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# TIMED IEM DC/DC Converter Cards

**Deanna Temkin**

**301-953-6000 x7519**

**temkindk@jhuapl.edu**

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# TIMED IEM DC/DC Converter Cards

- **Goal:**
  - **Minimize cost and development time by using standard high-rel "off the shelf" hybrid dc/dc converters with MIL-STD-883 screening.**
  - **Minimize risk by picking models from two sources which have the same footprints and same electricals.**
  - **Unique requirements handled by in-house custom design.**

# TIMED IEM DC/DC Converter Cards

- **QA Requirements:**
  - **MIL-STD-1772 Certified facility preferred (Requirements for hybrid facility & production line)**
  - **MIL-PRF-38534 Certified (Requirements for element evaluation, process control, device screening, inspections etc. of hybrid manufacturing), Class H parts with MIL-STD-883 test methods and PIND, XRAY, PreCap inspections**

# TIMED IEM DC/DC Converter Cards

- **Environmental Requirements:**
  - **Vibration**
    - » **Box Level 14.1 Grms, 1 min per axis**
  - **Radiation**
    - » **Expected Total dose < 5krads**
    - » **No SEU can impact mission and no Latch up allowed**
  - **Temperature**
    - » **Flight operational**
      - **Baseplate -19 to 45 °C (predicting -20 to 30 °C)**
    - » **Qualification operational**
      - **Baseplate -29 to 55 °C**
    - » **Survival**
      - **Baseplate -34 to 60 °C**

# TIMED IEM DC/DC Converter Cards

- **Input Electrical Requirements:**
  - **Operational Input voltage: 22 to 35 V**
  - **Operational input voltage transients : 22 to 35V and 35 to 22V in < 5ms**
  - **Survival Input voltage: 0 to 22 V and 35 to 40 V**
  - **Survival input voltage transient: drop-out down to 0V for 2 to 50ms (rise and fall time <2ms) then up to 40V for 50ms**
  - **Conducted susceptibility: Survive CS01-02 2Vpp 10Hz to 400MHz, CS06 56V for 10uS per Mil-STD-461, 462**
  - **Conducted Emissions: CE01-03 per 7363-9038 TIMED EMI/EMC spec**
  - **Inrush current: < 2.5Apeak after first 10uS (at relay turn ON)**
  - **Slow input voltage ramp up: Bench testing, no instabilities allowed**

# TIMED IEM DC/DC Converter Cards

- **Output Electrical Requirements** (expected performance of hybrid dc/dc converters):
  - Line regulation: +/- 1%
  - Load regulation: +/- 1%
  - Cross regulation: +/- 3% (Loading of cross regulated outputs are within 30% of each other)
  - Switching Ripple: <100 mVpp (550kHz)
  - Switching Spike: <150 mVpp (10MHz)
  - Step load response: +/-3% (20% of full load step)
  - Input transient response: +/- 2%
  - Efficiency (28Vin): >=75% at max rated load
  - Output voltage survival overshoot, 15ms duration: 3.3V=4.125V, 5V=6.25V, 9V=11.25V, 12V=15V, 15V=18.75V

# TIMED IEM DC/DC Converter Cards

- **Special Requirements:**
  - **Power on Reset**
    - » **Reset line held low when +5V digital power is below 4.5V. Maintain reset line low for min. of 10mS after +5V digital power is within its regulation range.**
  - **Sequence of XMTR/Dwnlink Analog Power**
    - » **At TURN ON: -5V_A must be above |-4V| for 5mS before +9V_A and +5V_A are allowed to turned on. At TURN OFF: -5V_A must remain above |-4V| for 5mS after +9V_A and +5V_A have fallen to below 0.5V.**

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## TIMED IEM Secondary Voltages and Peak Currents

| | IEM Unsw PWR | | | | IEM SW PWR | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| IEM Card | Dig +5V Amps | Ana +12V Amps | Ana +5V Amps | Ana -5V Amps | Dig +5V_1 Amps | Dig +5V_2 Amps | Dig +3.3V Amps | Ana +5V Amps | Ana -5V Amps | Ana +9V Amps | Dig +12V Amps | Ana +15V Amps | Ana -15V Amps |
| Uplink-RCVR | 0.31 | 0.07 | 0.50 | 0.05 | | | | | | | | | |
| Downlink-TR | | | | | 0.17 | | | 0.53 | 0.05 | 0.93 | | | |
| CMD&HSKP (includes TLM Acq) | | | | | 0.09 | | | 0.01 | | | | 0.01 | 0.04 |
| GPS | | | | | 2.20 | | | 0.17 | | | 0.12 | 0.02 | 0.01 |
| C&DH | | | | | | 1.80 | | | | | 0.14 | | |
| SSR | | | | | | 0.80 | 0.55 | | | | | | |
| 7 External RIUs | | | | | | | | | | | | | |
| | 1.57 | 0.88 | 2.51 | 0.27 | 12.29 | 13.00 | 1.82 | 3.53 | 0.24 | 8.39 | 3.17 | 0.53 | 0.68 |

Total Peak Output PWR: 53.30 W

# TIMED IEM DC/DC Converter Cards

- **Required Custom Design:**
  - **Inrush Current Limit**
  - **Input Under Voltage Lock Out**
  - **Power on Reset**
  - **Sequence of XMTR Analog Power**
  - **+9V Output for XMTR**
  - **+3.3V Output for SSR**

# TIMED IEM DC/DC Converter Cards

- **Initial Search:**
  - **Modular Devices, CMAC (Abbot), Lambda Advance Analog, and Interpoint**
- **Detailed Evaluation:**
  - **Electrical, vibration, and radiation testing on LAA and Interpoint models (units with same footprint and output power levels)**

# TIMED IEM DC/DC Converter Cards

- **Evaluation Conclusion:**
  - Both Interpoint and LAA units meet vibration and radiation requirements
  - LAA has some improved electrical performance
    - » step loads (ATR vs MTR)
    - » no output overshoot
    - » reduced switching noise (> 2MHz)
- **Manufacturer Selected:**
  - Lambda Advanced Analog (using AHF, ATR converter families and AFV461 input filter)
- **Backup:**
  - Interpoint (using MHF+, MTR converter families and FMC461 input filter)

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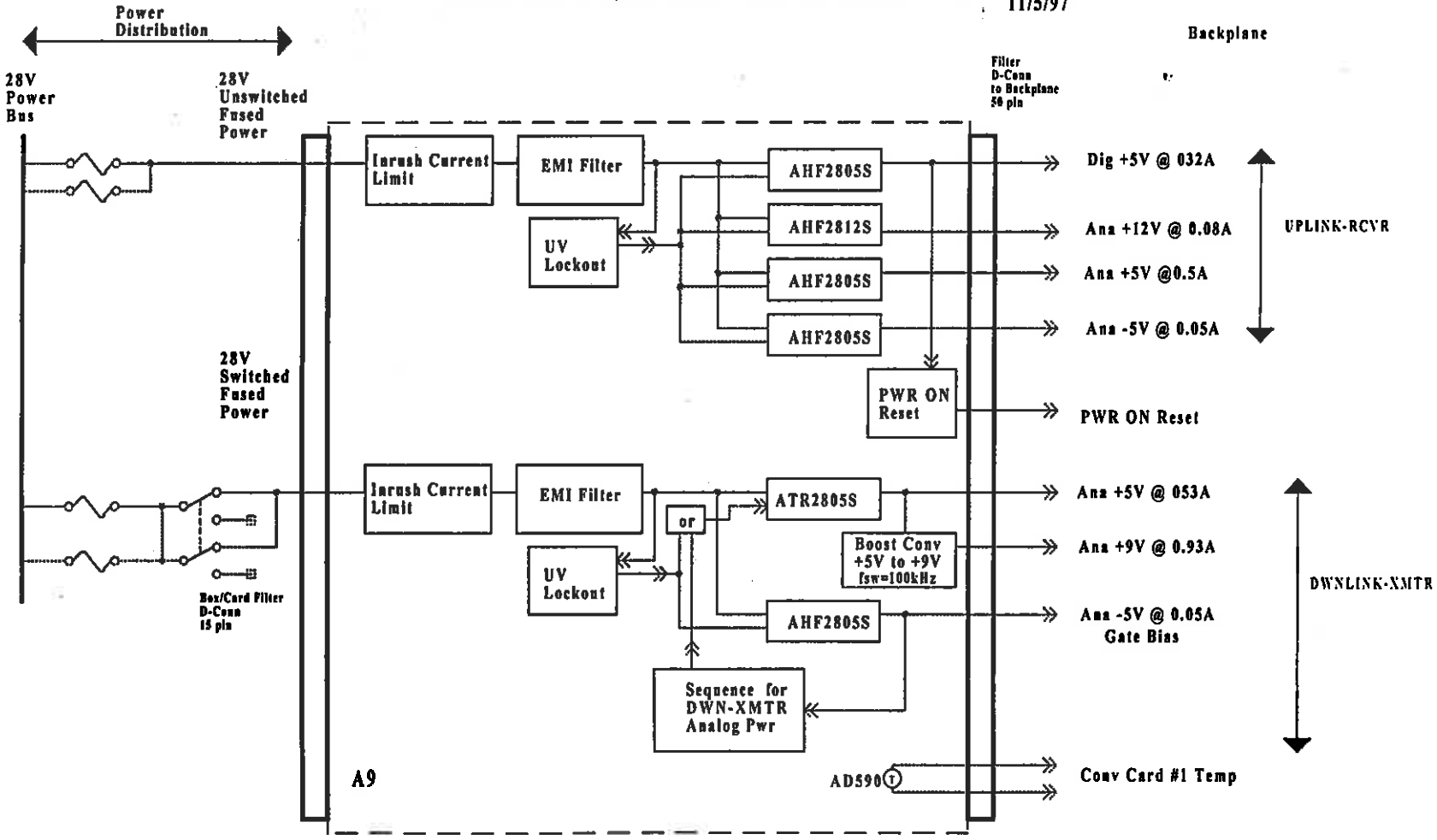
## TIMED IEM DC/DC CONVERTER CARD - A9 11/5/97




DKT-11

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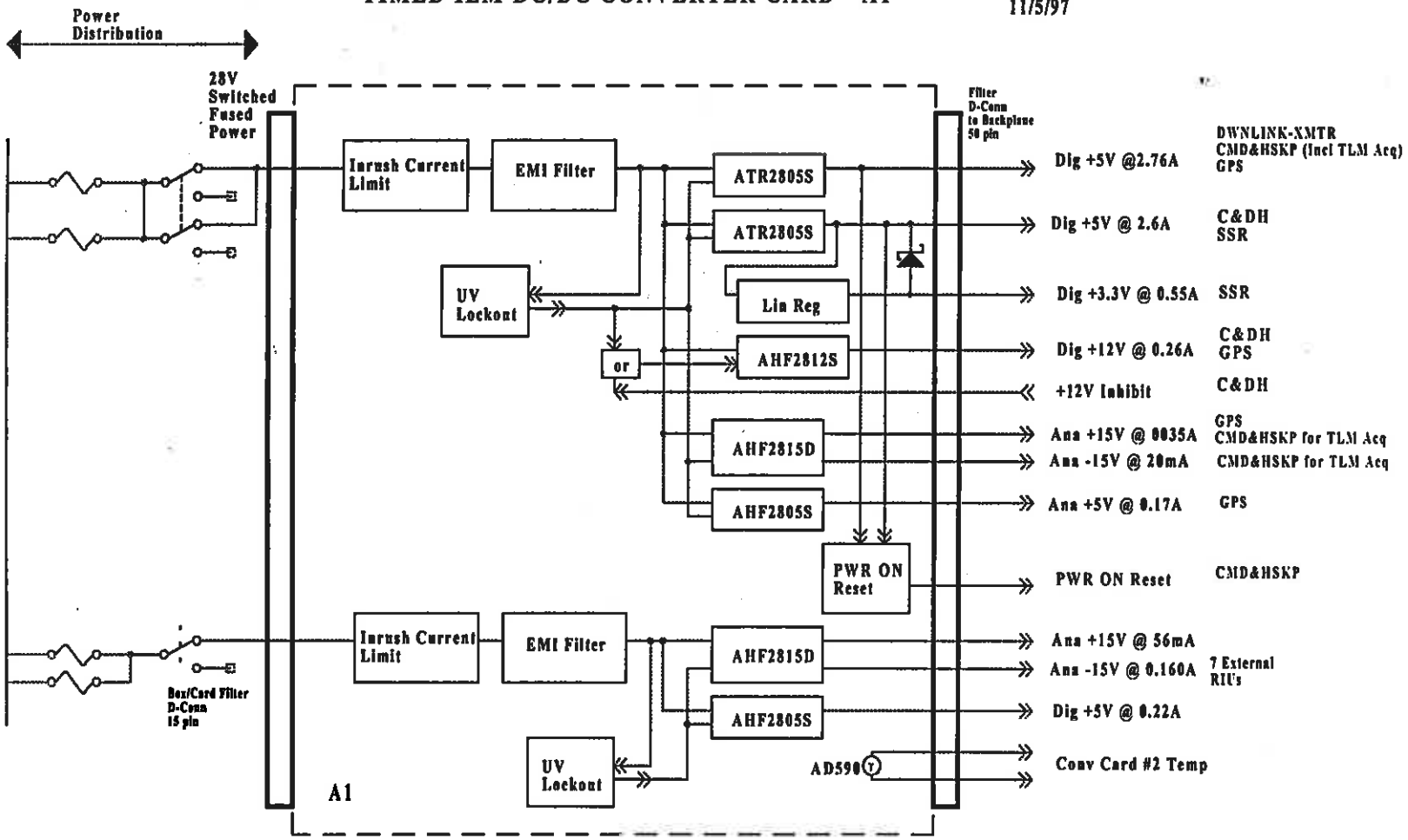
## TIMED IEM DC/DC CONVERTER CARD - A1

11/5/97



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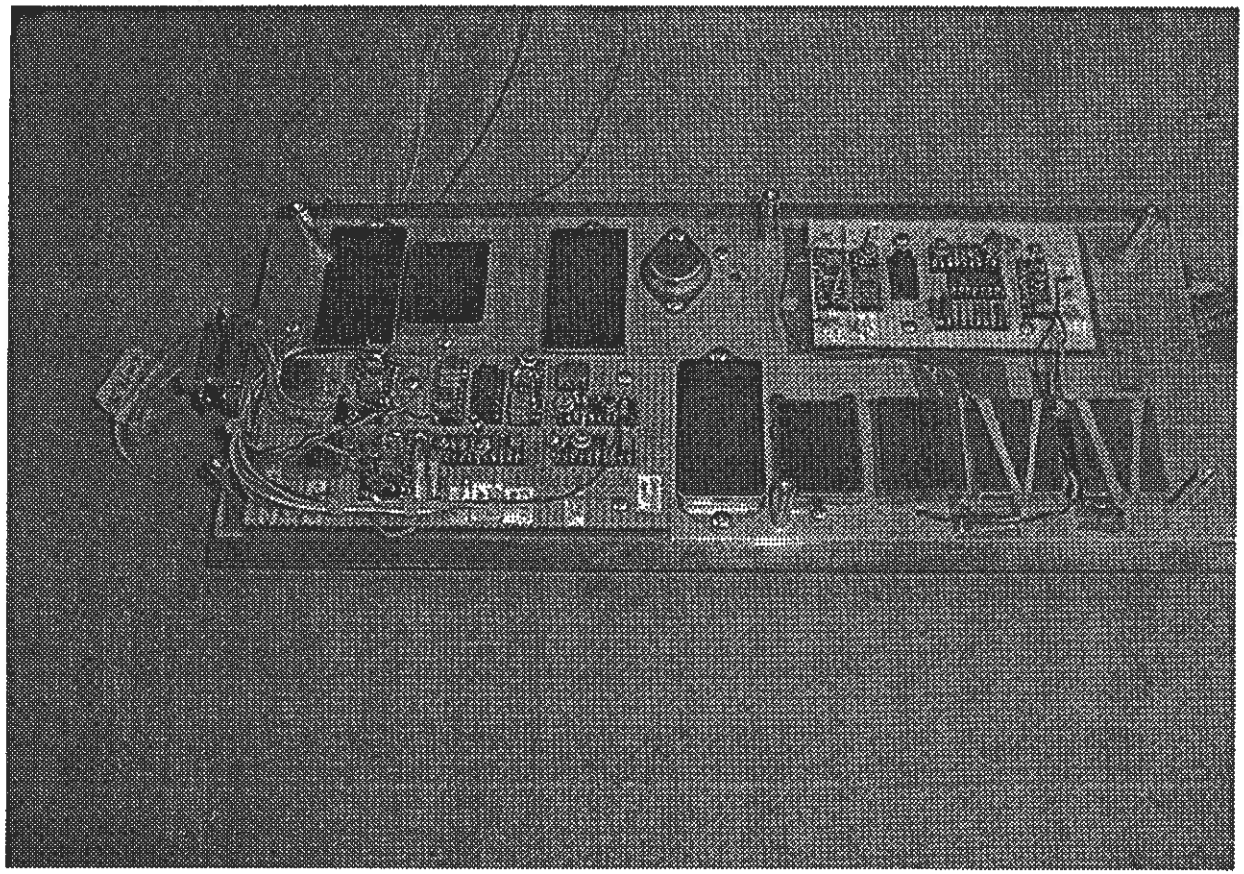

## A9 Power Converter Breadboard

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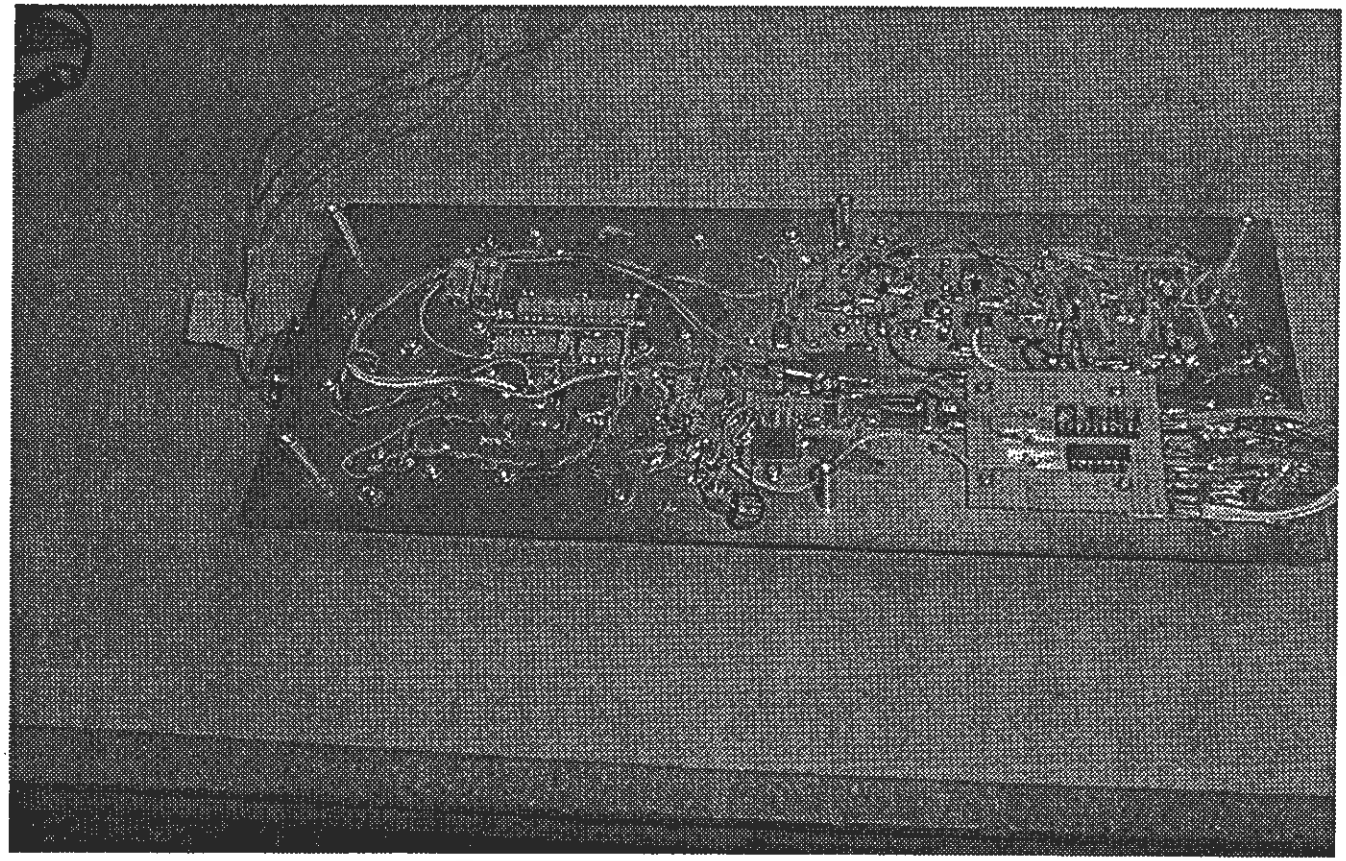
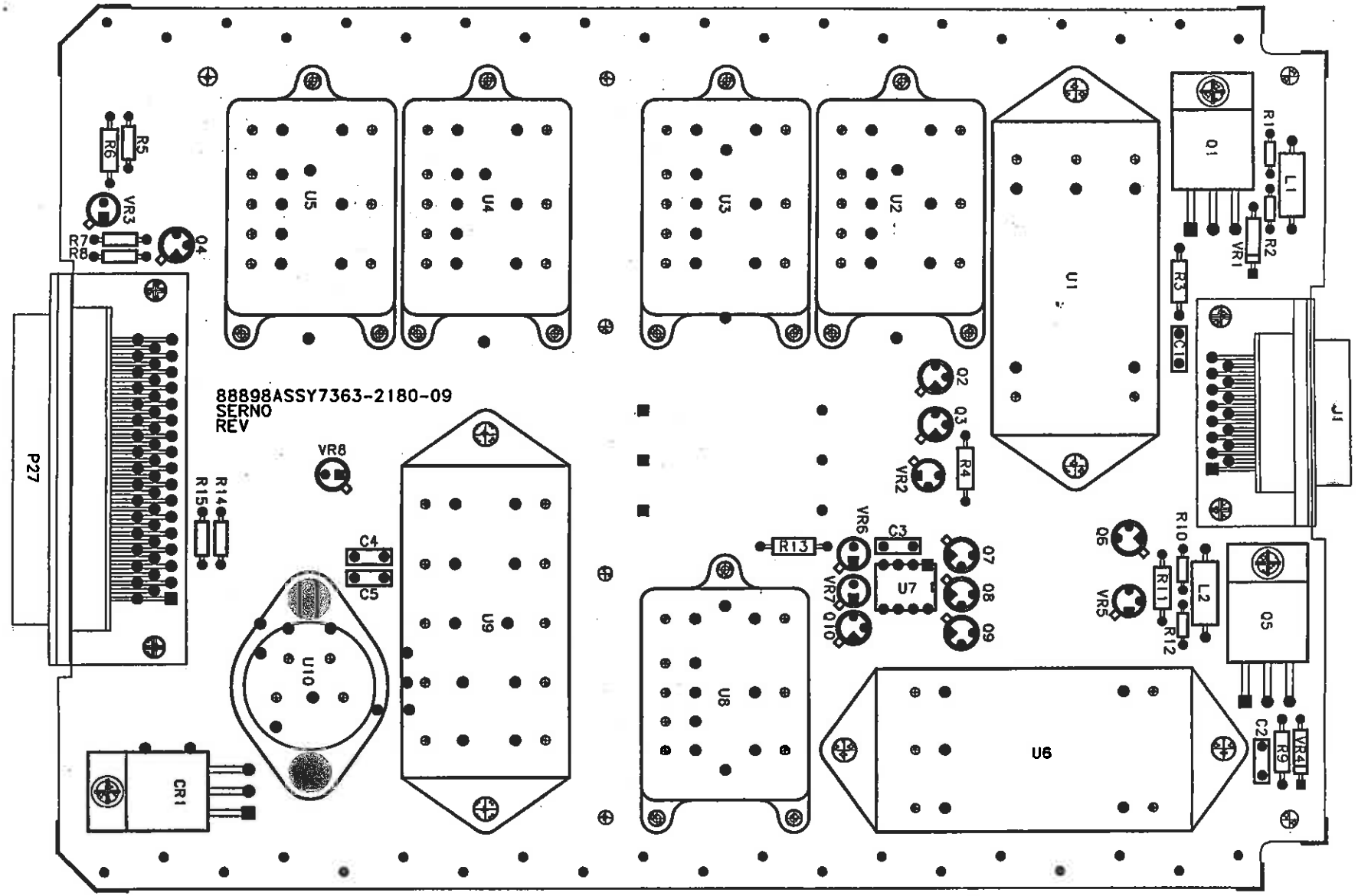
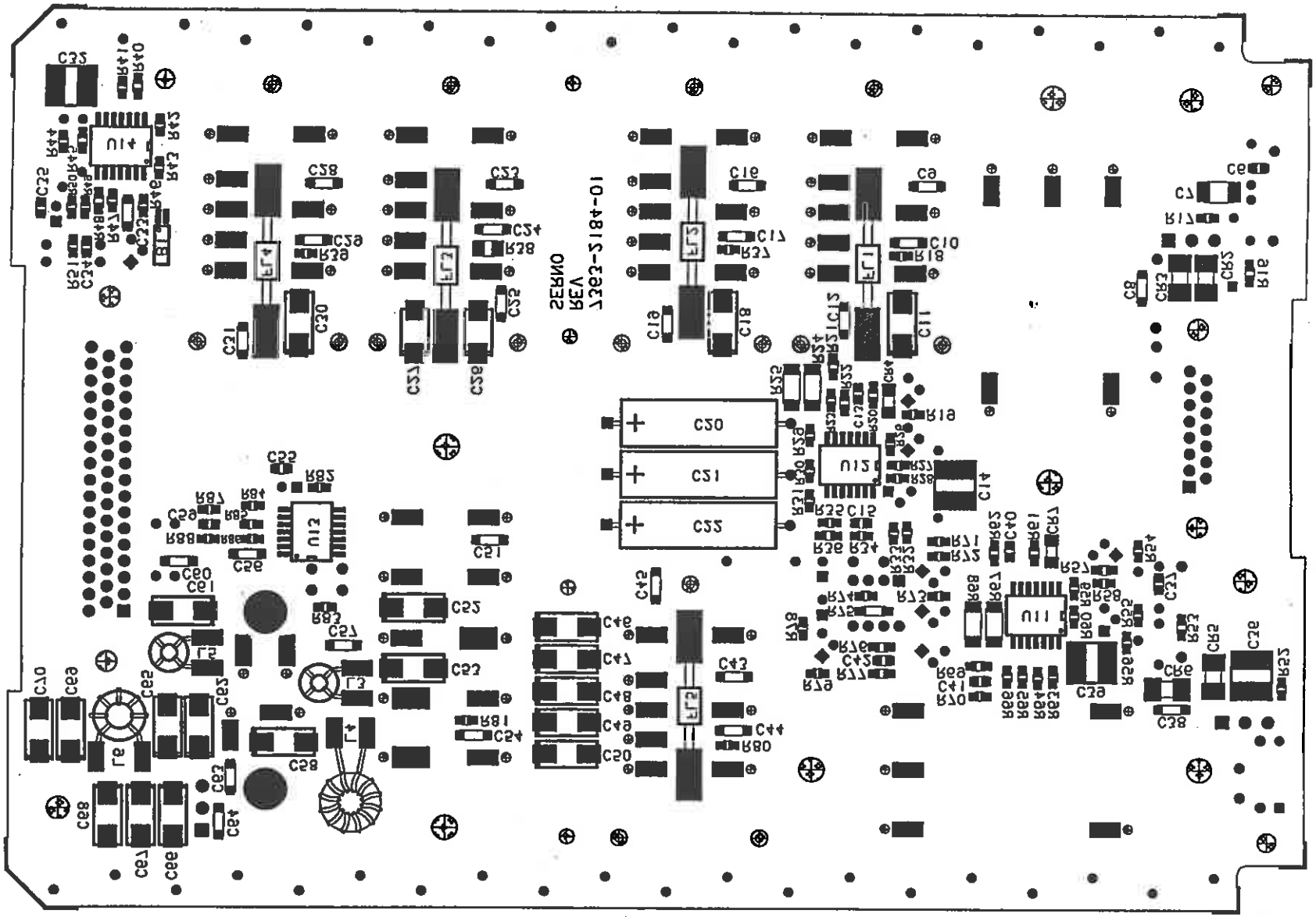


## A9 Power Converter Breadboard




# Placement A9 (Top Side)



# Placement A9 (Back Side)

**Breadboard Test Data Summary**

| Parameter | Spec/Expect Value over T | Measured Value @ 25°C | Units |
|---|---|---|---|
| Load Regulation<br>0A to max load<br>*0.3% due to voltage drop on BB card | +/-1 | +/-1.1 | % |
| Initial Accuracy | +/-1 | 0.42 | % |
| Line Regulation | +/-1 | 0.16 | % |
| Efficiency Dwnlnk BB, 28V<br>* Only includes converters @ max rated pwr<br>**Complete BB @ max rated pwr=50W | 75* | 72** | % |
| Efficiency Uplnk BB, 28V<br>* Only includes converters @ max rated pwr<br>**Complete BB @ max rated pwr=50W | 75* | 76** | % |
| Switching Ripple | 100 | 20 | mVpp |
| Switching Spike | 150 | 20 | mVpp |
| Step Load Response<br>for +5V digital pwr (20% of full load) | +/-3 | +/-1.4<br>Istep=1A | % |
| CS01 Rejection : 2Vppin | +/-2 | 1 | % |
| CS06 Rejection | +/-2 | 0.6 | % |
| Output Turn On Transient | 10 | 10 | % |
| Output Response due to<br>Survival Transient | 25 | 10 | % |
| Inrush Current | 2.5 | 2.2 | A |
| CE03 at fsw=550k | 38 | 30 | dBuA |
| Pwr Up/Dwn Sequence Timing | 5 | 15 | mS |

# TIMED IEM DC/DC Converter Cards

## Status and Work in Progress:

- **A9**
  - **Complete breadboard of power converter A9 has been built and tested. Integration with RF subsystem breadboard is ongoing.**
  - **Circuit design finished and schematic complete.**
  - **EM artwork routed.**
  - **Heat sink and assembly drawing complete.**
  - **EM parts in by 11/30/97**
  - **Flight parts in by 3/15/98**

# TIMED IEM DC/DC Converter Cards

## Status and Work in Progress:

- A1
  - Circuit design finished and schematic complete.
  - Artwork is being routed.
  - EM parts in by 11/30/97.
  - Flight parts in by 3/15/98.

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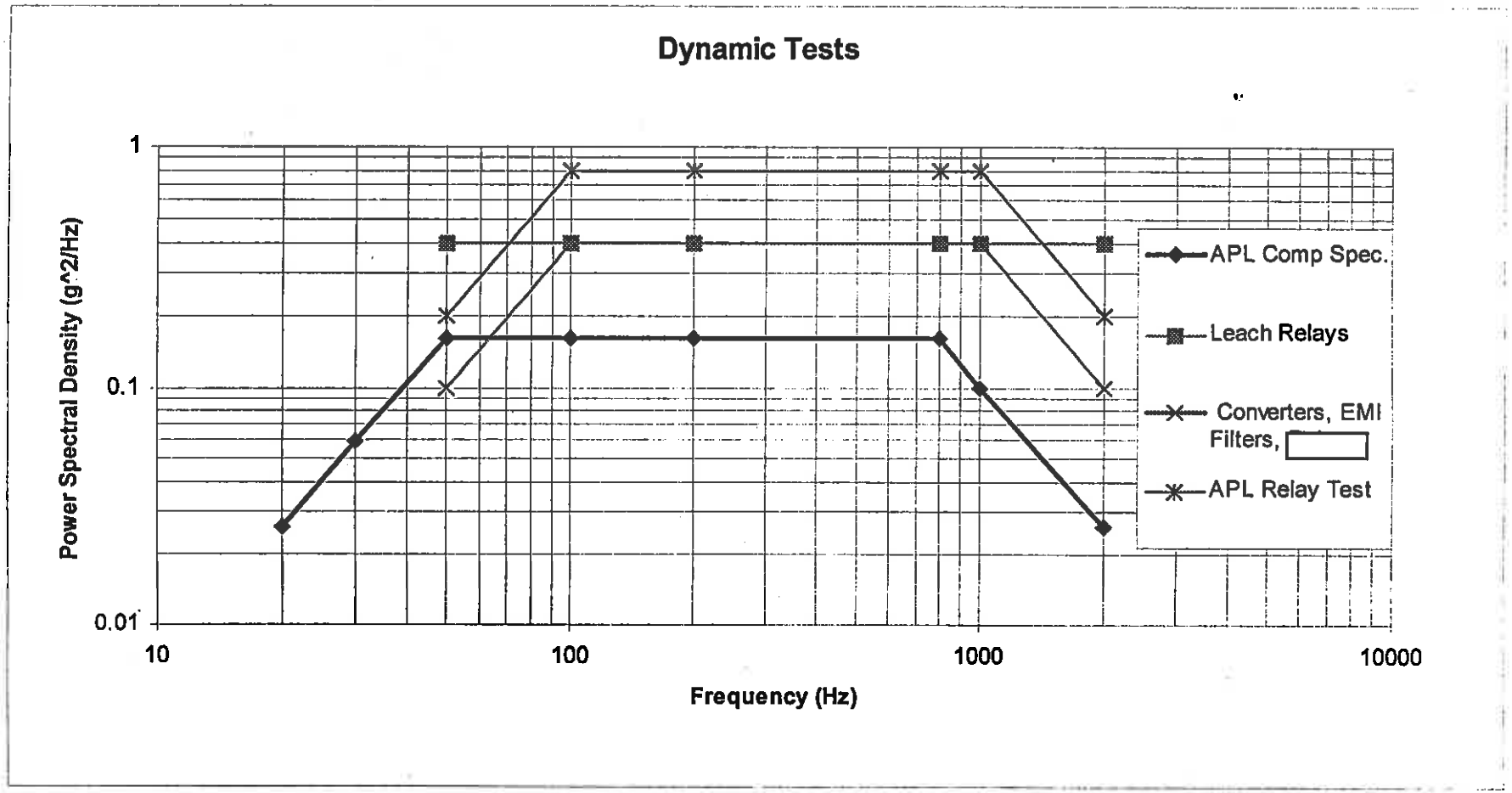
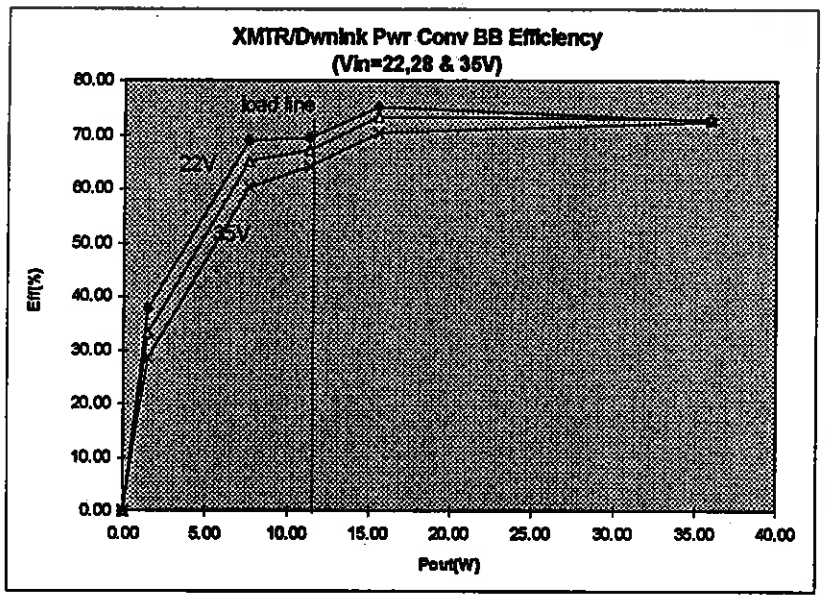
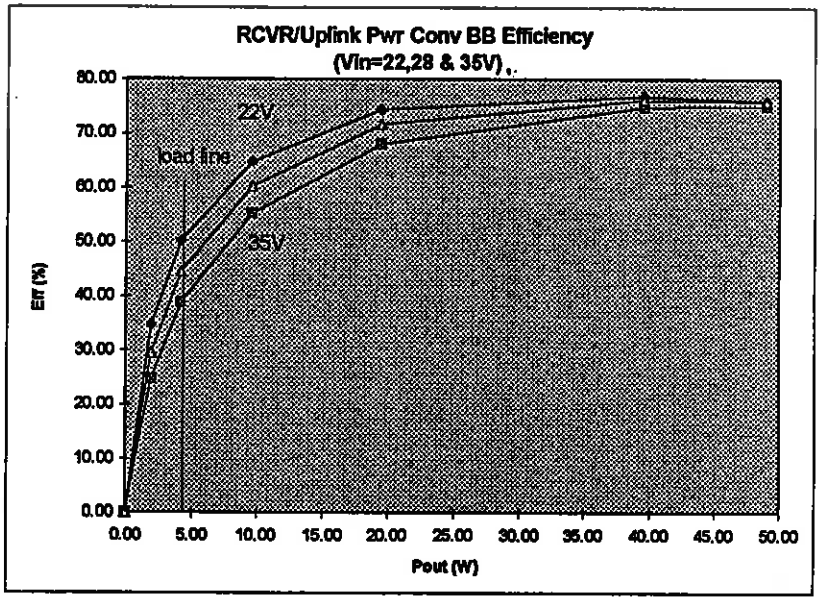
# TIMED IEM DC/DC Converter Cards

## Breadboad Test Data for Uplink and Dwnlink Power Converters




Converter and Filter Vibration Tests

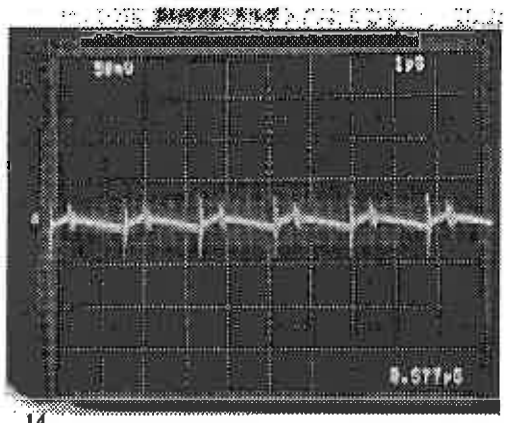



Power Converter BB Efficiency Measurements

no filter

Vout_ATR



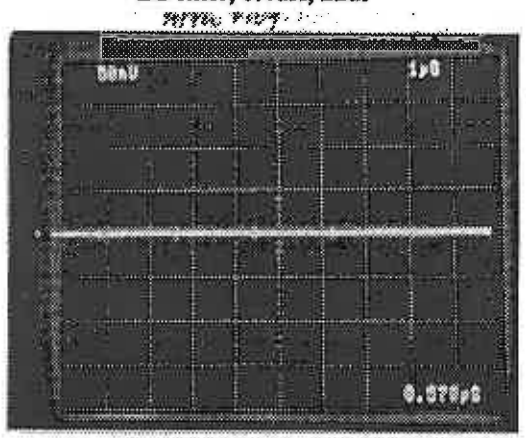
50mV/div

14

1uS/div

LC filter, 0.4uH, 22uF

+5V_A
after filt



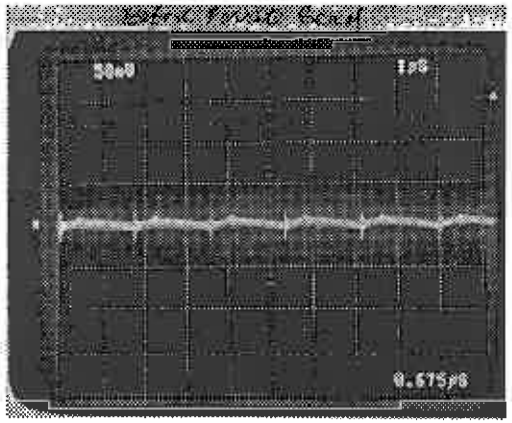
50mV/div

15

1uS/div

Cout = 47uF

+5V_A
after filt



50mV/div

16

1uS/div

Test: Measure switching ripple.
Summary: With LC filter switching ripple < 10mVpp
Conditions: Vin=34V, Iout=4A, +9V_A not connected.

ATR2805S and +5V_A Output Switching Ripple
(+9V_A not connected)
for Dwnlink Power Converter BB

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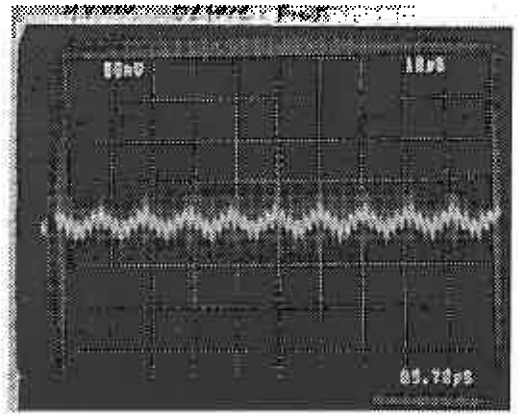
Cout=47uF

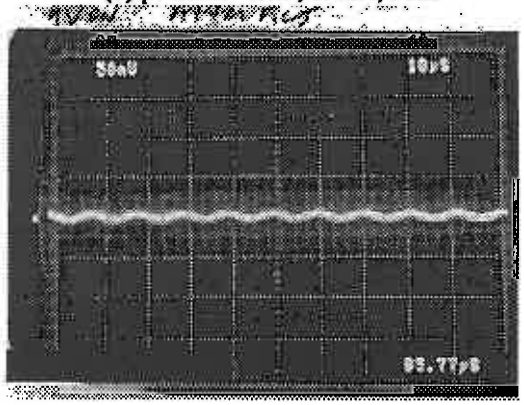


Vout_ATR

50mV/div

17 10uS/div

(1) pi filter: 47uF, 0.4uH, 22uF

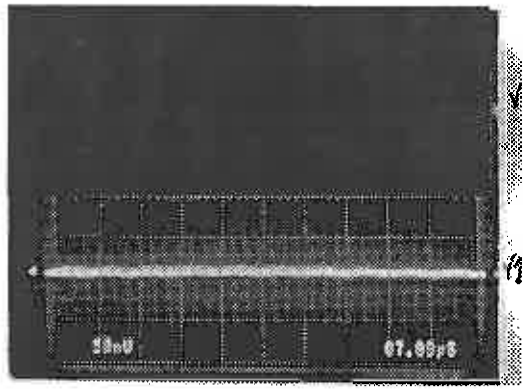


+5V_A after filt

50mV/div

13 10uS/div

(2) pi filter: 47uF, 0.4uH, 2 x 47uF



+5V_A after filt

50mV/div

12 10uS/div

Test: Measure switching ripple.
Summary: With LC filter (2) switching ripple < 20mVpp
Conditions: Vin=34V, +5V_A @ 1.5A, +9V_A @ 0.85A.

ATR2805S and +5V_A Output Switching Ripple
(+9V_A **connected**)
for Dwnlink Power Converter BB

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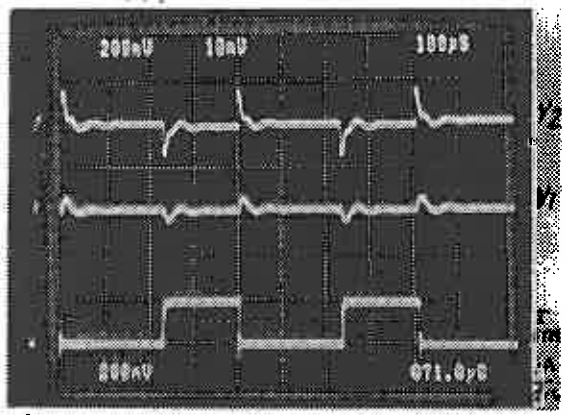
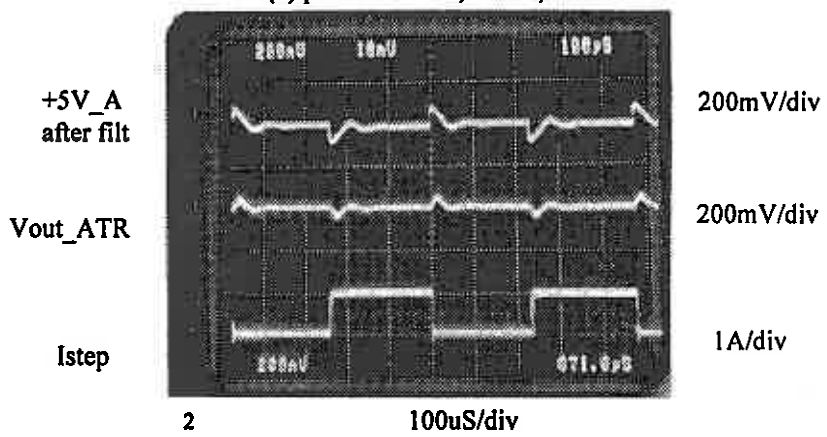
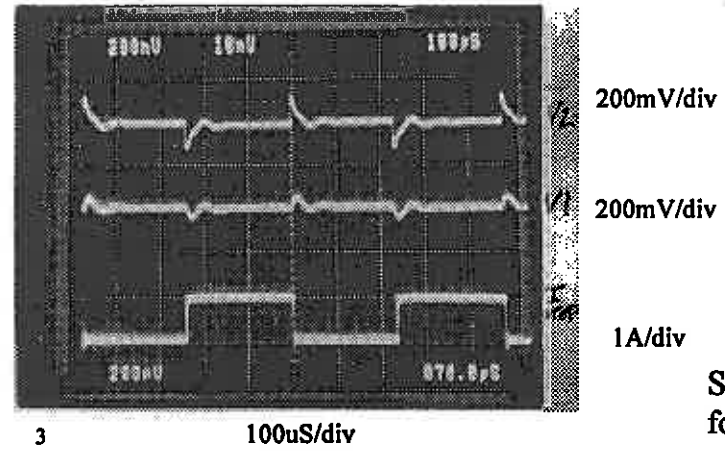
(1) pi filter: 47uF, 0.4uH, 22uF




(3) pi filter: 47uF, 0.4uH, 2 x 47uF




(2) pi filter: 47uF, 0.4uH, 47uF




Test:
Step Load Response with Different Output Filters - Istep=1A.

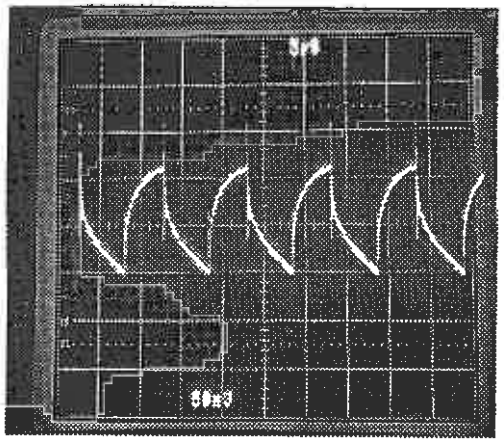
Summary: -
Converter response = 40mVpk.
Resulting output ripple is less than 70mVpk after filter using filter (3)

Conditions:
Vin=34V, +5V_A @ 1Adc.

Step Load Response for the ATR2805S Converter & Output Filter for Dwnlink Power Converter BB

Cout= 5 x 22uF

+9V_A

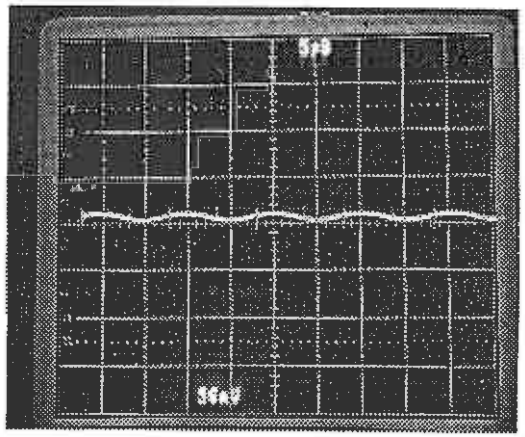


50mV/div

5uS/div

Cout= 5 x 22uF, LC= 1.4uH, 3 x 22uF

+9V_A

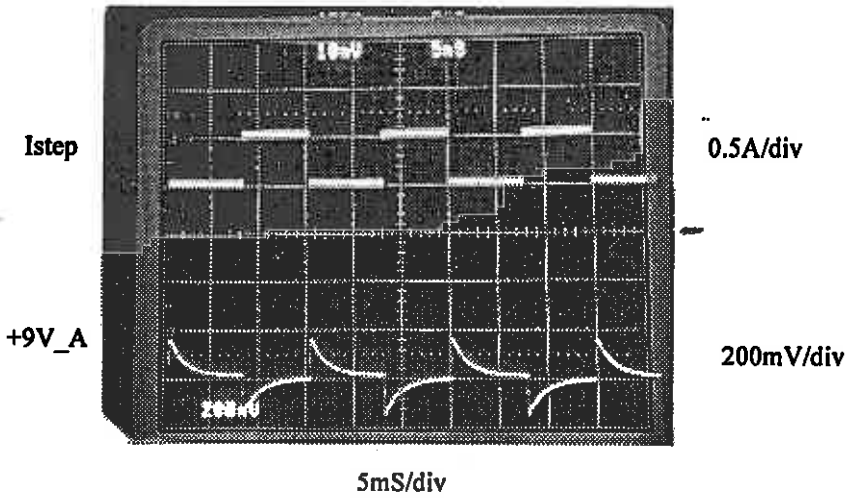


50mV/div

5uS/div

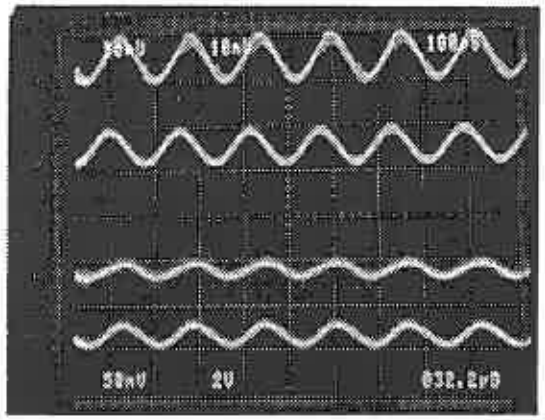
Test: +9V_A Output switching Ripple
Summary: With LC filter output switching ripple < 20mVpp
Conditions: +9V_A @ 1A

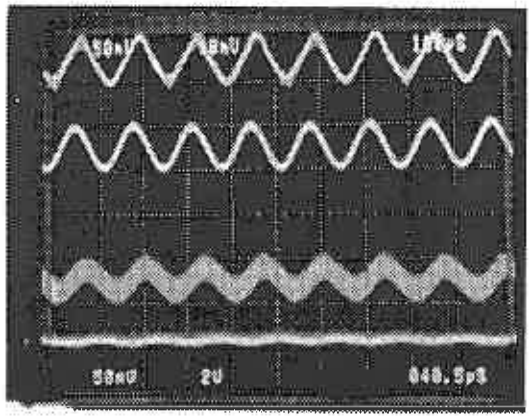
+9V_A (Boost Converter) Output Switching Ripple with/without LC filter
Dwnlink Power Converter BB




Test: +9V_A Step Response Istep=0.5A.
Summary: Response < 160mVpk
Conditions: +9V_A @ 0.5Adc

+9V_A (Boost Converter) Step load Response
Dwnlink Power Converter BB

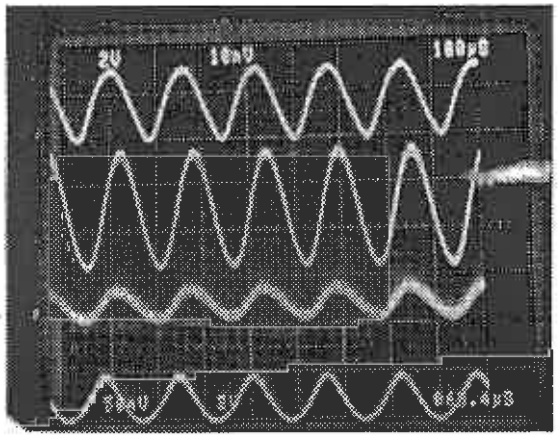


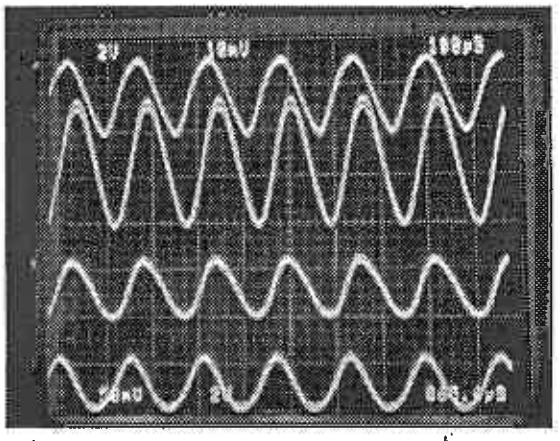

Test: CS01 - Inject 2Vpp onto 28V bus.
Summary: Resulting output ripple is less than 40mVpp.
Conditions: Vin=33.5V, -5V_A @ 0.39A, +5V_A @ 1.5A, +9V_A @ 85A.

CS01 for DWNLINK Power Converter BB

Vin =34V

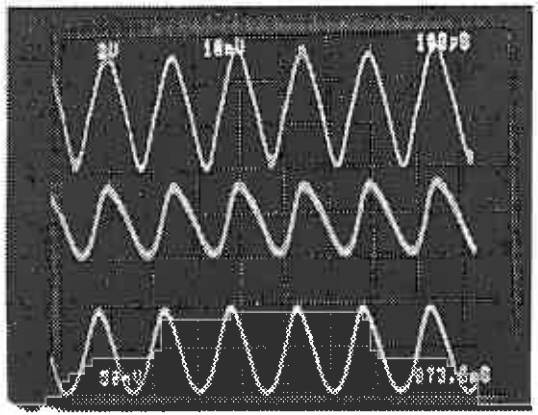


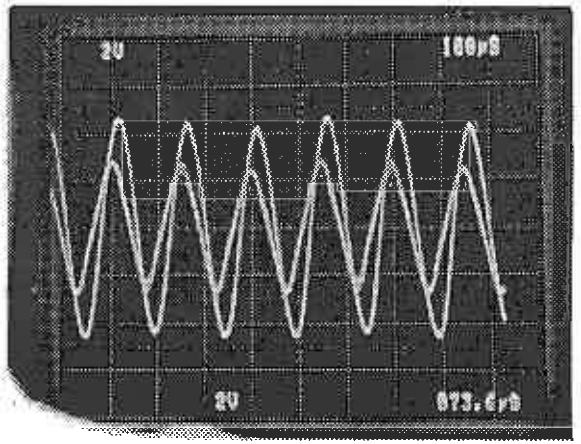

Vin =22V




Test: CS01 - Inject 3Vpp onto 28V bus.
Summary: Resulting output ripple is less than 70mVpp.
Conditions: Vin=22V & 34V, +5V_A @ 4A. -5V_A & +9V_A not connected.

CS01 for DWNLINK Power Converter BB




Test: CS01 - Inject 5.5Vpp onto 28V bus.
Summary: Resulting output ripple is less than 80mVpp.
Conditions: Vin=27V, +5V_A @ 3.85A. -5V_A & +9V_A not connected.
Test Duration: 45 minutes

CS01 for DWNLINK Power Converter BB

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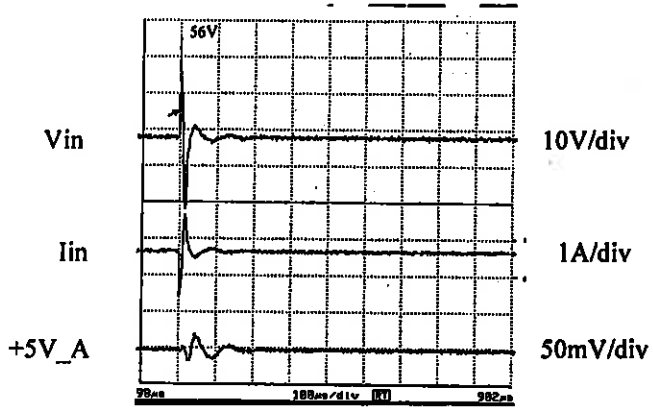


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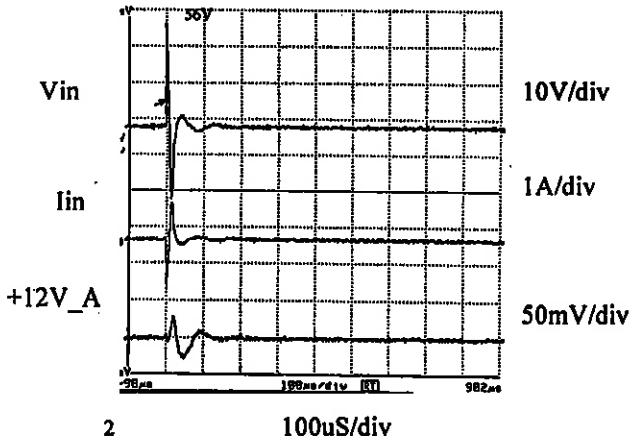


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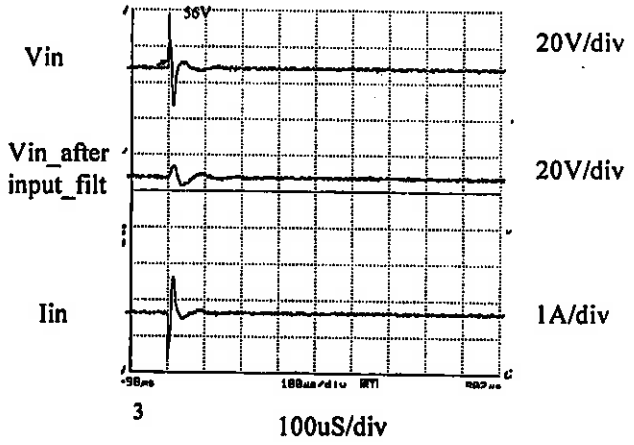
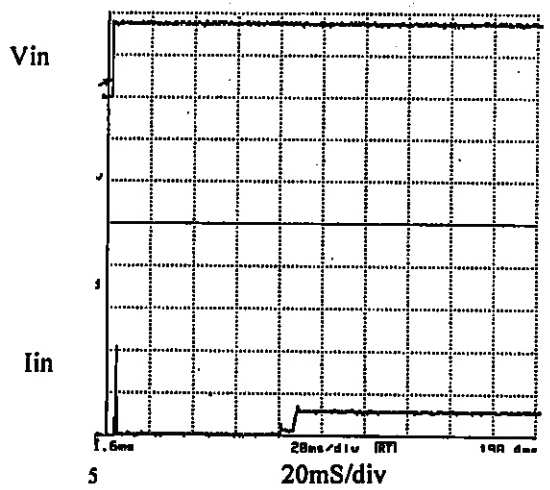


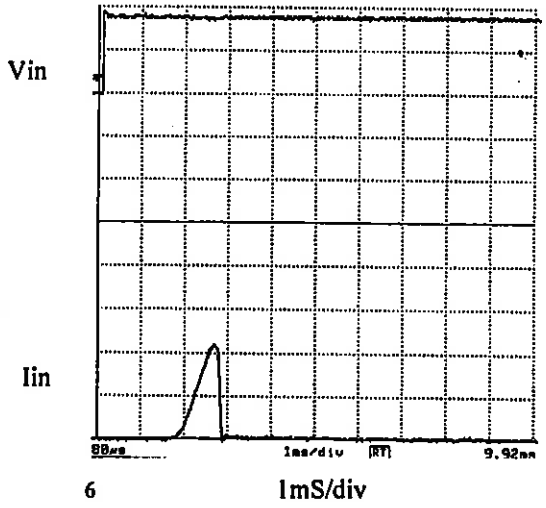

3

Test: CS06 test - Inject +/- 28V transient on 28V bus for 10uS.
Summary: Resulting output response is < 70mVpp.
Conditions: +5V_A, +12V_A, -5V_A, +5V_D all @ 0.5A.

CS06 for UPLINK Power Converter BB




5



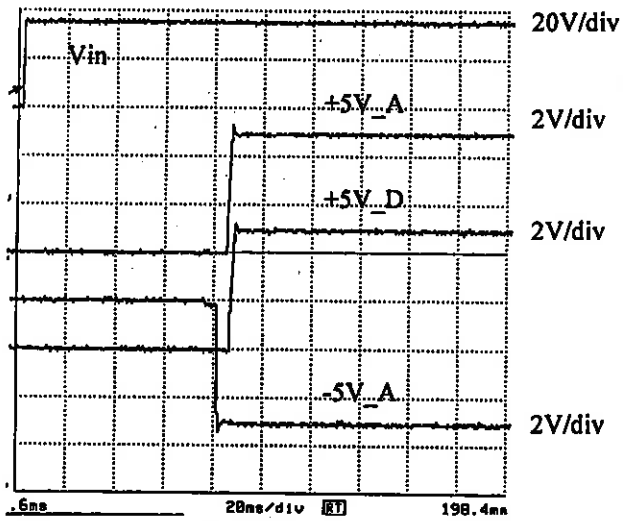

6

Test: Measure inrush current.
Summary: Iinrush < 2.2A.
Conditions: Vin=35V, all 4 outputs @ 0.5A

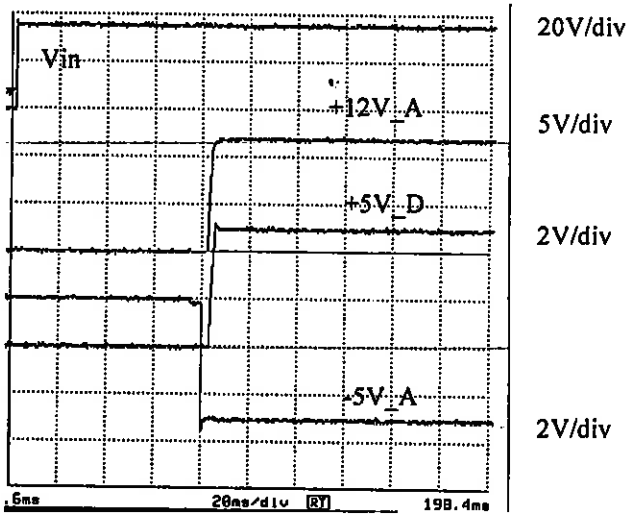
Inrush Current for UPLINK Power Converter BB

# TIMED

*Thermosphere • Ionosphere • Mesosphere • Energetics and Dynamics*




7 20mS



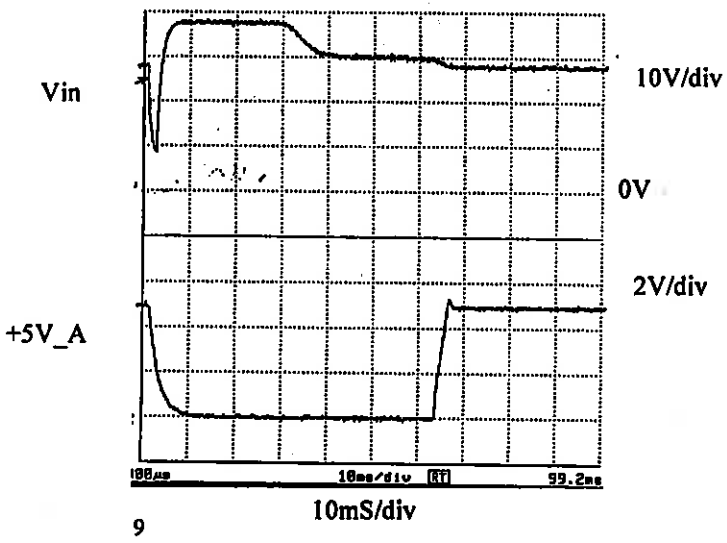

8 20mS

Test: Measure Output Voltage During Turn On
Summary: Overshoot at turn on < 0.5V.
Conditions: Vin=35V, all loads @ 0.5A.

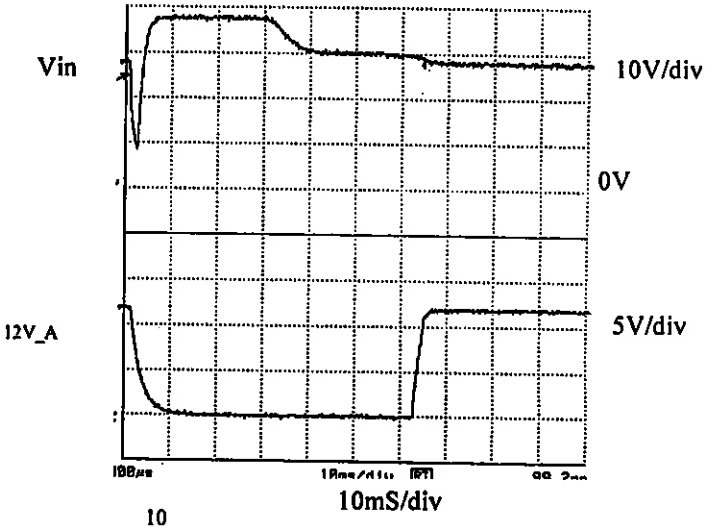
Output Voltage at Turn On for UPLINK Power Converter BB

# TIMED

*Thermosphere • Ionosphere • Mesosphere • Energetics and Dynamics*



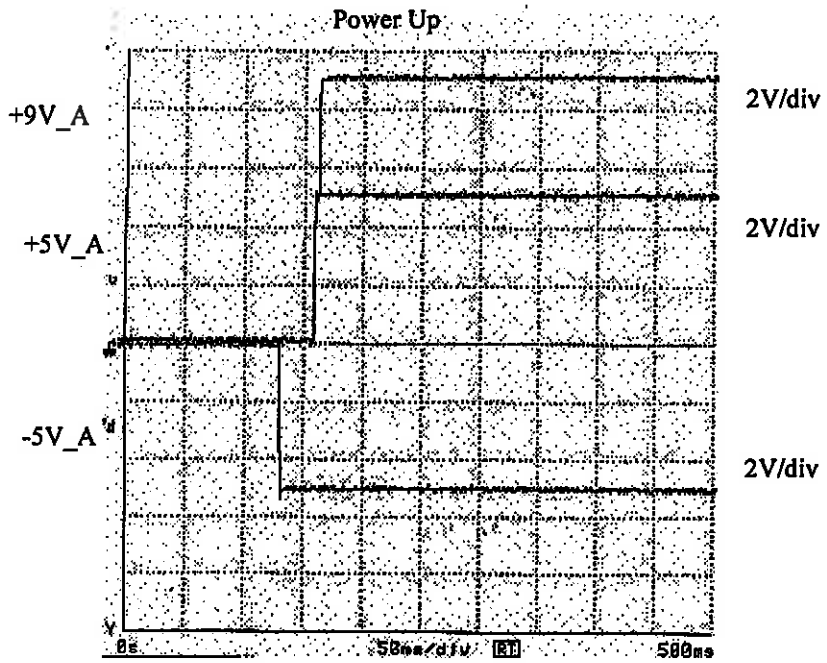

9

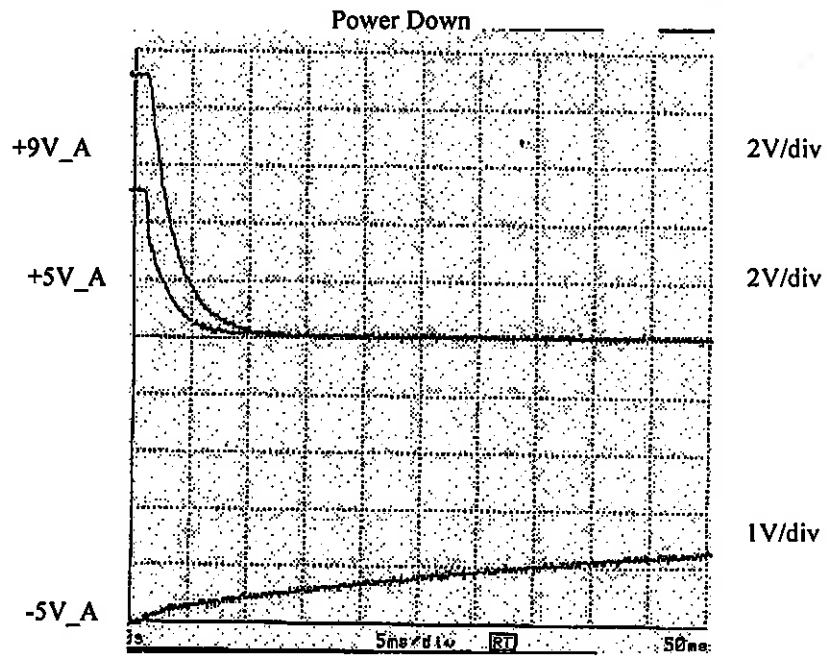



10

Test: Survival Input Voltage Transient - dropout for 2mS, 40V overvoltage for > 25mS.
Summary: Outputs look like normal turn on with overvoltage response less than 0.5V.
Conditions: All outputs @ 0.5A loads.

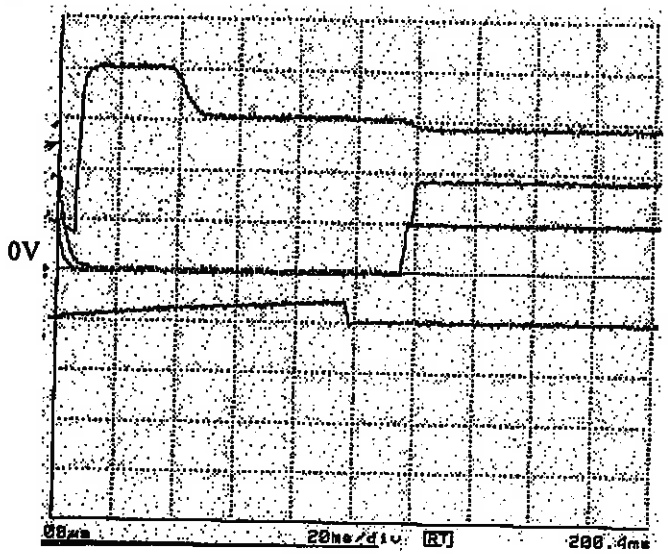
Survival Input Voltage Transient for UPLINK Power Converter BB




Test: Verify Power Up/Dwn Sequence Operation.
Summary: +5V_A & +9V_A turn on > 15mS after -5V_A is up.
-5V_A stays above |-4V| for 25mS after +5V_A & +9V_A have fallen well below 0.5V.
Conditions: Vin = 34V, -5V_A @ 50mA, +9V_A @ 0.75A, +5V_A @ 1A.

Power Up / Power Down Sequence for DWNLINK Power Converter BB

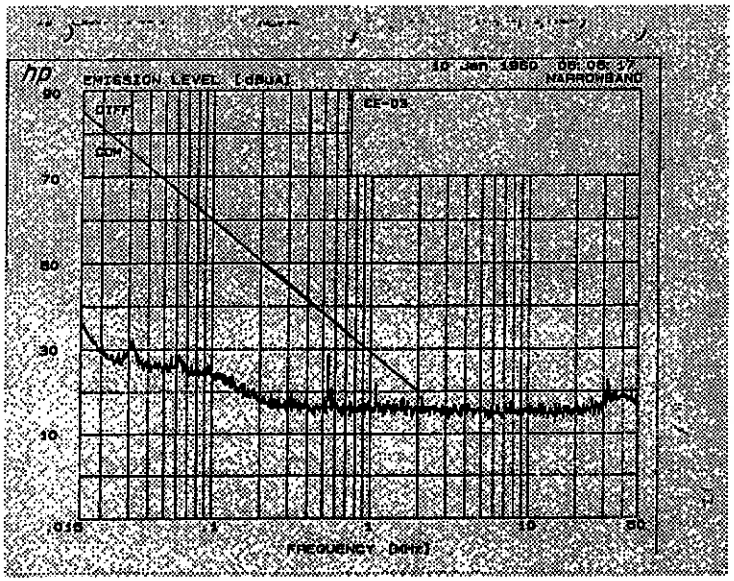



Test: Survival Input Voltage Transient - dropout 8mS, 40V overvoltage duration > 30mS.
Summary: Pwr Up/Dwn timing is same as for turn on / turn off :
+5V_A & +9V_A turn on > 15mS after -5V_A is up.
-5V_A stays above |-4V| for 25mS after +5V_A & +9V_A have fallen well below 0.5V.
Conditions: Vin = 34V, -5V_A @ 50mA, +9V_A @ 0.75A, +5V_A @ 1A.

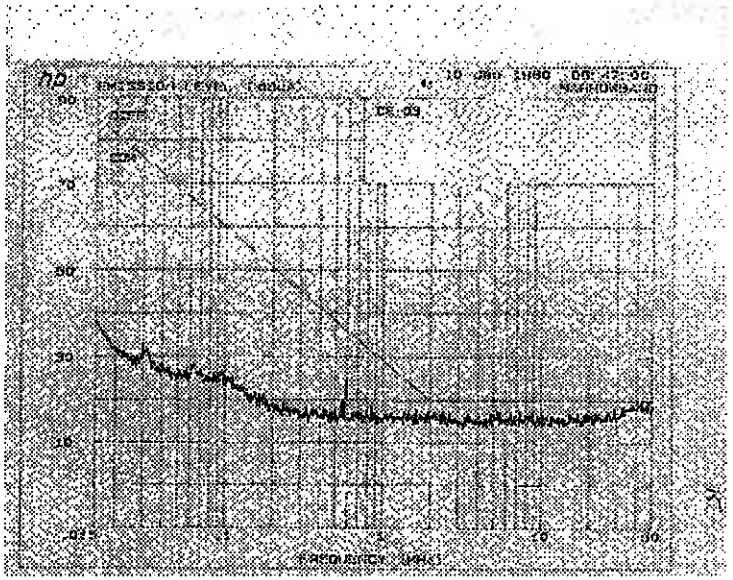
Survival Input Voltage Transient for DWNLINK Power Converter BB

# TIMED

*Thermosphere • Ionosphere • Mesosphere • Energetics and Dynamics*




Input Lines Common Mode




All Output (+) Lines - Diff Mode

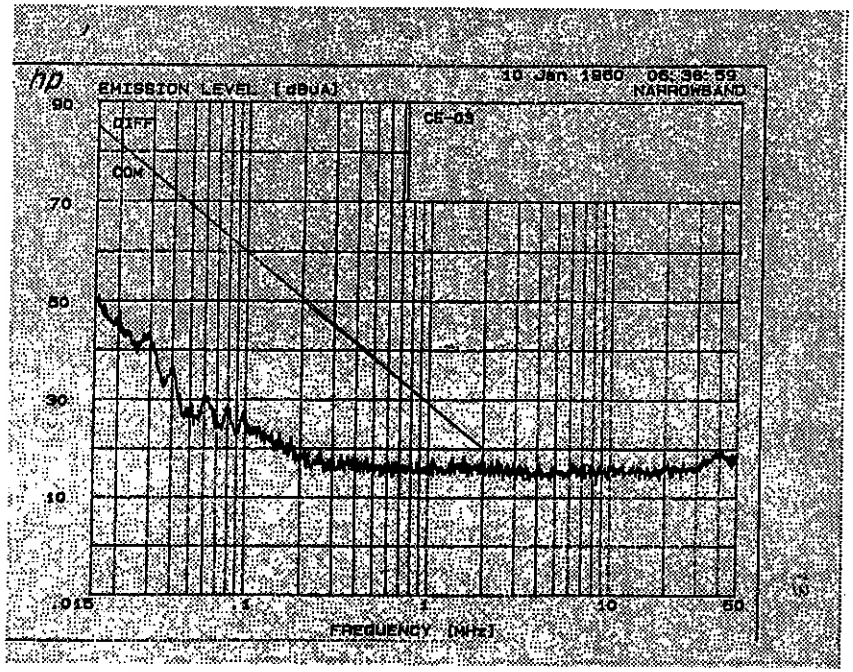
Test: CE-03 Narrowband
Summary: At fsw, Ice < 30dBuA
Conditions: Vin=28V, all loads at 0.5A

Conducted Emissions for UPLINK Power Converter BB

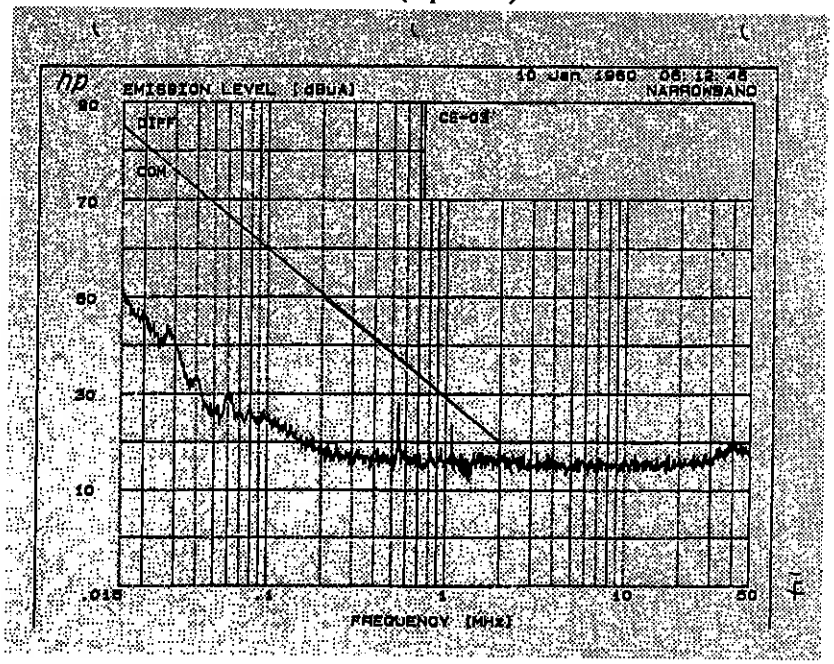
# TIMED

*Thermosphere • Ionosphere • Mesosphere • Energetics and Dynamics*

+Diff Input (Input +)




- Diff (Input Rtn)




Test: CE-03 Narrowband
Summary: At fsw, Ice < 30dBuA
Conditions: Vin=28V, all loads at 0.5A

Conducted Emissions for UPLINK Power Converter BB
Differential - Input lines