Repurposing of ATX computer power supplies for PV applications in developing countries

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Current Recycling Practice

- In 2007, EU countries disposed of 6.5 million tonnes of Waste Electrical and Electronic Equipment (WEEE)

- Traditionally WEEE processing has been focused on extraction of raw materials

- Processing centers in Germany were achieving recovery rates ranging from 29% to 61% from ICT equipment (Waste Management & Research, pp. 311–317, 2011)
Reuse of WEEE

• EAUC and CAI promote reuse of computer equipment in the developing countries in Africa
• Ecoinnovation use washing machine motors for small scale hydroelectricity generators
• Electrolux and Fab Lab Barcelona investigated the repurposing of constituent vacuum cleaner parts
ATX PSU

• ATX computer power supply for battery charging and bench power supply applications

• ‘Hobbyist’ sources regarding performance of such devices are unsubstantiated

• Suggests suitability of device for PV
WEEE processing stream
Active PFC

- Duty cycle of the switch within the boost converter stage is controlled dependent on input voltage
- Input current tracks voltage resulting in both being kept in phase and thus a power factor close to unity.
- Boost converters also used for MPPT!
Aims of Project

- Investigate the practical steps in recovering PSUs
- Develop generic MPPT converter tolerant to variable component choices/specification
- Present business case for dismantling, recovery and reuse of components
- Undertake socio-economic viability of PSU reuse through interaction with ICT recyclers and PV providers
Aspire – Sheffield
www.aspire-sheffield.co.uk

- Aspire-Sheffield provides a stable job and a supported working environment for vulnerable or marginalised people.
- They use the recycling of WEEE as a revenue and employment stream.
Identification and removal

• WEEE staff trained in identification of Active PFC PSU’s.

• Extra processing time less than 5 minutes...

• .....depends on PC model!
Conversion of ATX PSU

• New controller ‘piggy-back’ onto ATX, feeding both boost and half bridge stages with new switching control
• ATX now runs off DC at 12-25V!

Surplus output cables removed

New driver inputs
MPPT controller

Potential divider networks

Amplifier stage

Driver networks

Current sense resistors
The target for any conditioning converter is to maintain the solar panel at the MPP, often accomplished by boost converter. Two methods chosen, Perturb and Observe (P&O) and Look Up Table (LUT). P&O easy to implement, oscillatory nature can lead to inefficiency. LUT requires calibration but tends not to oscillate at MPPT.
Initial Testing

• Solar simulator used for initial trials
• Empirically tuned to match MCP12W solar array
Perturb and Observe

• Initially a Perturb and Observe (P&O) MPPT algorithm was chosen for its simplicity and ease of implementation (1)

• Inexpensive microcontroller can have resolution issues (2)

• Only 0.78% duty cycle change for each step

\[
\frac{dP}{dV} = \frac{P(n) - P(n-1)}{V(n) - V(n-1)} \quad R = \frac{F_{\text{oscillator}}}{2 \times F_{\text{pwm}}} \quad (1) \quad (2)
\]
Solar Simulator Tests

• Used solar profile as described by M. Berrera et al. “Experimental test of seven widely-adopted MPPT algorithms” IEEE Bucharest Power Tech Conference, 2009

Case 1

Case 2
Results (1)

• The adapted ATXPSU harnesses minimum of 94% of available energy in case 1 and case 2
• The LUT approach performs better producing 1% more input power
• In a lab situation the LUT approach does provide an excellent benchmark to which other algorithms may be compared.
• P&O preferred due to LUT cumbersome recalibration requirement.
Testing (2)

- The MCP-12W solar array was mounted roof of the Civil Engineering Department, Sheffield University (bearing of 180° and located at 53.38N,-1.48E)
Results (2)

- For external tests only P&O was implemented
- Allowed performance during identical solar irradiance profiles to be compared

(12:00Hrs-13:00Hrs, 2/9/2013) (12:15Hrs-12:21Hrs, 2/9/2013)
• Between the 2/9/2013 and 10/9/2013 the P&O methodology harnessed 872.33kJ
• Theoretical maximum of 886.98kJ using the LUT approach
• P&O only harnessed 1.65% less energy.
• This is in line with the emulator trials, where a maximum deficit of 2% was recorded
Conclusions

In the last 6 months.......  

• ATX PSU successfully converted to MPPT converter  
• P&O suitable for low cost MPPT converter  
• Low resolution boost converter control microcontroller penalises P&O operation  
• For little extra cost, PWM IC would dramatically improve P&O operation
Conclusions(2)

• Such a device could provide affordable PV converter hardware to some of the poorest parts of the world
• Pollution/energy use incurred during recycling of these discarded PSU’s would be reduced.
• Furthermore if minor changes were made to PSU manufacture from the outset, adaption would be easier
• 1 conference paper accepted (ICRERA2013)
Further work

- Alternative circuit topologies
- Develop test and assessment systems
- Economic viability of complete reuse scheme
- 1 further conference paper submitted, 2 journal papers in preparation.
Any questions?

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