C.M.TECHNOLOGY

Designed and Manufactured in Australia

FULL DATA SHEET

www.cmtechnology.com.au **Tel: + 61 2 9764 6550**

PS 7412 Locomotive DC. to DC. Converter.

A Caspian Technology Company

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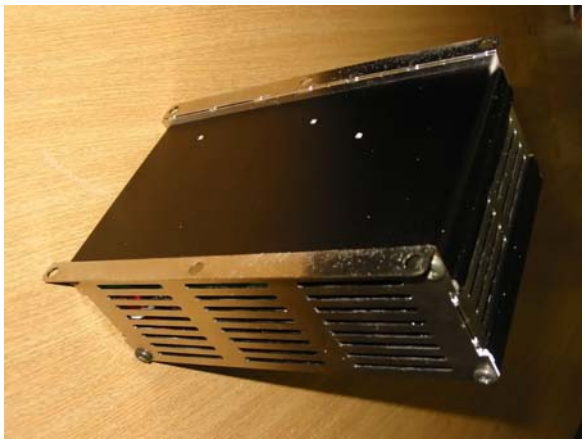
1.0: General: 1.0: PS 7412 at a glance:

- Wide Input Range : 60 to 130 V D.C.
- No input voltage selection needed.
- High Energy Varistor voltage spike clipping.
- Front panel input and output fuses.
- MILSPEC connector.
- Input RFI filter with common mode transformer.
- Completely floating input & output.
- Isolation >1 Kv. rms Input-Output & input-case.
- Reverse Polarity protection. (Series diode)
- Output 13.8 V DC. +/- 2% internally adjustable.
- Load Current 10amp max., 6 amps RMS e.g.
  7.5 Amp at 25% with 1.5 amps continuous.
  (open case model as pictured.)
  Case without vents version: 3 amps RMS
- Dust Proof, Splash Proof version. (case without vents)
- Output can be shorted without damage. Supply restarts automatically.
- Over voltage protected at >16 volts.
- Power good floating relay contacts
- Laser cut stainless steel & custom aluminum case.
- Dc input led indicator
- Dc output led indicator.
- Thermal overload protection
- Efficiency typ. 82% at full load. No Fans.
- Temperature -10 to +60C, no de-rating.
- Each Product Burnt In 100%
- Regulation 1% typ. over current & input Volts range..
- Output Noise & Ripple < 40mV Rms in 100 mHz Bw..
- Visual indication of DC output.
- 6 bolt flange mounting
- 105 mm Wide, 75 mm High, 190 mm Deep, with a
- 12mm mounting flange.
- Vibration tested.
- MTBF > 125,000 hr per MIL-HDBK-217F
- Designed for > 20 year field life
- Australian Design and Manufacture



1.1: Target Application:

The PS7412 has been designed as a lower output current member of the C.M. Technology PSTR series of D.C. to D.C. converters for railway applications. The PSTR series is widely used in Australia (see 3.2, "Customers using CMT power systems.") The PS 7412 has been designed for locomotives with DC supplies ranging from 60 to 130 volts, without any voltage selection being needed.

The PS 7412 has also been designed for a high energy efficiency of >80%. This relatively high efficiency allows convection cooling, low chip temperatures (+35C on ambient) on the power MOSFET switch elements and allows maximum 60 C ambient for operation for the unit. High grade professional and some MILC specific parts are used throughout, with an emphasis upon multiple sources and Australian content where that is still possible. The high Australian content we have achieved allows the "Australian Made" logo to be used upon the back label.

1.2: Design Philosophy:

The PS 7412 is an example of a generic approach to locomotive power system design. Essentially the same circuit configuration is used for all switch mode locomotive supplies made by C.M. Technology.

This approach minimizes the circuit simulation (PSPICE) required for a new design. The PCB layouts are held in a library data base that can be merged relatively quickly to produce a new design and a quick time to market, with a large number of components held in common across the product line.

C.M. Technology only uses the best available professional grade components, well documented & qualified under AS, DIN, CSA, VDE, JIS, UL and related standards, and some MIL SPEC devices where that is required or sensible. The finished supplies are all burnt in at elevated temperatures to provoke any infant mortality failures, with some products held on long term burn-in.

Most of these components have multiple sources as specified in the parts list appended. Our suppliers are registered under AS3902 or equivalent or have a customer list that includes major international companies, Government bodies and the Australian Defence Forces.

1.3: Australian Content:

C.M. Technology is a wholly owned Australian Company. The Australian content of the supply is >75%, and as such qualifies for the "Australia Made" logo to be displayed (upon the back label). C.M Technology is registered under this scheme, producing a wide range of Australian designed and manufactured power supplies sold to several multinational companies and Government bodies and also exported.

1.4: License to Use:

While the PS7412 may appear under various brand names, type numbers and logos, C.M. Technology retains all the associated intellectual property and the sole right to the manufacture of the PS 7412. All aspects of its design, circuit diagrams, printed circuit boards logos and this document are copyright or subject to registered design.

2.0 Electrical Specification:

2.1: Thermal Environ for the PS 7412:

Operating on any input (60 to 130 V DC) and at full load (as specified in section 2.7), the design maximum temperature Environ is :

Maximum Temperature of Operation: 60 Degrees Celsius

At this temperature, the junction temperatures are << 100 C, and therefore "safe". The internal case temperature rises to ~ 65 C under these conditions and all passive components are well inside their published data ratings. However, the section on Reliability (3.0) and Design Lifetime (4.0) should be read here. A thermal overload operates at mounting base temperatures >80C

The temperature rating assumes free air can circulate around the metal case. At full peak load for the supply, there is about 20 watts lost to the air. The heat sinks are internal to the case, and the case then radiates to the environment. Radiant energy sources such as bulkheads, motors and the like should be considered in assessing the thermal environ.

2.2: DC Input Range for the PS 7412:

The input power required is:

Fully floating D.C. Only . Normal 60 to 130 Volts, Absolute Maximum 150 V.

There is no voltage selection needed. The input should have <5% low frequency ripple due to phase control SCR systems and rectifiers. Other input voltages, and higher ripple inputs will be considered by CMT. Please consult the factory.

2.3: Locomotive Side of the PS 7412:

The input DC is via a panel mount MIL C connector. This goes via an input panel mount 3AG HRC fuse to the down converter.

2.31: Voltage Isolation:

The PS 7412 will tolerate without damage a 1000 V RMS voltage for 1 minute between the DC inputs (shorted together), and the DC outputs (shorted together) & also between the DC inputs (shorted together) and the Case.

2.32: Input Transient Clipping:

Metal Oxide Varistors are used to clip any transients upon the locomotive wiring into the PS7412. The POSITIVE and NEGATIVE input rails are bypassed to case with Y grade (3500v AC) capacitors of 4700 Pf. The supply is not susceptible to input voltage spikes as below: (after Freight Rail Spec 1122)

- Peak 5000 V
- Rise time <0.1 uS
- Fall time to 2000V 160 uS (RC type time-constant)
- Energy in spike < 100 joules

2.33: Input RFI filtering:

The PS 7412 has a common mode input filter. This provides a minimum 30dB extra rejection on input DC noise, over and above that due to the PS7412 itself. The DC output is individually by-passed for RF as well (see section 2.46, "The Nature of the Output Impedance").

- Operation is not affected by a voltage of 200 mV rms (50 ohms source) at any frequency up to 50 mHz, connected to the DC input.

2.34: Case Grounding:

The instrument case should be grounded, via the 6mm mounting screws in the base. The PS 7412 is a switch mode supply, and the case grounding is important for RFI rejection.

2.35: Overall Efficiency:

The PS7412 has an efficiency at 10 amps load of:

- Efficiency > 80%, typically 82%

2.36: Input Inrush Current Limiting:

On initial turn on, the inrush is limited to:

- In rush limit < 20 amps peak from cold

2.37: Input Polarity Protection:

The PS7412 is input diode isolated. The PS7412 is not affected by indefinite reverse power connection within the range 0 to 148V DC. Normal operation is restored immediately upon correct application of power. Under reverse power, no output voltage is present.

2.4: Output Voltages (Power Good Relay):

The adjustment range of the output voltage and the associated current:

- 13.8 V +/- 2% at 7 Amps

The input and output are isolated from each other by the transformer windings, and are bypassed to the case (ground) for RF. Internal voltage feedback is via optical isolators. A power good open contact pair is available (pins C &D)

2.41: Output Adjust Range:

The PS 7412 uses a precision adjustable shunt regulator integrated circuit as its reference. This makes it simple to adjust the output voltage without altering the temperature coefficient of the reference. The adjust pot is accessed by removing the top of the metal case. Other adjust ranges are possible. Please consult the factory.

2.42: Reference stability with Temperature:

The reference is the Motorola TL431. This is a precision adjustable shunt regulator, with a temperature coefficient that is independent of the output. The absolute stability is quoted as 3 mV typical, max 17 mV over 0 to 70 C. This translates into < 100 mV worst case shift in the 13.6 Volt supply in 0 to 70 C.

2.43: Regulation with Input Variation:

This is specified at full load (10 amps) over the input range 60 to 130 Volts DC. The Input Regulation for PS 7412 is:

- Input Regulation 1% typical.

2.44: Regulation with Load Variation:

This is specified for the nominal 110 V DC input voltage, and from 1 amp to 10 amps. The PS 7412 has a regulation with load of:

- Load Regulation 1% typical

2.45: Transient Load Regulation :

A 10% load to 90% load current step is applied. The supply settles, and the reverse step is applied

- 10% - 90 % step < 200 mV pp settles in 2.5 mS
- 90% - 10% step < 200 mV pp. settles in 2.5 mS

2.46: Nature of the Output Impedance with Frequency:

Output (Rail to Rail)

- At low frequencies, the output impedance is best described by the transient load regulation.
- At 100 Khz and above, the output impedance is controlled by a high grade Philips 053 series capacitor. The ESR of this part (normally used in switch mode supplies) is such that the output impedance is <.035 Ohm.
- In the megahertz region, a ceramic multilayer capacitor controls the impedance.

Output (Rail to Case)

- Both rails are bypassed with ceramic mains Y grade capacitors of 4700pF. This shows a series resonance dip at ~ 20 megahertz. and offers an 3000 v AC isolation. If better by-passing is required, consult the factory.

2.47: Stability:

The output is unconditionally stable from no load, part load up to full load conditions.

2.48: Settling Time:

The turn on time is from the application of DC power, to the settling of the output voltages to within 1% of the steady state voltage. There is no voltage overshoot under these conditions.

- Settling Time < 500ms

2.49: Generated Noise:

Over the input voltage range at 10 amps full load, the output noise shall not exceed:

- Output Noise (100 Megahertz Band width) < 40 mV rms

2.5: Output Voltage Protection:

Correct supply operation is shown by a GREEN daylight visible LED "Output DC OK".

2.6: Output Voltage Protection:

The PS 7412 uses an optically isolated latch to turn off supply should the terminal voltage exceed 15.6 Volts. The over-voltage comparator uses a separate reference IC to the voltage regulator, but of the same type, so it tracks the set point exactly with temperature. This can be factory set to other voltages.

2.61: Over-voltage limit:

The over voltage tolerance limit can be set by 1 resistor. The PS 7412 is set at + 15% upon the nominal set point. Other tolerances can be factory set.

- Over Voltage Limit > 15.6 V

2.7: Output Current Limit:

The current limit is specified in two ways over the temperature range -10C to 60C.

- Current limit 10 amps max.
- 6 amps RMS . For example 7.5 A DC at 25 % duty and 1.5 Amps DC continuous.

2.71: Output Current limit Application:

The current limit is factory set and is not adjustable.

2.72: Short Circuit Behavior:

A short circuit causes the PS7412 to go into constant current. The supply can be left in this state indefinitely. Removing the short allows the supply to start automatically and it will start a load (current sink or resistive or any combination) up to 95% of the current limit.

2.73: Ability to start a load after a short:

The supply will start any load that draws less than 95% of its current limit. This means in the worst case it will start a current sink type load, as well as a simple resistive one, or any desired combination of these.

3.0: Reliability:

C.M. Technology uses a limited range of component suppliers and common components in many products, once they have proven reliable. Only qualified parts are used. The suppliers are either qualified to AS 3902 or equivalent or supply Australian Government bodies or the Military.

3.1: Calculated Reliability Based on MIL-HDBK-217F:

A calculation of expected MTBF has been made, assuming environ GB

- Calculated MTBF : >125 ,000 Hours

3.2: Customers Already Using C.M Technology Power Systems:

A guide to the quality of C.M. Technology's quality and reliability of design and manufacture can be obtained from the quality of the customer list appended.

- **Freight Rail Corp.** (per SIMOCO PACIFIC). On locomotive high power Dc-Dc converters PSTR24, PSTR74 & PSTR110. NATA lab tested product for extreme vibration conditions. Same technology used in PS7412.
- **Hamersly Iron (WA).** PSTR74 series (as above) on locomotive converters
- **N.R.C. National Rail Corp**. PSTR74 series (as above) on locomotive converters
- **Telstra** trunking DC-DC converter PS1248.
- **ADTRANZ** PS48ADJ adjustable instrument lighting supply
- **Telstra** PSTR 24-2 Solar Battery Charger for Trunking, North West Coast
- **Rohill Communications (Holland).** Mobile base station supplies R1015.Product carries the "CE" registration mark for the European market
- **Freight Rail Corp.** (SIMOCO PACIFIC) Trackside supply PPS15-3, a NATA lab tested product for extreme vibration and high mains operation, rated for 70C operation.
- **P.T.C.** Victoria Trackside supply PPS15-3 (110v input variant)
- **SAFT NIFE** (Aust) Power systems PS4824, PS4805, PSM110, PS1248. These railway power systems sold to Westinghouse Brake, exported to Indonesia and Singapore & Thailand and sold also to Telstra in Australia.
- **SPECTRA LTD**., type PPS12 communications power supply, The PPS12 carries the Australian Ctick Mark .***The PPS12 has been tested and certified by the Underwriters Laboratory (UL) carries the UL marks for the U.S.A. and Canada*** *E227212*

4.0: Design Lifetime:

C.M. Technology designs for a 20 year field life.

4.1: Burn in and Useful life:

C.M. Technology only uses the best available professional grade components, well documented & qualified under AS, DIN, CSA,VDE, JIS, UL and related standards, and some MIL SPEC devices where that is required or sensible. The finished PS 7412 supplies are all burnt in for > 1 hours at elevated temperatures to provoke any infant mortality failures, with some products held on long term burn-in.

4.2: Life of the Electrolytics:

The most probable failure mechanism for a power supply is failure of the electrolytic capacitors. These capacitors show a typical bathtub failure pattern. That is, an initial failure rate called infant failure, a long term constant failure rate, where the "MTBF" statistics approach can be applied, and an end of life, or burn-out phase that is described by "Life expectancy" or end of life.

The Infant failure period is screened out, firstly by the component manufacturer, then by C.M. Technology's burn in period on the finished supply at elevated temperature. The second segment is the useful life. Failures occur at a constant rate on a random basis with a low frequency. Failure modes are related to temperature and voltage stress. Failure rates are generally tested using MIL-C-39018 at a 60% confidence level. The capacitors in the PS 7412 are qualified this way.

The last segment is end of life. Here vapour transmission through the end seals causes loss of electrolyte, and the capacitor goes open. This is strongly related to ambient temperature, and to the heat rise caused by ripple currents in the capacitor.

A Nippon Chemicon KMH series, 2000 Hrs at 105 C, is considered. The capacitor is qualified under characteristic W of the Japanese standard JIS C 5141.

The capacitor is 330 uF, 200 V running at 0.5 x its rated ripple current, and ~0.5 x voltage at 65 C. This allows 5 C above the 60 C ambient for the PS 7412:

Ambient	65 C
Heat rise due to ripple	1 C
Operating Temperature	66 C
Base Failure rate	0.1%/1000 hrs
Corrected for 1/2 volts	0.007 % /1000 hrs.
MTBF	14x106 unit hours.

The capacitor is very reliable in the useful life region. What limits the actual product is the onset of the "End of Life" phase.

The end of life phase is a strong function of ripple current and temperature. A good set of curves appears in the Philips data hand book " Electrolytic Capacitors Solid & Non-solid", 1989, Page 24. The real objective is to make a supply with a life in excess of 20 years, or 175,000 hours. The base life of the capacitor is >2,000 hours at 105 C, rated ripple. Correcting to the actual current (~0.5x rated ripple), the curves show that an ambient of about 45 C is needed over the life of 20 years to do this with a safety margin. A 10C increase will halve this life.

In summary, a 20 year field life requires low ambients < 45 C.

5.0: Mechanical Design:

The C.M. Technology PS 7412 Power Supply is constructed from brushed stainless steel laser cut pressings screwed together with high tensile screws. The supply mounts (see pictures) on its base, which is flat. Six 6 mm pre-cut holes are provided in the mounting base. Installation should allow an air space around the PS7412 for convection cooling of the case.

The front panel information is rear printed onto a polycarbonate label glued to the stainless steel front panel. Annunciator super bright diagnostic LEDS shine through this label. The label colour and LOGO applied can be altered to suit the customer's request for an order of 100 or more. The supply qualifies for the Australian made LOGO, and C.M. Technology is registered under this scheme. This logo is printed on a plastic side label, together with product details and the unique production unit serial number. This serial number is completely traceable.

The input and output is via a front panel locking MIL C connector.

The printed circuit board is made from double sided 70 micron (2x normal) glass fibre. It is roller tinned and through hole plated. The PCB is secured in many places by stainless steel screws to stop components vibrating. The short loom wires are made from high temperature plastic.

5.1: Input and Output Connections:

The input and output t is via a locking MILC connector.

5.2: Acoustic Noise:

The PS 7412 generates no measurable acoustic noise.

5.3: Maintainability:

In the field a failed supply is indicated by the lack of a Green LED indicating “12 V Out".

Internally, one large PCB is used. All high voltage heat sinks are free standing on this PCB and are not connected to the case. The PCB is screwed into place, and it and its I/O connector are removed together. This makes service on a PCB replacement basis very quick. The PCB can be replaced in 15 minutes.

5.4: Weight and Size:

Weight < 1 kilograms

Size 70mm High 105 mm Wide 190 mm Deep

5.5: Environmental Conditions:

The PS 7412 will pass the following type approval test:

- Temperature +60Cat 7.5 A (25%) 1.5 A (100%) 16 hours (after AS1099.2)
- Vibration 10-50 Hz 0.25g p (after AS1099.2)

6.0: Principles of Operations (in Short form):

6.1: Input Signal Conditioning:

Refer to drawing pstr7412-1 & 2 supplied. Input from the IO connector is via a front panel fuse F1, and the NTC R2. The NTC limits the inrush current at turn on.

A Metal Oxide Varistor, R3 clips any transient induced upon either leg of the DC input. U1 is a DELTA RFI filter, used to attenuate any incoming RF on the input. It provides 30 to 40 dB extra attenuation, over that due to the PS 7412. It characteristics are available from C.M. Technology on request.

6.2: Polarity Protection & Indication:

D9 is a series diode to isolate the supply from reverse inputs. D13 is a RED LED that shows the DC input has been reversed to the PS7412. There is another LED D12 that shows that input DC is available.

6.3: RFI Filter and Switches:

C1, L1, C3 and C4 form an RFI filter for the input DC. This DC is chopped by the two MOSFET down converter Q1 and Q2, with transient diodes D1 & D2. The gates of Q1 and Q2 are supplied by the pulse transformer T1, driven by the SMPS IC U3. The resulting DC square wave is transformed by the transformer T2. This is a split bobbin type, giving 3500 V RMS isolation..

6.4: Output DC Filter:

The transformed square wave is rectified by D8 and then filtered by inductor L3 and capacitors C5 & C6.
A common mode transformer T3 and the capacitors C7 to C10 filter any spikes and the 13.6 V DC is taken to the front panel plug.

6.5: Control Loop:

The control loop rail voltage is derived from a small auxiliary winding upon T3. A start up current is provided by R6 and R7.
U3 is a current mode SMPS IC. It derives a trapezoidal current reference from the resistor R5. This signal is filtered by R1 and C1, and then taken to U3 as the current feed back term.
U3 has a voltage feedback term supplied by the optical isolator ISO1. Any feedback current from ISO1 reduces the duty cycle of the square wave drive signal (pin 5) to the pulse transformer T1. Therefore the loop settles to accommodate the load current term.

ISO 1 is driven from the output side of the PS7412. A precision shunt regulator U2 compares via R16 and R15 the output voltage with its internal reference. R14 is 20 turn trim upon the voltage. Should the output voltage be high, more LED current flows in ISO 1, and so the feedback current increases, reducing the on time of the converter.

6.6: Over Voltage:

Should the feedback loop break, the output voltage can rise. To clamp this, the down converter has a separate voltage supervisor U4 and ISO 2. At a clamp voltage set by R25, R26 and its internal precision reference U4 turns the photo transistor in ISO 2 on.

After a delay controlled by C18, Q3 latches the photo transistor on, pulling pin 1 of U3 low, turning off all drive and stopping the supply.

7.0: Circuit Diagram and Parts List:

Supplied upon Purchase

8.0: Document Revision History

Rev. 1.0	July 1995	First Issue
Rev 2.0	Dec 1995	Include short operation description
Rev 3.0	Dec 1995	Include a sealed IP50 version
Rev 3.2	Jan 1999	Simoco Variant
Rev 3.3	June 2000	Microsoft Word format
Rev 4.0	Dec 2002	Extruded case model with Power Good contacts

9.0: Related Documents

Calibration PS 7412 7412CAL.SAM Rev 2.0 Dec 1995