TINY DEMETER – HPSDR POWER SUPPLY

Document v1.0

Specification:

Input voltage: 12.6...14.0 Volts (the lower limit is needed because of the 12V LDO-regulator)

Output voltage:	Power:
• +12V @ 1 A	12 W
• +5V @ 2A	10 W
• -12V @ 0.3A	3.6 W
Total output power	25.6 W

Protection:
Input protection:
- Reverse polarity
- Under- and over-voltage

Output protection:
- Current limit
- Crow-bar on each individual output

Physical specification: Fits on the HPSDR Atlas-board, connects directly to the ATX-power supply connector.

Design Consideration

In order to keep the dissipation low, a switching topology will be used to convert the input voltage to 5 Volt. A DC/DC converter creates a 5.6 V (approximately) which will be fed to a low-drop regulator. The low-drop regulator generates the +5 V.

The DC-DC converter should be a low noise type. Both, with respect to the output noise electrical, but EM-radiation as well.

The frequency of the switcher should be tunable. This will give the opportunity to move the signal out of the frequency-band of interest.

Two topologies seem to be suitable:
- Push-Pull converter, using a transformer (suitable regulator e.g. LT 1533)
- Multiphase Buck converter (suitable regulator e.g. LTC 1629)

Each system has its own characteristics, in the table below a short comparison will be made:

Parameter	**Push-pull converter**	**Multiphase Buck converter**
Magnetics	Uses a transformer, winding ratio should be close to the voltage conversion ratio (Note: the transformers proposed by Linear Technology, are no longer produced)	Uses single inductors
Input current	Input current peaks at the switching frequency	Input current peaks (ripple) at a multiple of the switching frequency
Output current peaks	Output current ripple at the switching frequency	Output current ripple at a multiple of the switching frequency
Capacitor ESR	Low ESR of the capacitor very important	Low ESR of the capacitor less important, due to the smaller current ripple
Amplitude of the current ripple, important for the magnetic radiation	Relative high	Relative low
Operating frequency	20 kHz – 250 kHz	150 kHz – 300 kHz (up to 1.8Mhz effective switching frequency)
Power	In case of the LT1533 limited to approx. 12 Watt	No theoretical limit
Duty Cycle	Depends on the required power, **uses slew-rate control**	Depends on the wanted input/output voltage ratio
Switching element	Integrated in the LT1533 (power limiting factor)	External (no obvious power limit)

Both topologies have their own advantages. Because the power requirement in this application is relative low (around 10W) the losses in a slew-rate controlled switcher are acceptable. An extensive search has been done among the available switch-mode power supply control ICs on the market. It can be concluded that, although possible in theory, slew-rate controlled Buck converter controllers do not exist. Therefore, if one wants to use a slew-rate controlled switcher, a push-pull topology has to be chosen.

The polyphase Buck-converter looks still very appealing for power conversion at higher power. The smaller current ripple will create less unwanted magnetic radiation. The converters in parallel ar sharing the load, putting less stress on the individual components (e.g. ESR can be higher). At this point it can be concluded that: This topology looks very promising for the Demeter design.

A Closer Look To The Push-Pull Converter Design

The push-pull converter implies the use of a transformer, of which the winding ratio should be close to the wanted voltage conversion.

The wanted output voltage of the DC-DC converter will be 5.6 Volts (This is the lower limit, including the ripple).

The secondary side of the transformer needs rectification diodes. By using a center tapped secondary, only a single diode is needed. A typical Schottky diode will have a forward voltage drop of about 0.45V (decreasing at higher temperatures).

The transformer secondary voltage needs to be: 5.6 + 0.45 = 6.05 V

This is excluding any losses on the series resistance of the transformer windings.

On the primary side the calculation looks as follows:

For a slew rate controlled converter the voltage drop over the current sensing resistor and the switching element will be around 0.2 V (0.1 V for the resistor, and 0.1 V for the FET @ Rds-on = 0,1 Ohm and a current of 1A).

The available primary transformer voltage at:

Vin = 12.6 V => 12.6 – 0.2 = 12.4V
Vin = 14.0 V => 14.0 – 0.2 = 13.8V

Wanted secondary voltage = 6.05V

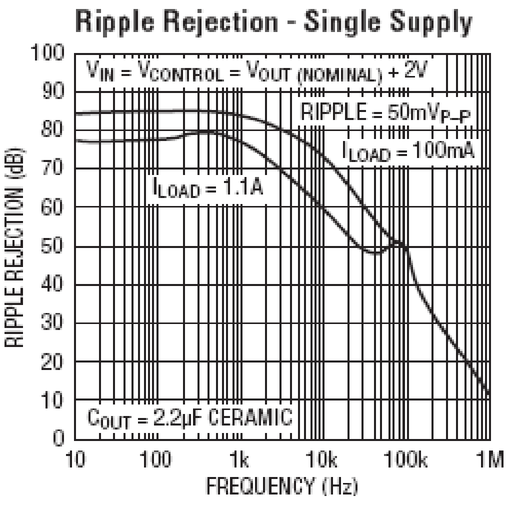
Ratio needed at Vin = 12.6 V:	12.4 : 6.05	=>	2.05 : 1
Ratio needed at Vin = 14.0 V:	13.8 : 6.05	=>	2,28 : 1

From this it can be seen that a 2:1 transformer ratio will be sufficient. Suitable transformers are available from e.g. Cooper, Coilcraft and Midcom.

A suitable controller IC is available from Linear Technology the LT1683.

The Low Drop Regulators

Tiny Demeter will use a number of LDO regulators. These can be built either discrete or by using integrate circuits. The LT3080 seems a good candidate, as it allows paralleling, without any special provisions. In the graph below (source LT3080 datasheet from Linear Technology) it can be seen that the ripple rejection at frequencies around 200 kHz is still in the order of 30dB. At 100 kHz it is almost 50dB.



The Oscillator

Linear Technology has a nice alternative available for the built in oscillator in the DC/DC controller; the LT6908.

This chip contains an oscillator plus additional circuitry to create a spread-spectrum signal. At least for the prototype of Tiny Demeter the use of this IC will be considered.