Direct Format Usage for PMBus Data Transfer

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Introduction

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The DIRECT format

• simple
• intuitive to use
• simplifying choices
Data Format Review

- Linear11 (Called Literal Format in tutorials)
- Linear16 (May be signed or unsigned)
- Direct
- IEEE Half Precision Floating Point
- IEEE Single Precision Floating Point

This talk will focus on Linear and Direct formats only
LINEAR11 Format

LINEAR11 format is used for non-output voltage (See PMBus Part II, Section 7.3)

\[ X = Y \cdot 2^N \]

Where

– \( X \) is the real world value
– \( Y \) is a signed 11 bit 2’s complement integer
– \( N \) is a signed 5 bit 2’s complement integer

The values \( N \) and \( Y \) form a 16-bit value sent over the bus as \( \{N, Y\} \).
LINEAR16 Format

LINEAR16 format is used for output voltage only (See PMBus Part II, Section 8.4.1)

Voltage = V \cdot 2^N

Where
- Voltage is the value in Volts
- V is a 16 bit integer (unsigned for LINEAR16 signed for SLINEAR16) sent over bus
- N is a signed 5 bit 2’s complement integer from the VOUT_MODE Parameter
DIRECT Format

DIRECT format is used for any value (See PMBus Part II, Section 7.4)

\[ X = \frac{1}{m} \cdot (Y \cdot 10^{-R} - b) \]

Where
- \( X \) is the real world value
- \( Y \) is a two byte 2’s complement integer sent over bus
- \( m \) is the slope coefficient, a two byte 2’s complement integer
- \( b \) is the offset, a two byte 2’s complement integer
- \( R \) is the exponent, a one byte 2’s complement integer

Coefficients \( m \), \( b \), and \( R \) are read using the COEFFICIENTS command or obtained from the device literature.
VOUT_MODE Command

VOUT_MODE is an 8-bit value \{Mode, Parameter\}

- Upper 3 bits define the Mode
- Lower 5 bits define the Parameter

Two cases of interest

- LINEAR16 - Mode = 0, the Parameter is the 2’s complement exponent
- DIRECT - Mode = 2, the Parameter is zero

Typical usage – Read-Only
Format Comparison

All data formats have a restriction on range and resolution

Range
• LINEAR11 has only 1024 steps
• LINEAR16 has 32768 steps signed or 65536 unsigned

Resolution
• LINEAR11 and LINEAR16 formats have resolution that is a power of 2
• DIRECT format has resolution that is $1/m$ times a power of 10

Which has better fit for overall accuracy? Ease of use?
Analog System

RD_TEMP ↔ A/D ↔ Temperature Sensor
RD_VIN ↔ A/D ↔ Input Voltage Sensor
RD_IOUT ↔ A/D ↔ IOUT Sensor
RD_VOUT ↔ A/D ↔ VOUT Sensor

VOUT_COMMAND ↔ D/A ↔ V_Error

Digital LSB = Analog LSB

Offset

V_Error → targetOutput

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Digital System

RD_TEMP → DeMux Filter And Scale → A/D → Analog Mux → Temperature Sensor → V_Error → targetOutput
RD_VIN → A/D
RD_IOUT → A/D
RD_VOUT → A/D

VOUT_COMMAND → Reg → +
Offset
Need for Better Resolution

• VOUT positioning resolution versus absolute precision available with LINEAR16 and DIRECT are basically equivalent – difference is power of 2 versus power of 10.

• Telemetry data is a different story – 11-bits for LINEAR11 versus 16-bits for DIRECT.
LINEAR16 Format Examples

Choose exponent N to be -10

\[ X = Y \cdot 2^{-10} \] which gives 0.977 mV LSB size with +/-32 V range

Choose exponent N to be -12

\[ X = Y \cdot 2^{-12} \] which gives 0.244 mV LSB size with +/-8 V range

Unfriendly values in base 2 radix
Direct Format Examples

Simplify the DIRECT Format to use $m=1$ and $b=0$:

$$X = Y \cdot 10^{-R}$$

With $R = 3$, the LSB size is 1mV with 32.7V range
With $R = 2$, the LSB size is 10mV with 327V range

Nice user friendly values in base 10 radix
Conclusion

• Direct Format is simple to use with wise coefficient choice
• Can represent wide range with decimal radix
• Data read back is exactly the setting value
• Exact voltage positioning relative to specifications
• Telemetry data is readable real world units
• Simplified debug – convert to decimal then move decimal point