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USB PD3.1 and Electricity Access

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USB-Power Delivery 3.1

- USB PD3.1 was published on 25th May2021
- On the USB-C connector, it uses the two CC pins, VBUS and GND
  - One CC pin provides the USB-PD signalling channel
  - The other provides VCONN (a fixed 3.3-5V supply to power the intelligence in the load or smart cable)
  - Because the connector is reversible, the two CC pins have to be interchangeable
- The D+, D- pins are also required to support legacy fast charging via USB-BC2.1

USB-PD3.1 voltages

- USB PD3.1 now supports up to 48VDC and 240watts
- 3 voltage-setting modes:
  - Choice of fixed 5, 9, 15, 20 V @ 3A, 20V @ 5A
  - Adjustable voltage 3.3V to 20V @ 3A in 50mV steps (SPR mode)
  - Adjustable voltage 15V to 48V in 100mV steps (EPR mode)
    - (Available current <5A determined by power limit)
- Voltage starts at 5V, digital handshake negotiates the voltage and current required
  - Method of notifying user if required V/A is not available is not defined

USB-PD3.1 and Electricity Access

- USB PD3.1 is complex and expensive to implement
- Why would one therefore want to use USB-PD for Electricity Access in uncontrolled environments?
- Answer: USB has huge momentum:
  - Backing of major industry players
  - Economies of scale on Day 1
  - Dedicated silicon
  - Adoption by smartphone and laptop manufacturers
  - Unconditionally safe

USB-PD3.1 and Electricity Access

- However, as published, the standard is not ideal for use in uncontrolled environments:
  - Very cost-sensitive markets
  - Dirt, humidity, airborne salt have not been considered
    - Connector pin separation is 0.21mm worst-case, = 2.28kV/cm!
  - Poorly educated users, limited language skills
  - Limited cable distances, no allowance for voltage drop
  - Tree structure required – no connection of any kind permitted between branches
  - Uncertain Internet access – field upgrading may be impossible
  - No support for analogue interfaces*
  - Huge range of functional subsets on the same connector
    - No definition of how these are communicated to the user

* (One very limited exception)

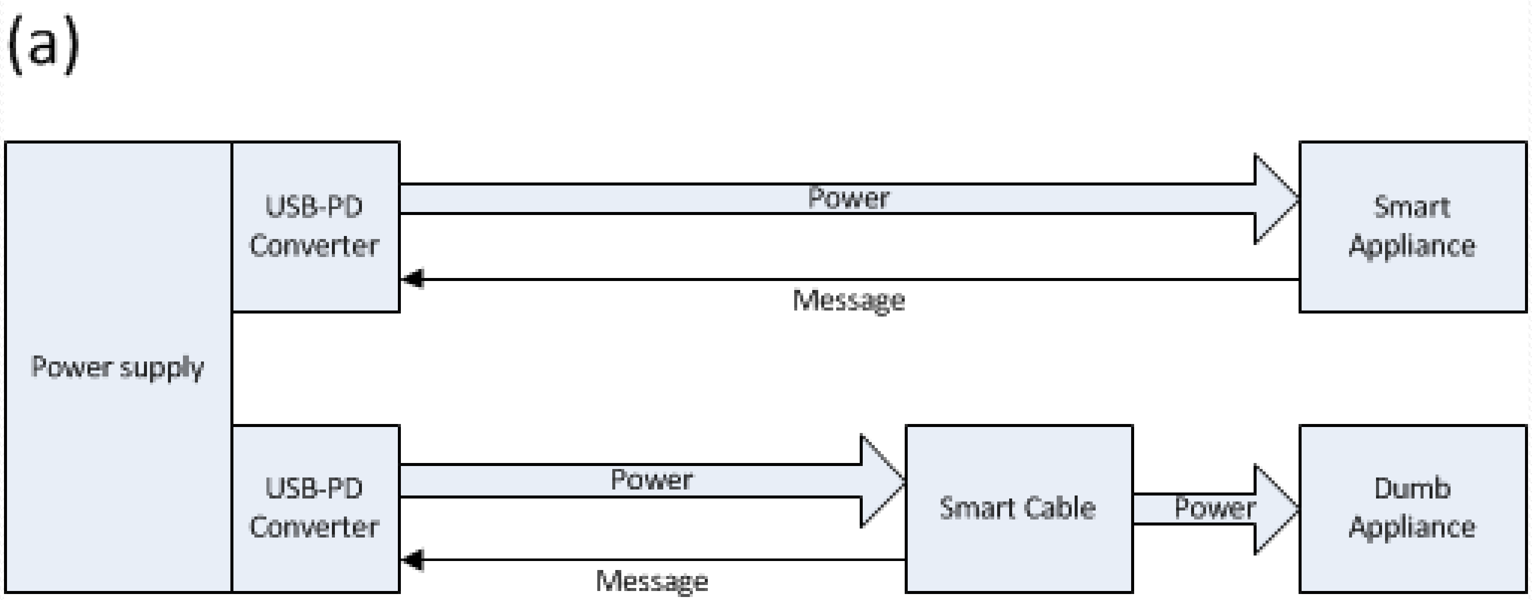
Can these issues be fixed?

- The answer appears to be a qualified yes:
  - A larger, more robust connector, with far fewer pins
    - (2 fat power pins, 1-4 thin pins - fewer means more electronics, and protocol modifications)
  - A simple subset of the USB-PD protocol
  - Omit the high-speed data features
  - Smart adapter cables for legacy loads (barrel connector) and smartphone charging (USB Type A, USB-C)
  - A standardised method for reporting incompatibilities
- Lack of galvanic isolation remains a stumbling block when powering legacy kit
  - Analogue signal cables must not be used between two items of USB-PD-powered equipment

Is USB-PD the right approach?

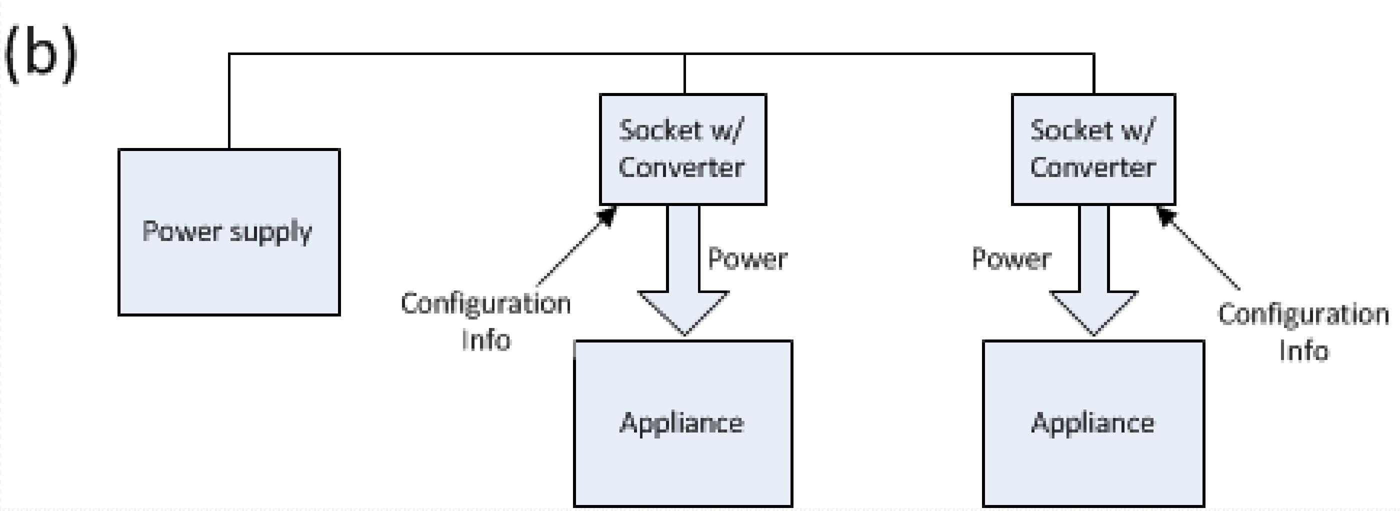
- Electronic devices need very specific DC voltages
  - ….and they're all different!
- A distribution voltage has to be converted to the voltage the electronics needs. This can be done:
  a) In the supply, via a message that requests the desired voltage & current
  b) In the socket, via electronics included in the socket
  c) In a wall-wart or lump-in-line power supply
  d) In the equipment itself
- How is this done today?
  - All grid-powered domestic appliances today use (c) or (d)
    - Known as "Point-of-Load (PoL) conversion"
  - Only smartphones use (a) – this is what USB-PD delivers, too
  - A few LVDC minigrids use (b)

Point-of-supply conversion



Superficially simple minimum-box solution, but:
- Complex signalling - digital messaging must be used
- No compensation for voltage drop
- No possibility for sharing wiring between appliances
- Galvanic isolation is very difficult

Socket conversion



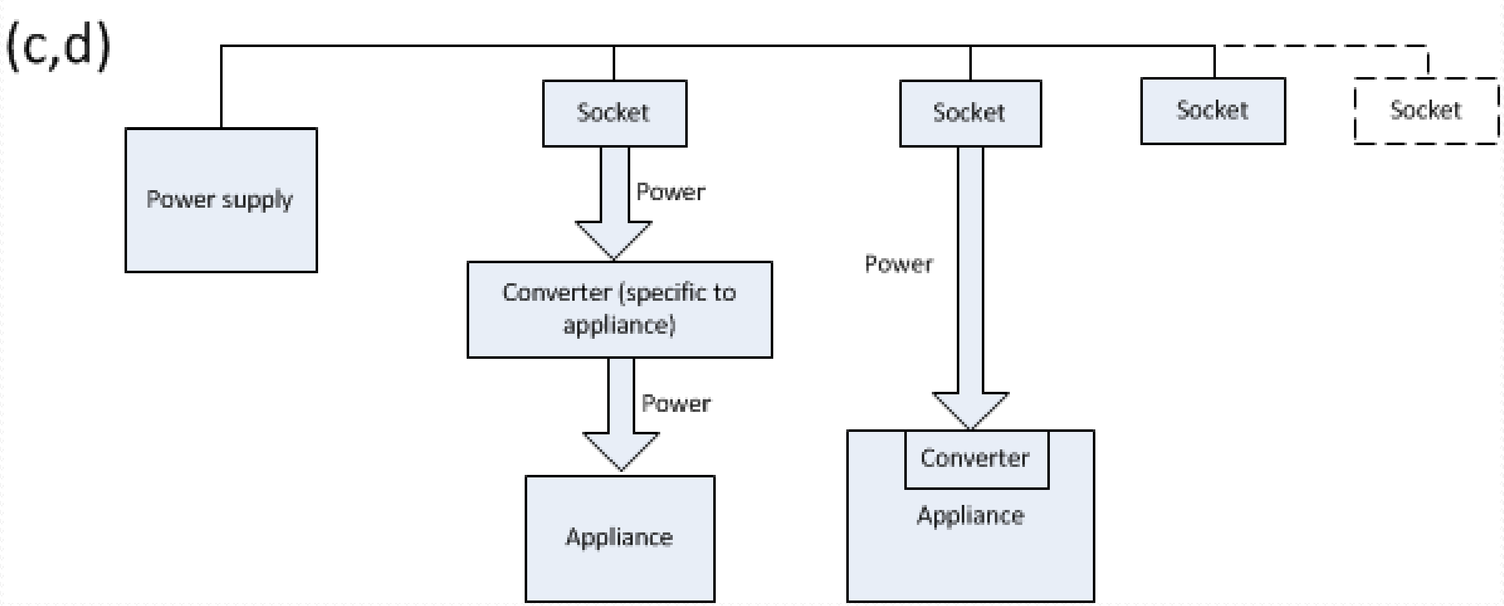
(Configuration info may just be a resistor to indicate required voltage)

- Converter must cater for the most powerful supported appliance

+ Addresses cable voltage losses

NB: Galvanic isolation may be required in the converter!

Point-of-Load Conversion



- Not a minimum-box solution, possible to use the wrong converter
+ Wiring simple, may be shared, highly cost-effective
+ Scheme is familiar to electricians – may be debugged with a multimeter

Summary

- Associating conversion with the appliance (c),(d) means that undemanding low-power appliances can have very small and inexpensive converters
  - Unusual requirements (eg multiple voltages) are also possible
  - Disadvantage: the converter is specific to the appliance
- ***Conclusion: Point-of-Load conversion (c,d) is more efficient, more flexible and more cost-effective than (a) or (b)***