



System Management
Interface Forum



Monitoring and Optimizing AC/DC Power Supply Performance for Different Applications Using PMBus™

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Outline



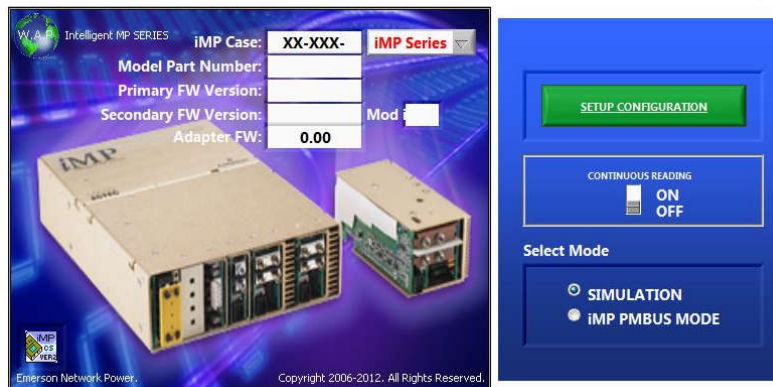
- Adoption of PMBus™ in AC-DC Supplies
 - With Power Supply Examples
 - With Technology and Component Trends
- Application Examples
- Special Application of PMBus over Various Interfaces



Early-Adoption – Configurable Supplies



- Higher Power (1.5KW to 5.0KW)
- Higher Margin (Low Volume, Complex Applications – Customers Pay for Flexibility)



- PMBus™ programmability and monitoring added value in both Development Environments and for Real-Time System Tuning
- 2005 Release
 - Probably the first AC-DC 'Catalog' Power Supply with PMBus™



PMBus™ Benefits - Configurable Supplies



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Specification	Standard SMPS	SMPS With PMBus
Turn-On	Fixed	Programmable
Global Inhibit/Enable	Fixed	Programmable
Adjustment Range	Manual +/-10%	Programmable entire module range
OCP	Fixed	Programmable
OTP	Fixed	Programmable
OTW	N/A	Programmable
Software Inhibit	N/A	Programmable
OVP	Fixed	Programmable
DCOK Window	Fixed	Programmable
Module Enable	MOD Only	Programmable
Constant Current	MOD Only	Programmable
Elapsed Time Meter	N/A	Available for Readback
Fan Control	Fixed	Monitor and Override control
Input Status	LED Indication	Monitor Voltage/Current/Power
Output Status	LED Indication	Monitor Voltage/Current/Power/Faults



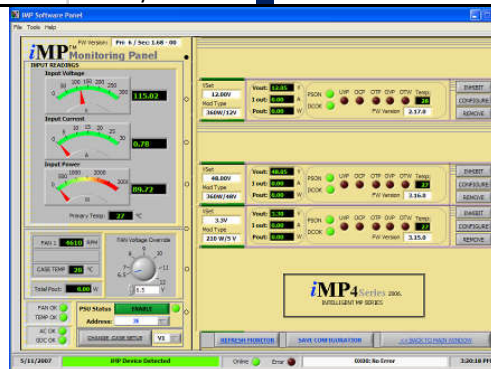
PMBus™ Flexibility - Configurable Supplies

User Defined Commands



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Command	Command Code	Transaction Type	Command	Command Code	Transaction Type
CASE_FIRMWARE_VERSION	D0h	Read Block	READ_MODULE_VERSION	DFh	Read Block
ACTIVE_SLOTS	D2h	R/W Byte	IOUT_SENSOR_CALIBRATION	E0h	Send Byte
SMART_MODULES	D3h	R/W Byte	OVP_LIMIT_PERCENT	E1h	Write Byte
MODULE_AUTO_DETECT	D4h	Send Byte	UVP_LIMIT_PERCENT	E2h	Write Byte
PSU_CONFIG	D5h	R/W Byte	MODULE_OTP_LIMIT	E3h	Write Byte
PSU_SETUP	D6h	Read Byte	MODULE_CONFIG_FLAGS	E4h	Write Byte
TOTAL_POWER	D7h	Read Word	LOAD_PREDEFINED_SETTING	E5h	Write Byte
CASE_STATUS_BYTE	D8h	Read Byte	MODULE_VSCALE_CALIBRATION	E6h	Write Word
CASE_FAULT_BYTE	D9h	Read Byte	MODULE_OPERATIONS	E7h	Read/Write Word
MODULE_COMMUNICATION_ERROR_BYTE	DAh	Read Byte	PSU_MONITOR	E9h	Read Block
MODULE_STATUS_FLAGS	DBh	Read Byte	MODULE_MONITOR	EAh	Read Block
EXTRACT_MODULE_CONFIG_BYTES	DCh	Read/Write Word	OVER_POWER_LIMITS	EBh	Read/Write Block
READ_MODULE_CONFIG_BYTES	DDh	Read Block	OUTPUT_INDEX	ECh	Read/Write Word
EXTRACT_MODULE_VERSION	DEh	Send Byte			



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Controller Architecture with PMBus



- Traditional control architecture
 - Analog controller + optional MCU for digital communication
 - Cost Adder, but cost effective for optional communication!
 - Minimum learning curve
 - Tailored controllers
- Digital control architecture
 - Control and communication handled by a digital controller
 - Flexibility
 - Reduced parts counts
 - Built-in digital communication



Component Technology Evolution



Cost competitive Choices emerge



Coincides with Artesyn's (fka Emerson)

- 1st Digital Control Front-End (07)
- 1st PMBus™ Front-End (08)

	General purpose DSCs	SMPS DSCs		Microcontrollers
	GEN 1	GEN 2	GEN 2 (alt)	GEN 3
MIPS:	32	32	40	800
Bytes Flash:	16-32K	32K	16K	1024K
Bytes RAM:	4K	8K	2K	204K
ADCs:	2x 3-ch,12-bit (1.125us/sample)	2x 8-ch,12-bit (1.125us/sample)	12x,10-bit (500ns/sample)	4 x 16/12 bits (1.1msps/channel)
Comparator:	None	2x Analog	4x Analog	
DAC:	None	2x 12-bit	None	
Timers:	4x PWM	4x PWM	3x GP (2x PWM)	
PWM Outputs:			8x PWM (4 pairs)	24
Relative Cost:	2.0	1.0	0.65	2.2
Features:	Basic	Peak-by-peak current control capable Analog output availability Remappable I/Os for optimum flexibility		Dual-Core Architecture Two 32-Bit CPUs 200 MHz Single –Precision FPU + TMU

2006

2008

2018



Smart Battery System Implementers Forum

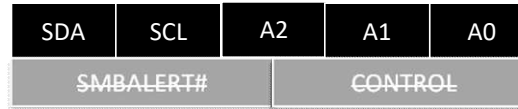
Early Adoption – Server Power Supply



- Not as Cost Sensitive as some (Blade Server)
 - Primary side DSP
 - Secondary side DSP



- Extensive Command Set
 - 63 PMBus™ Commands implemented, including:



Command Code	Command Name
01h	OPERATION
02h	ON_OFF_CONFIG
03h	CLEAR_FAULTS
10h	WRITE_PROTECT
11h	STORE_DEFAULT_ALL
12h	RESTORE_DEFAULT_ALL
15h	STORE_USER_ALL
16h	RESTORE_USER_ALL
19h	CAPABILITY
20h	VOUT_MODE
21h	VOUT_COMMAND
22h	VOUT_TRIM
23h	VOUT_CAL_OFFSET
24h	VOUT_MAX

31h	POUT_MAX
35h	VIN_ON
36h	VIN_OFF
38h	IOUT_CAL_GAIN
39h	IOUT_CAL_OFFSET
3Ah	FAN_CONFIG_1_2
3Bh	FAN_COMMAND_1
40h	VOUT_OV_FAULT_LIMIT
41h	VOUT_OV_FAULT_RESPONSE
42h	VOUT_OV_WARN_LIMIT
43h	VOUT_UV_WARN_LIMIT
44h	VOUT_UV_FAULT_LIMIT
45h	VOUT_UV_FAULT_RESPONSE
46h	IOUT_OC_FAULT_LIMIT
47h	IOUT_OC_FAULT_RESPONSE
48h	IOUT_OC_LV_FAULT_LIMIT

5Ch	IIN-OC-FAULT_RESPONSE
5Dh	IIN_OC_WARN_LIMIT
5Eh	POWER_GOOD_ON
5Fh	POWER_GOOD_OFF
60h	TON_DELAY
61h	TON_RISE
64h	TOFF_DELAY
78h	STATUS_BYTE
79h	STATUS_WORD
7Ah	STATUS_VOUT
7Bh	STATUS_IOUT
7Ch	STATUS_INPUT
7Dh	STATUS_TEMPERATURE
7Eh	STATUS_CML
80h	STATUS_MFR_SPECIFIC
81h	STATUS_FANS_1_2

PMBus™ Benefits – Server Power Supply



- Facility management
 - Power system health reporting and monitoring
 - Thermal management
 - Protection of power system
- Rack-level management
 - Server-level power reporting and monitoring
 - Fault management and logging
 - Power budgeting
- System level optimization for optimizing power losses at different conditions



Performance and Feature Evolution



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- Standard PMBus commands
- Reporting accuracy typically at 5%
- Manufacturer specific in configs

- Reporting accuracy capability at 1%
- Energy reporting
- System-optimized efficiency management
- In-system programming
- Fault logging
- Event logging
- Imminent fan failure prediction
- Throttle (Intel)

Increase in manufacturer specific commands to add feature sets

2005

2009

2015

2020



Application Example



- Power loss optimization
 - Objective: Reduce power supply losses at system idle, sleep, and hibernate mode
 - Main commands used

01h	OPERATION
8Ch	READ_IOUT
79h	STATUS_WORD
D0h	MFR_SPECIFIC_00

- Description
 - Provides different levels of power supply operating modes depending on system status and load



Application Example



- Super-capacitor charging
 - Objective: Provide a method of charging a bank of super-capacitors
 - Main commands used

01h	OPERATION
46h	IOOUT_OC_FAULT_LIMIT

- Description
 - Series of IOOUT_OC_FAULT_LIMIT commands issued by the host to allow for charging a bank of super-capacitors for energy storage.

Application Example



- System Airflow Matching

- Objective: Optimize the airflow through power supply while accounting for the backpressure that system fans will present

- Main commands used

3Bh	FAN_COMMAND_1
8Dh	READ_TEMPERATURE_1
8Eh	READ_TEMPERATURE_2
8Fh	READ_TEMPERATURE_3
90h	READ_FAN_SPEED_1

- Description

- Power supply internal fan speed adjustment to manage backpressure, acoustic noise, and airflow recirculation



Application Example

- Active Management in response to Line Voltage
 - Objective: Maximize usage for 115Vac and 230Vac
 - Main commands used

88h	READ_VIN
D0h	MFR_SPECIFIC_00

- Description
 - Voltage Monitored
 - System reconfigured based on Line



Application Example



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- Simultaneous Dynamic Management of Voltage and Current
 - Electrolysis – Salt concentration
 - Objective: Monitor and Adjust V and I to maintain Salt Concentration
 - Main commands used

8Bh	READ_VOUT
8Ch	READ_IOUT
D0h	MFR_SPECIFIC_00

- Description
 - Voltage Monitored
 - Current Monitored
 - Estimate Salt Concentration
 - Adjust



Application Example



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- Wide Range Outputs
 - Objective: Programmable Power Supply with Outputs from 2V to 36V
 - Main commands used

21h	VOUT_COMMAND
D0h	MFR_SPECIFIC_00

- Description
 - EEPROM values adjusted to facilitate wide range
 - Voltage commands sent to power supply modules via PMBus™ interface



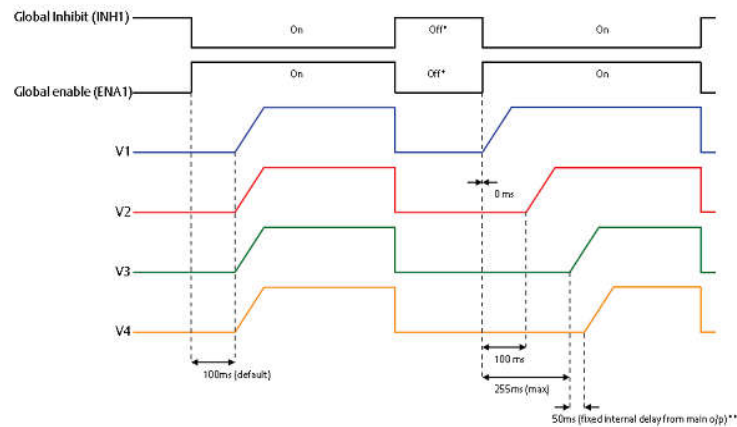
Application Example



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- Timing Sequence
 - IC Tester
 - Objective: Adjust sequencing and timing delays
 - Main commands used

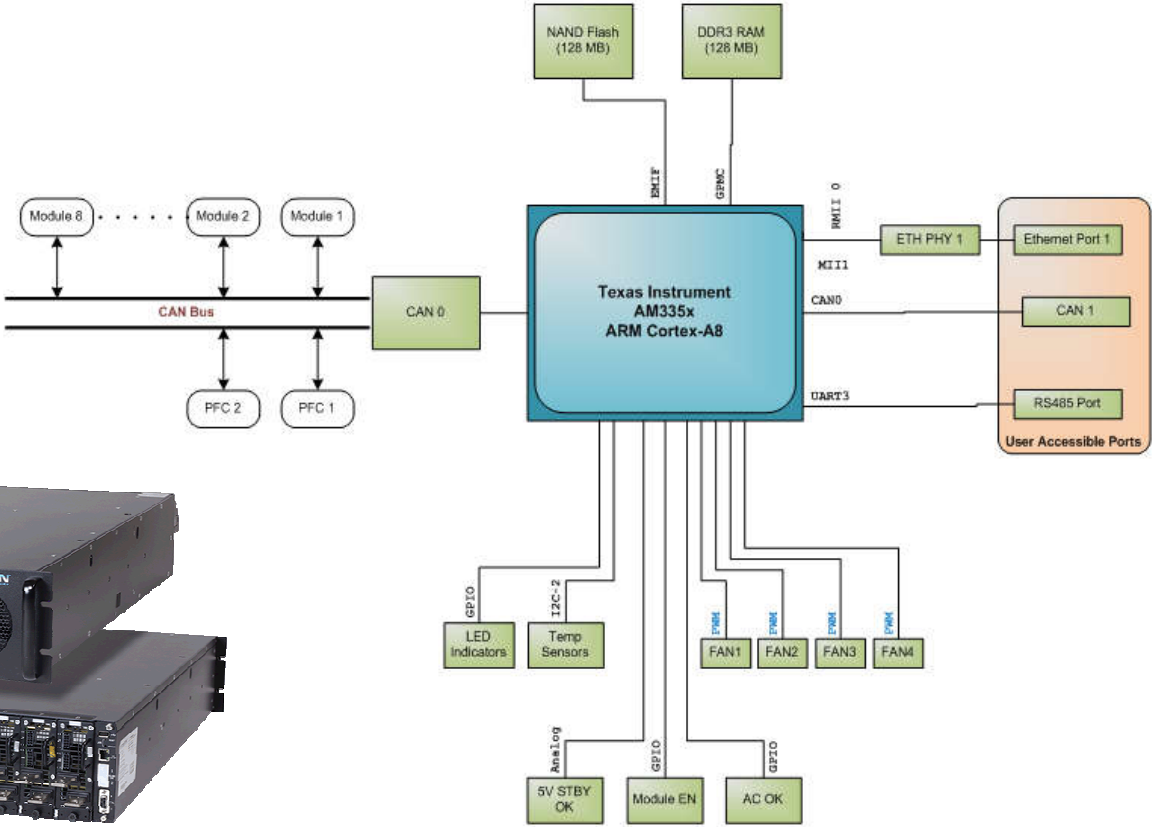
60h	TON_DELAY
64h	TOFF_DELAY
D0h	MFR_SPECIFIC_00



Next Level Implementation of PMBus over various interfaces



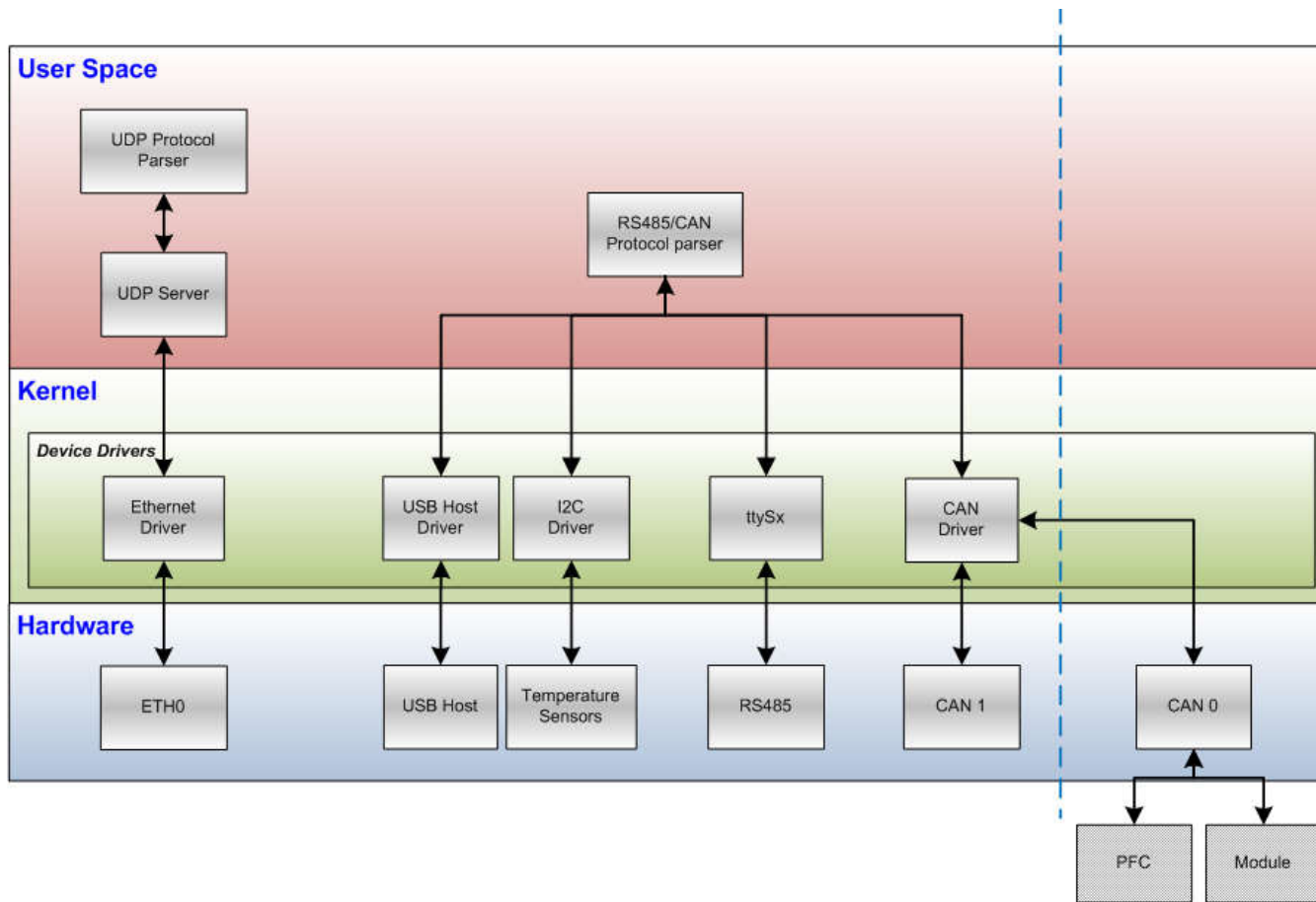
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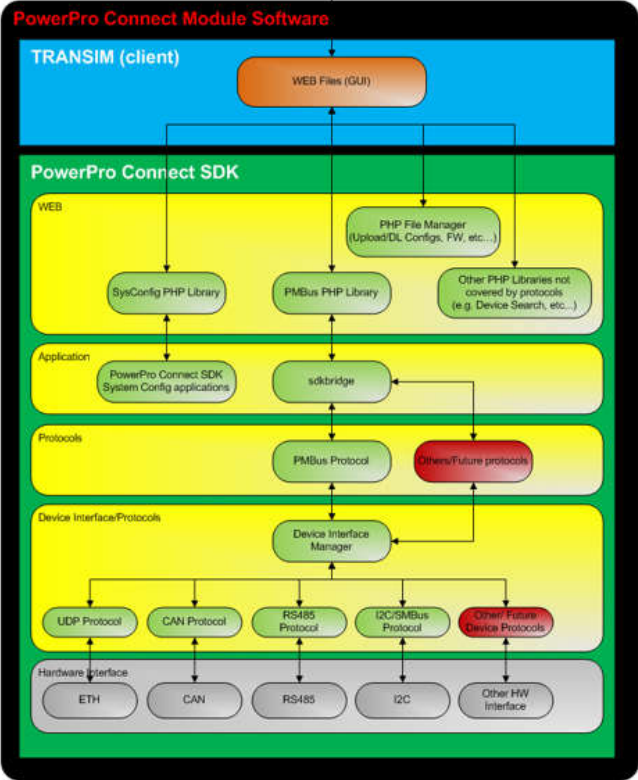
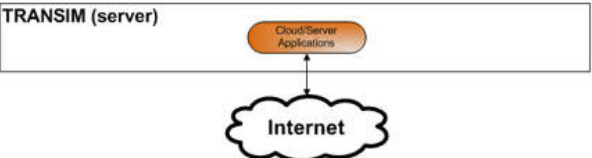
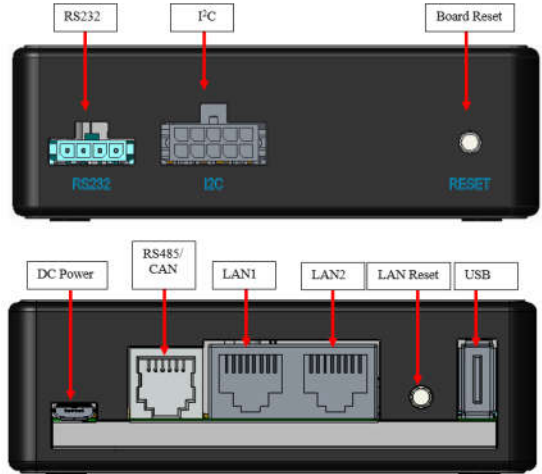
Next Level Implementation of PMBus over various interfaces



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Next Level Implementation of PMBus over various interfaces



CONCLUSION

- PMBus command structure can easily be leveraged for all Power system applications.
- User created Dashboards are designed for simple drag and drop widgets that are assigned to PMBus commands, and can be used to create basic to complex scripts for high level system control.



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The screenshot displays the TRANSIM dashboard interface. It features a central data table with columns for Time, Message, and Message. Below the table is a gauge for 'TRM-02 WIND VOLT'. To the right, there are several control widgets including a 'DISPLAY VOLT' gauge, a 'VOUT' slider, and a 'VOUT > 5' indicator. A script editor is visible at the bottom, showing a logic flow with 'Subscribe to Datasource - Vout', an 'if' condition 'Read Datasource - Vout > 5', and two 'Return LED Color' actions with different 'On/Off' and 'Blink' settings.

Time	Message	Message
Jan 20 2017 4:27:27 AM	327812488300001	
Jan 20 2017 4:27:28 AM	307034762707000	
Jan 20 2017 4:27:30 AM	418366017040000	
Jan 20 2017 4:27:31 AM	355462252420000	
Jan 20 2017 4:27:32 AM	330749430880000	
Jan 20 2017 4:27:33 AM	494943478080000	
Jan 20 2017 4:27:34 AM	043385581622700	
Jan 20 2017 4:27:35 AM	337087434640000	
Jan 20 2017 4:27:36 AM	818144530980000	
Jan 20 2017 4:27:37 AM	353290242102000	
Jan 20 2017 4:27:38 AM	424238778660000	



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Thank you!

Questions?

