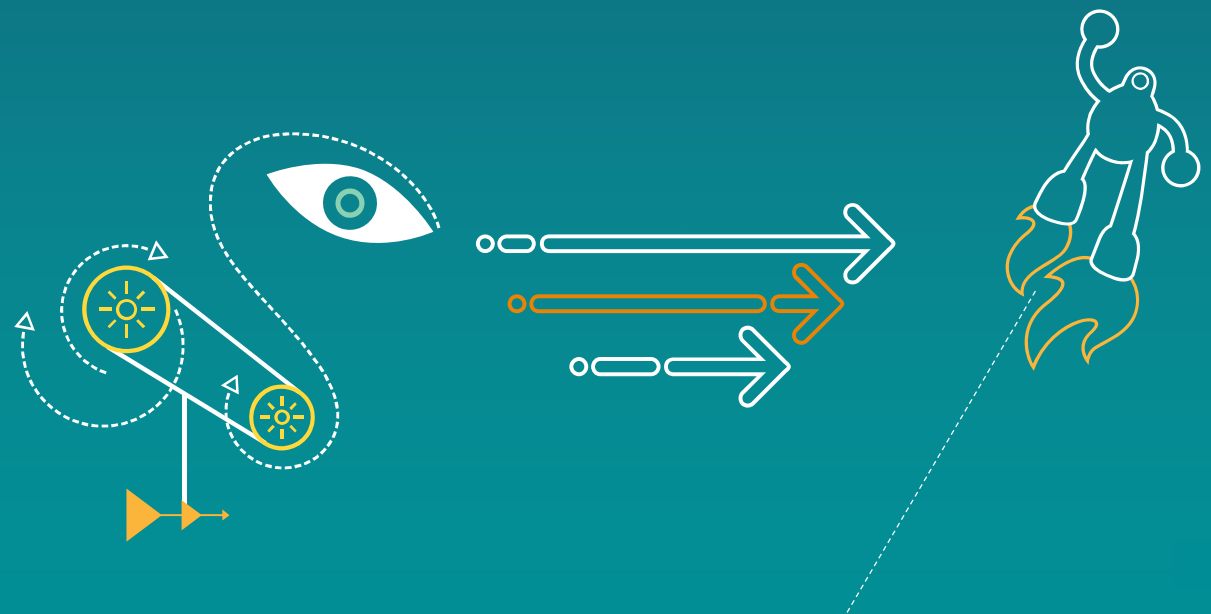
Jim Zyren, Director of Product Management
Qualcomm Technologies, Inc.

EV Combined Charging System Featuring HomePlug Green PHY

QUALCOMM®



1. Why do we need AC and DC Charging?
2. Combined Charging System
3. Comparing CCS to CHAdeMO
4. Production Vehicles Featuring HPGP
5. HPGP for DC and Smart AC Charging

Agenda

Why do we need AC and DC charging?

	Description	Max. Rated Power	Connector	User Experience
Level 1	Single Phase 120VAC charging. Suitable for most household wall outlets in US & Canada. 16A max continuous current	120VAC @ 16A = 1.92 KW	J1772	~ 3 miles of range per hour of charging. Can take up to 20 hours to recharge vehicle
Level 2	Single Phase 240VAC charging. Suitable for 240 VAC outlets with 40A breakers. Max continuous current rating is 80A.	240VAC @ 80A = 19.2 KW	J1772	~ 30 miles of range per hour of charging. Most vehicles are recharged in 3 – 4 hours.
Level 3	200 - 500VDC supplied from off-board charger. Maximum current is 200A.	500VDC @ 200A = 100 KW	CHAdeMO, or J1772 Combo	200 - 400 miles of range per hour of charging. Most vehicles are recharged in 20 -30 minutes.

- All batteries require Direct Current for charging
- "AC charging" means Alternating Current is provided to the vehicle
  - On-board charger module rectifies AC to create DC
- "DC charging" means Direct Current is provided to vehicle
  - AC rectified by off-board charger
- Capacity of charger determines charging time
  - On-board chargers must be small, light, and relatively inexpensive
  - High capacity rectifiers are big, heavy and expensive – Too big, too heavy and too expensive to place on a vehicle
  - Fast charging means DC charging, thus the term "Fast DC charging"

DC Fast Charger

Combined Charging System (CCS)

- Different (incompatible) charging systems in use today in North America
  - Combined Charging System (CCS) defined by SAE and ISO/IEC Standards
  - CHAdeMO developed by Japanese OEMS and TEPCO
  - Tesla (can interface with J1772 and CHAdeMO charging equipment via adapters)
- CCS: Single charging interface capable of supporting both AC and DC charging
  - Includes physical connector definition (SAE J1772)
  - low level signaling (SAE J1772)
  - high level communications between PEV and EVSE (SAE J2931 and ISO/IEC 15118)
- CCS Relies on HomePlug Green PHY for high level PEV/EVSE Communications
  - Use of HPGP is mandatory for DC charging
  - Optional for AC charging
    - HPGP-equipped AC chargers are referred to as “Smart AC Chargers”

What is HomePlug Green PHY?

- HomePlug Green PHY (HPGP)
  - A new, innovative variant of HomePlug powerline communications technology
  - HomePlug Alliance certified, fully interoperable with IEEE1901/HPAV
  - Operating frequency (2 – 28 MHz) is well above switching noise generated by EV charging equipment
  - Low power, low cost, robust performance @ 10 Mbps
- HPGP defined & developed in collaboration with the US Department of Energy, utilities, automobile manufacturers and HomePlug Alliance

HomePlug AV vs HomePlug Green PHY

	Parameter	HPAV/IEEE 1901	HPGP (HPAV/IEEE 1901 interoperable)
PHY	Spectrum	2 – 28 MHz	2 – 28 MHz
	Modulation	OFDM	OFDM
	# Subcarriers	1066	1066
	Subcarrier Spacing	24.414 kHz	24.414 kHz
	Supporting subcarrier modulation formats	BPSK, QPSK, 16QAM, 64QAM, 256QAM, 1024QAM	QPSK only
	Data FEC	Turbo Code Rate 1/2 or Rate 16/21 (punctured)	Turbo Code Rate 1/2 only
	Supported data rates	ROBO 4 Mbps (5X repeat code) 5 Mbps (4X repeat code) 10 Mbps (2X repeat code) Adaptive bit loading 20 Mbps – 200 Mbps	ROBO 4 Mbps (5X repeat code) 5 Mbps (4X repeat code) 10 Mbps (2X repeat code)
MAC	Channel access	CSMA/CA w/optional TDMA	CSMA/CA only
	CCo capable?	Yes	Yes
	Channel Estimation	Adaptive bit loading Per subcarrier via Pre-negotiated tone maps	ROBO eliminates the need for pre-negotiated tone maps

Denotes Green PHY change from HPAV

HPAV / IEEE1901 Interoperability @ Lower Power & Cost

Comparison of CCS and CHAdeMO

	CHAdeMO	CCS
Charging Modes	DC Fast Charging Only *AC Charging must be supported via separate connector*	Level 1 AC, Level 2 AC, and Level 3 DC Fast Charging
#Pins on connector	10 PIN Connector	5 pin connector (AC only) 7 pin connector (AC/DC Combo)
Higher Level Communications	CANbus via dedicated lines	HPGP multiplexed onto Control Pilot and Equipment Ground lines
Higher Level Comm Data Rates	1 Mbps (CAN)	10 Mbps (HPGP) 500 Mbps (HPAV/HPAV2)
Higher Level Comm Use Cases	Control DC Fast Charge	Control DC Fast Charge, Simple Payment & Billing, Time-of-Day Pricing, Home Network integration

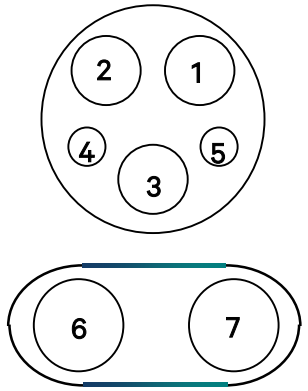
Comparison: CCS Combo Connector (J1772)

J1772 AC Connector

J1772 DC Connector

J1772 Charging Connectors

J1772 AC/DC Combo Vehicle Receptacle

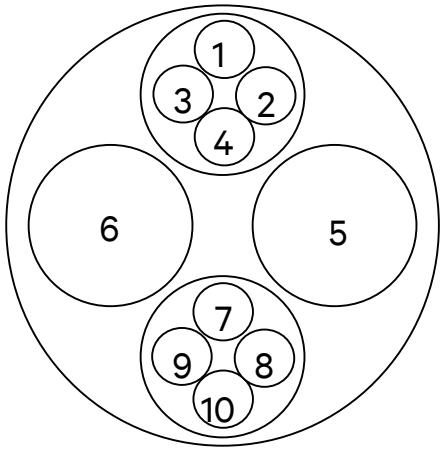


Pin	Function
1	L1
2	L2 / N
3	Equipment Ground*
4	Control Pilot
5	Proximity Detect*
6	DC -
7	DC +

** Note: HPGP signal is multiplexed onto Control Pilot and Equipment Ground lines*

Comparison: CHAdeMO Connector

CHAdeMO Connector is DC ONLY



Pin	Function
1	Reference GND
2	Control EV Relay 1
3	not assigned
4	Ready-to-Charge Control
5	DC -
6	DC +
7	Proximity Detect
8	Communication +
9	Communication -
10	Control EV Relay 2

Comparison: CHAdeMO & CCS vehicular configurations

CHAdeMO Vehicular Config

- Nissan Leaf shown
- CHAdeMO connector for DC Fast Charge
- Separate J1772 connector for AC Charge
- Two separate on-board systems

CCS Vehicular Config

- VW e-Golf shown
- CCS connector for DC Fast Charge & AC Charge
- Single integrated on-board system

Production vehicles featuring HPGP

Manufacturer	Model	Vehicle Classification	Charger Classification
BMW	i3	BEV	DC Fast
Chevrolet	Spark EV	BEV	DC Fast
Daimler	C-Class	PHEV	AC Smart
Daimler	S-Class	PHEV	AC Smart
Porsche	918 Spyder	PHEV	DC Fast
VW	XL-1	PHEV	DC Fast
VW	e-Golf	BEV	DC Fast
VW	e-Up!	BEV	DC Fast

QCA7000/7005 product overview

Low energy single chip HomePlug GreenPHY PLC solution family

Features

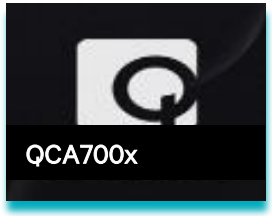
- Standard HPAV/ IEEE1901 Interoperable
- Simple & robust – 'ROBO' mode modulation
- Scalable data rates up to 10Mbps
- Single chip low cost HPGP
  - Integrated: AFE, PMU, RAM & ROM
  - Single 3.3V supply
- Low power HomePlug-compliant modes
- Simple Hostless capabilities
- Low cost, low power MCU interface options
  - SPI & UART host interfaces
  - Small Host driver
- Wettable Flank option: solder visual inspection

Applications

QCA7000 C-temp [QCA7000-AL3C]	Home automation, appliances, smart plugs
QCA7000 I-temp [QCA7000-AL3B]	Building and Industrial Automation, Electric Meters, water heaters
QCA7005-AL33	PEV, EVSE, Enhanced Industrial

Schedule

QCA7000-AL3C	Production	Available
QCA7000-AL3B	Production	Available
QCA7005-AL33	Production	Available

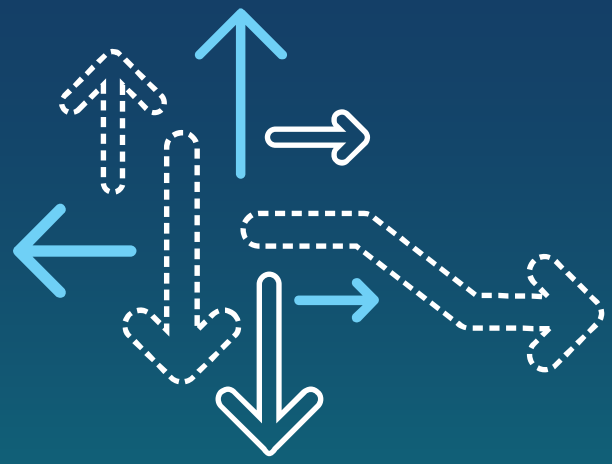


QCA7000 and QCA7005 are products of Qualcomm Atheros, Inc

HPGP product comparison

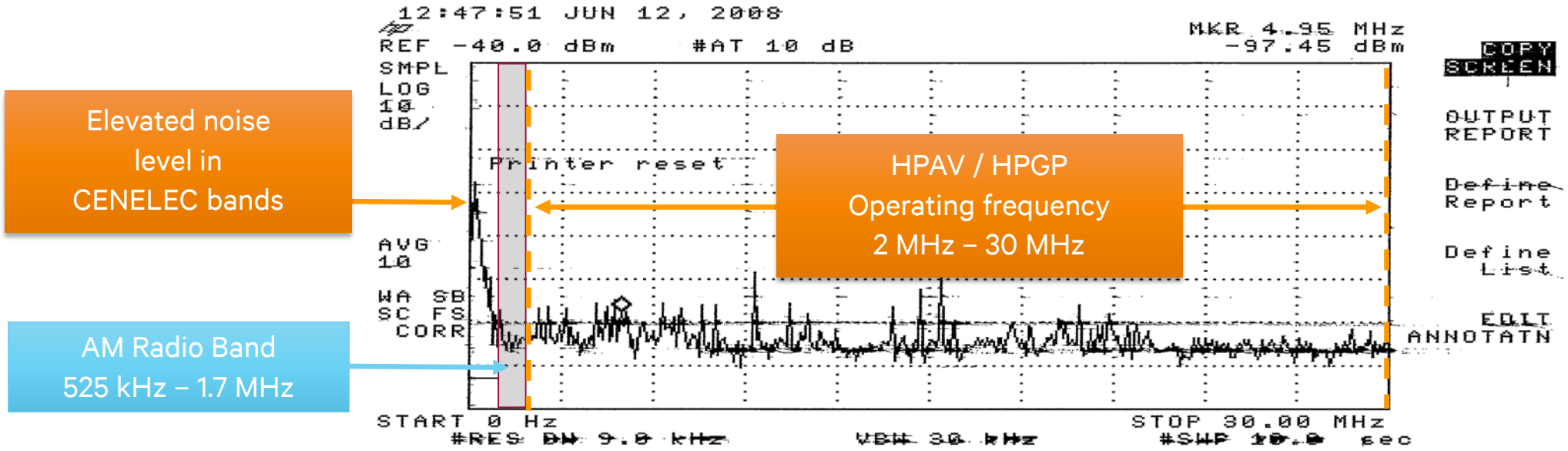
	QCA7000-AL3C (Commercial)	QCA7000-AL3B (Industrial)	QCA7005-AL33 (Enhanced Industrial)
Description	temperature range HPGP single chip MAC/PHY	temperature range HPGP single chip MAC/PHY	HPGP single chip MAC/PHY Tested for conformance with AEC Q-100 Grade 3 Environmental Stress Limits
Temp Range	0 to +70C	-40 to +85C	-40 to +85C *Enhanced production test*
T_{case}	0 to +105C	-40 to +110C	-40 to +110C
Package	0 to +70C	QFN68	QFN68 with wettable flanks
Target Applications	Gateways, appliances, home automation	Electric meters, pool pumps, water heaters	PEV, EVSE, Enhanced industrial usage

* Qualification test report demonstrating performance over ESD and temperature limits as defined by AECQ100 Grade3. Product sold under Qualcomm Atheros standard T&C's



Back up slides

HomePlug advantage: Lower ambient noise in 2 MHz – 30 MHz band



- Consumer appliances and electronics create noise on power line
  - Ambient noise levels are MUCH higher in homes for CENELEC bands
- HomePlug operates above AM radio band
  - Much lower ambient noise levels above 2 MHz
  - Enables higher data rates and enhanced reliability
- Similar noise levels are present in Europe, Asia, Americas
  - Results above measured in USA
  - Example of European measured results:
    - Schwager, Stadelmeier, and Zumkeller, “Potential of Broadband Power Line Home Networking”,
    - Figure 2, IEEE Consumer Communications and Networking Conference, 2005

Thank you

Follow us on:

For more information, visit us at:
www.qualcomm.com & www.qualcomm.com/blog