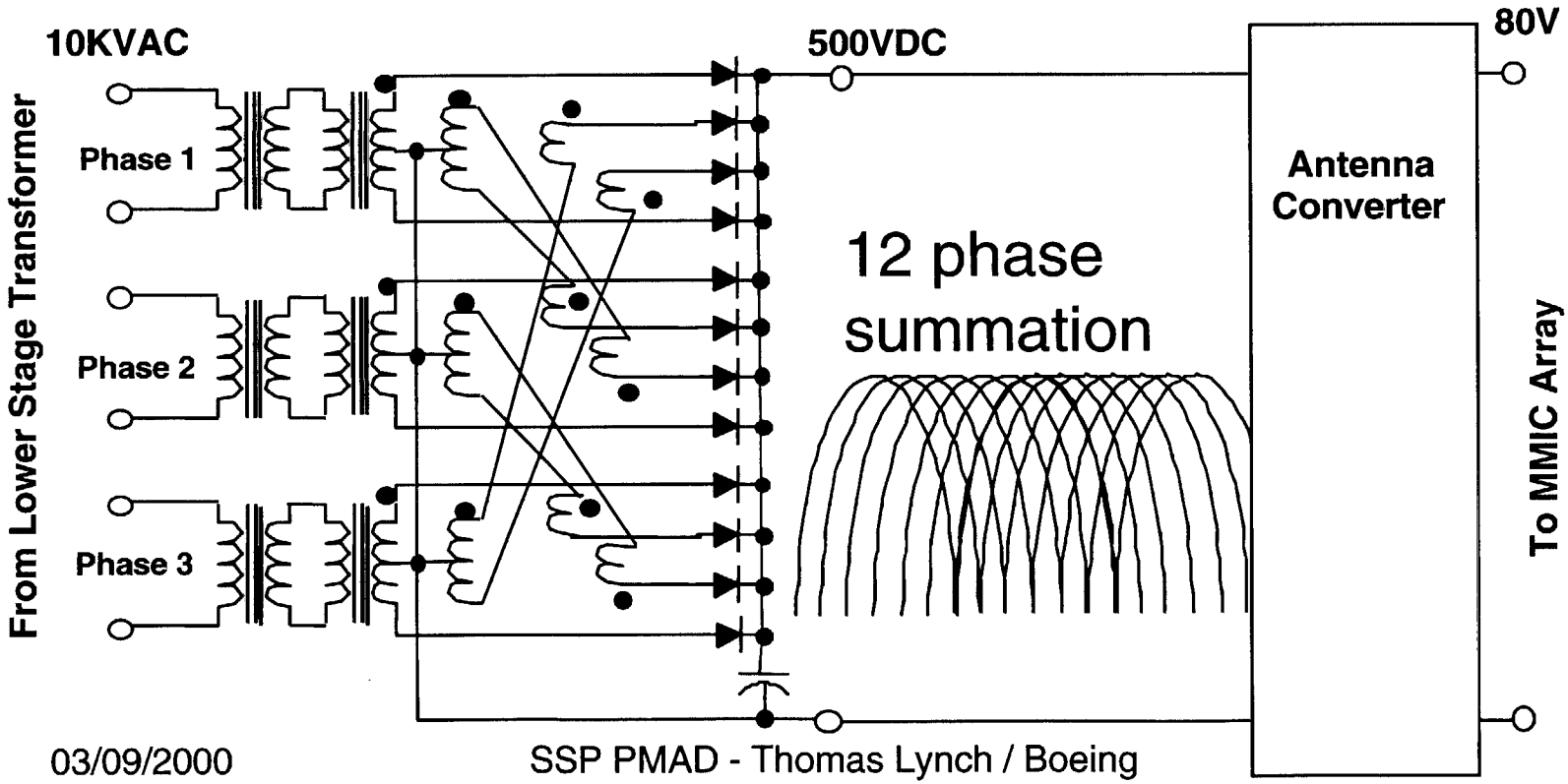
Transformer Risk

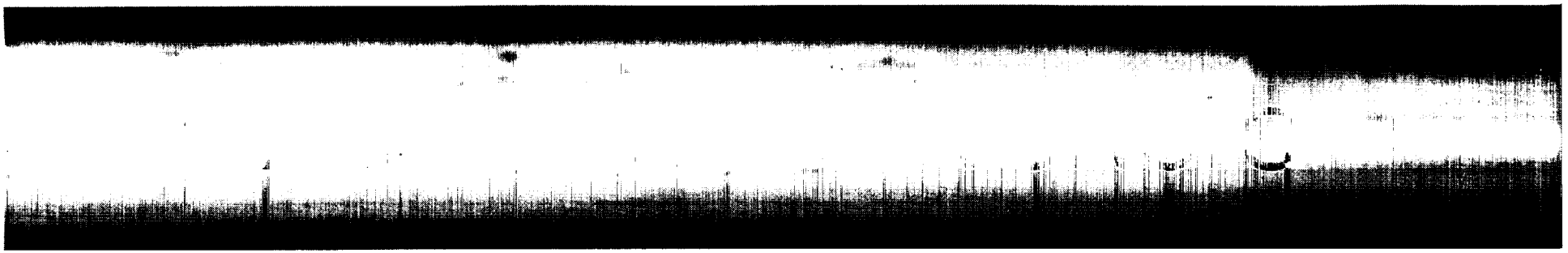
- Leakage inductance of 10:1 ratios (x2)
- Corona, interwinding & distribution
- Dielectric voltage stress
- Core dissipation
- Interface to 100KV lines
- Potting or Oil filled
- Operation at 200°C

12 Phase Rectifier

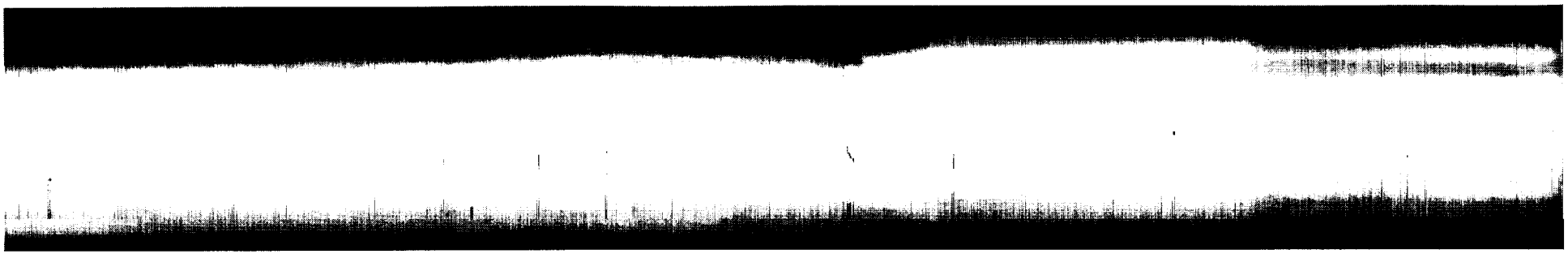
Advantages

- Simplicity
- Rugged & robust
- Excellent power factor





- Architecture
  - 80 VDC output
  - 500VDC input
  - 4488 watt module for 64 MMICs
  - Current limit to 80V grid
  - Redundancy with “N+1” converters per module
  - Weinberg topology



Transformer 3ph	4488W	
Weight	2	kg
Volume	8,503	cm3
Length	20.4	cm
Dissipation	105	Watts
Module Power	4488 W	
Volume	1,471	in3
Length	28.9	cm
Weight	9.0	lbs
	4.08	kg
Dissipation	224.4	Watts
Total		
Weight	6	kg
Volume	9,974	cm3
Length	21.5	cm
Dissipation	329	Watts

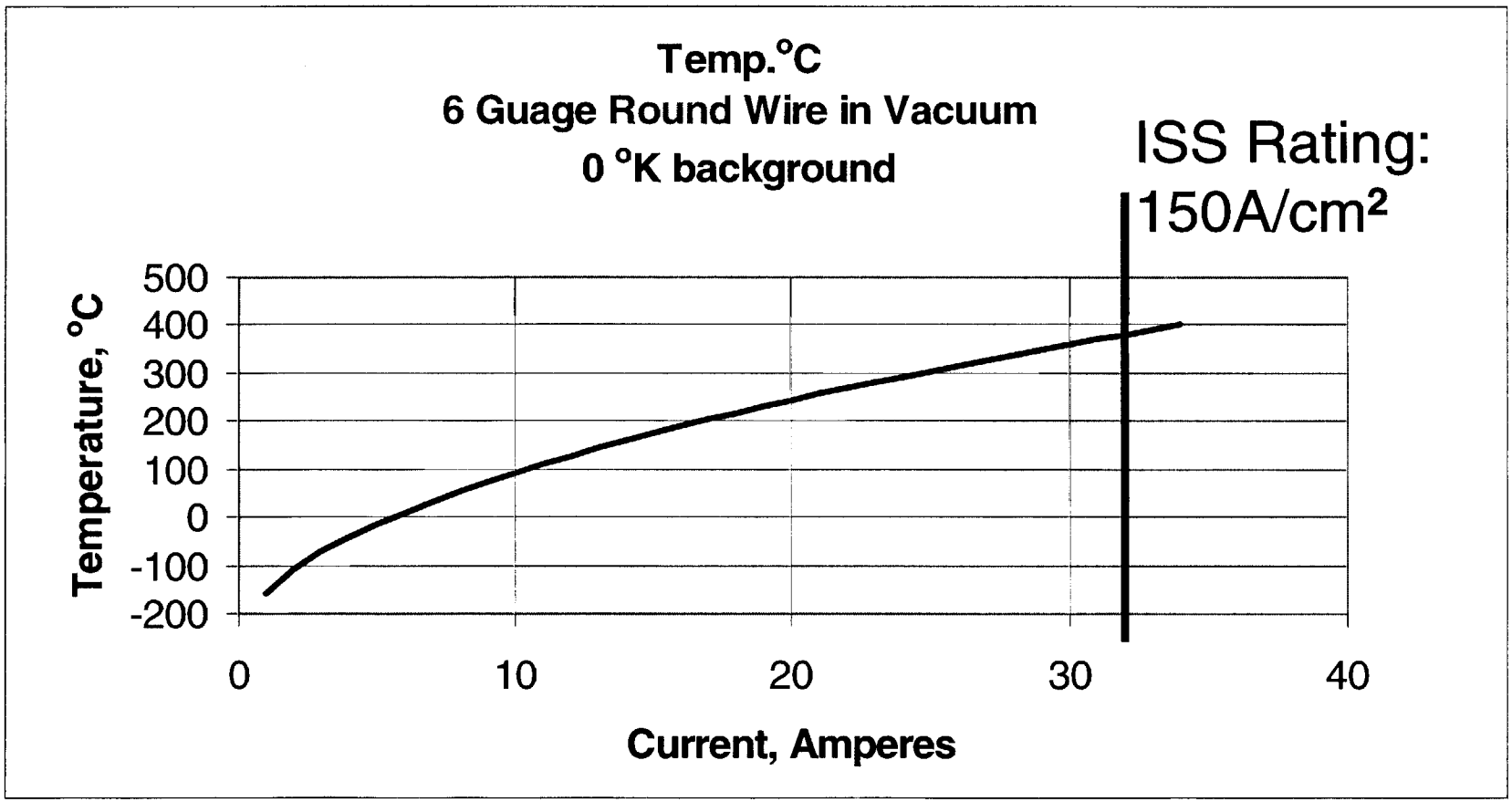
Assumptions:

10KV 3 phase AC input

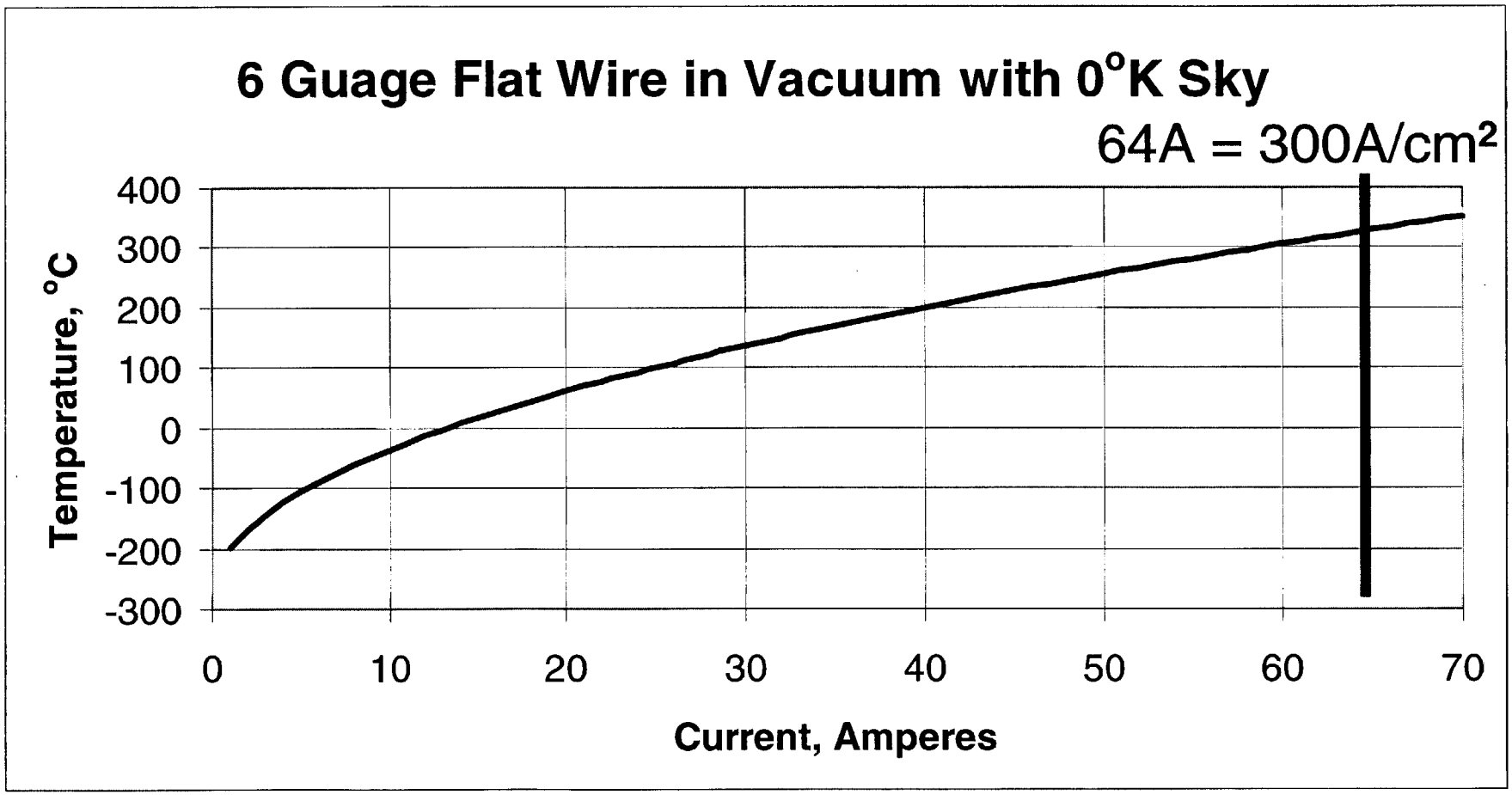
80VDC output at 4488W

Efficiency	95%
Density	500 w per lb
Volume	50 w per in^3

State-of-the-Art


Temp.°C
6 Guage Round Wire in Vacuum
0 °K background
ISS Rating:
150A/cm²
Temperature, °C
500
400
300
200
100
0
-100
-200
0
10
20
30
40
Current, Amperes

Could double ISS Current Rating with Flat Wire

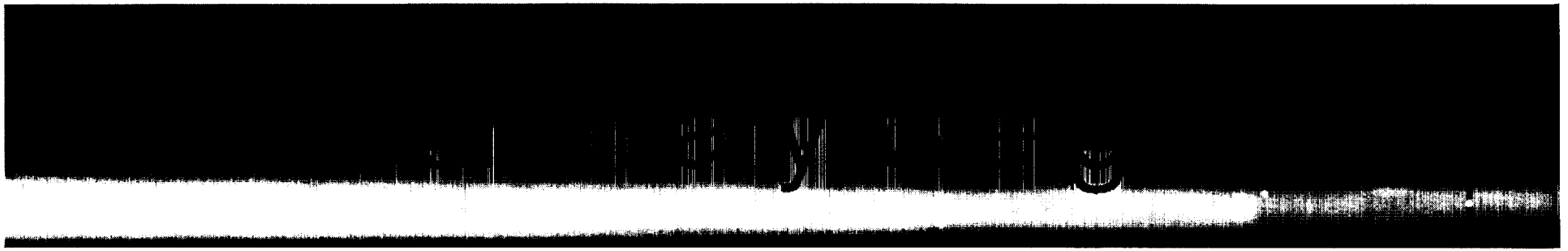


Assuming use 300A/cm^2 current density with flat wire
935 Amperes at 10KVDC per cable

Antenna Distribution Cables

	Qty	Length, m	kg per cm^3	Area, cm^2	Weight, kg	
Hot	**340**	**200**	**9.21E-03**	**3.12**	**1.95E+05**	**kg**
Return	**340**	**200**	**9.21E-03**	**3.12**	**1.95E+05**	**kg**
				Total	**3.90E+05**	**kg**

- Trade must be done to evaluate use of smaller cables
- Radiation occlusion from dark sky from other structures
- Adjacent cables cloud view of dark sky
- Careful attention to termination of small cables



At 3.18 GW to 500 meter Antenna

	kg	kg/kw
Array Converters	3,362,061	1.06
Upper Transformer	88,712	0.03
3 phase cable	1,463,049	0.46
Lower Transformer	88,712	0.03
Distribution Cables	390,296	0.12
Antenna Converters	2,890,909	0.91
Total	8,283,740	2.61

PMAD Risks

Issue	Straw man	Risks
Cable Voltage	100KV	Corona, plasma, cable weight
Power cable Topology	Single Cable, 3PH 10KHz AC drive	Weight, Spaghetti distribution, Feed access, coupling & drive
Array Voltage	1KV and higher	Corona, rotary joints
Grounding, plasma, corona	Exterior surfaces of PMAD to be at structure ground	Insulator interface degradation & failure due to voltage gradients
Command & Control	Autonomous status & control from each node	Failure analysis, distribution imbalance
MTBF & MTTR	Careful topology design trades and mechanical interface design	Connector interfaces prevent disassembly

- Cable usage at higher current density
- Re-visit weight on all fronts
- Evaluate solar array point drive
  - Single cable access with 10.3MW drive/node
- Tower termination at antenna
  - PMAD interface & distance from antenna
  - Thermal radiation shield for antenna
  - Wire distribution to antenna
- Invest in PMAD R&D