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OFDM - the 3rd generation of narrowband Power Line Communications

4th Annual European Utilities
Intelligent Metering

Barcelona, May 2008



About ADD GRUP

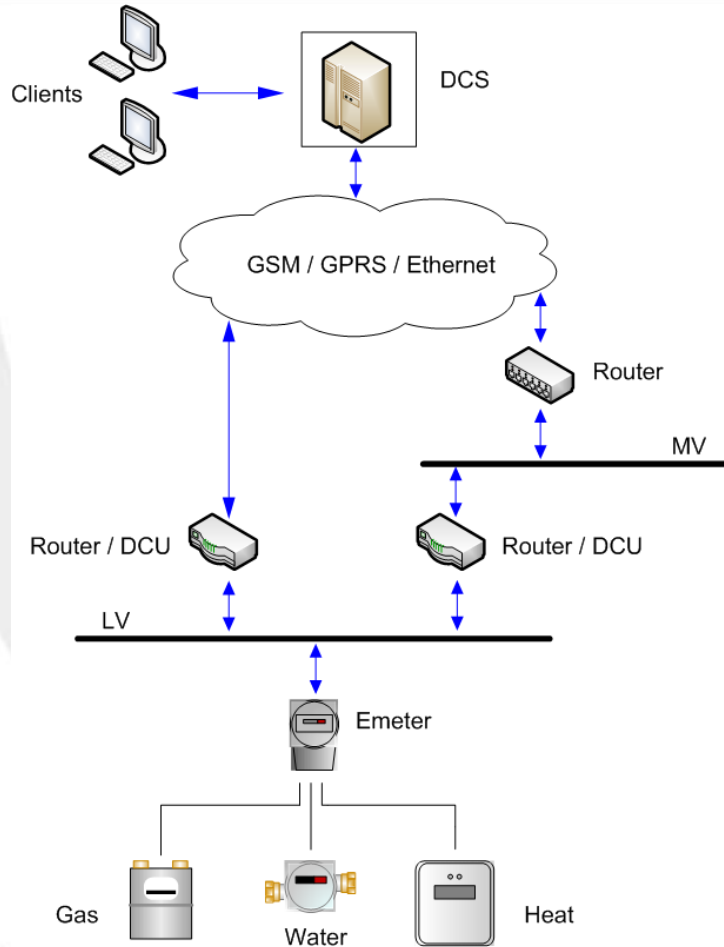
ADD GRUP history:

- 1992 – ADD was founded as a high-tech company
- 1998 – Started development of AMR solutions (Smart IMS)
- 2002 – The largest AMR project in Europe, Ukraine based on PLC communications (ScottReport, 2000)
- 2007 – 1 million AMM meters deployed

The Head-office is situated in Moldova with representations in Europe, Oceania, South America (Itron), Middle East, Africa.

More than 300 employees, from which about 100 in the R&D Department.

Typical AMI Communications



• TCP/IP stack used
• High public services cost

• Zero operational cost
• No standards for MV PLC
• High data rates required

• Zero operational cost
• Applications expansion
• Higher data rates required

PLC issues

- Hazardous medium for communications
- CENELEC limitations
- No standards for MV communications
- Various technologies used on LV
- Interoperability problems
- New applications required by the market
- Increasing demand for higher data rates

Narrowband PLC Generations

1st Generation

- Mono carriers (FSK, S-FSK, BPSK)
- Low data rate (<2400 bps)
- Proven implementation

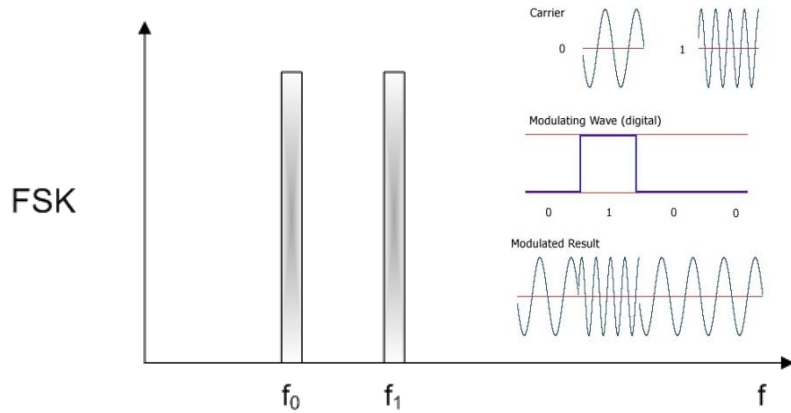
2nd Generation

- Spread spectrum (DCSK)
- Low data rate (<2400 bps)
- Few implementations

3rd Generation

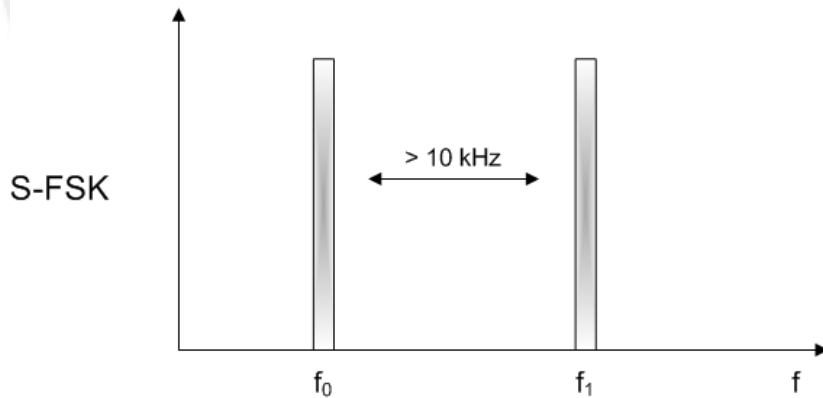
- Multi carriers (OFDM)
- High data rate (>10 kbps)
- Some implementations

1st Generation



Mono Carriers

- FSK, S-FSK, BPSK
- Proven implementation
- Low data rate (<2400 bps)
- Sensible to narrowband noise

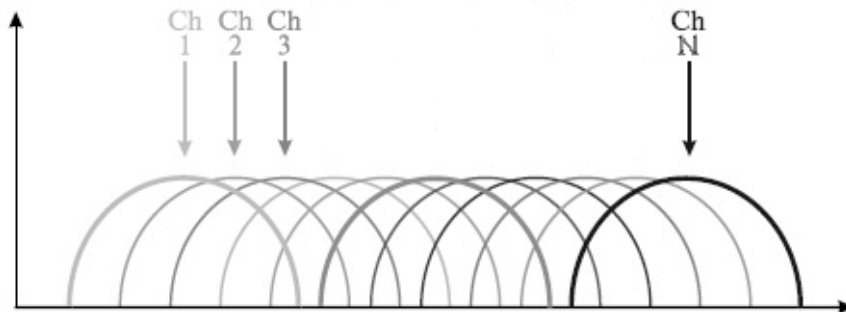
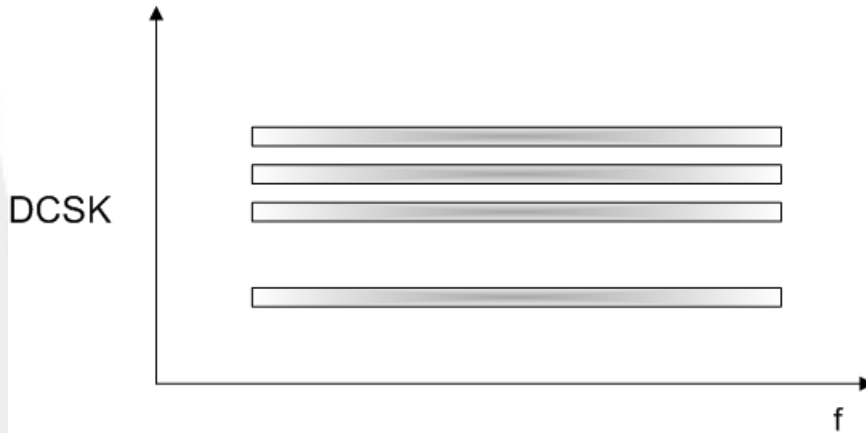


Reference application

AMIS-30585 S-FSK PLC modem



2nd Generation



Spread Spectrum

- Differential Code Shift Keying
- Robust against narrowband noise
- Low data rate (<2400 bps)
- Wide bandwidth required
- Few implementations

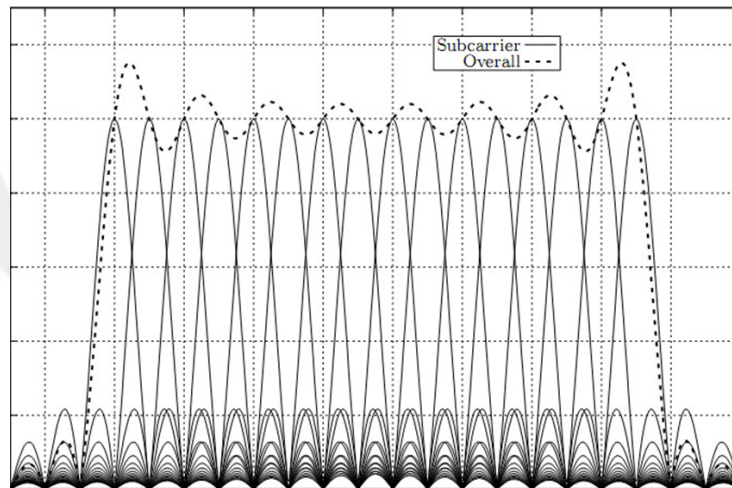
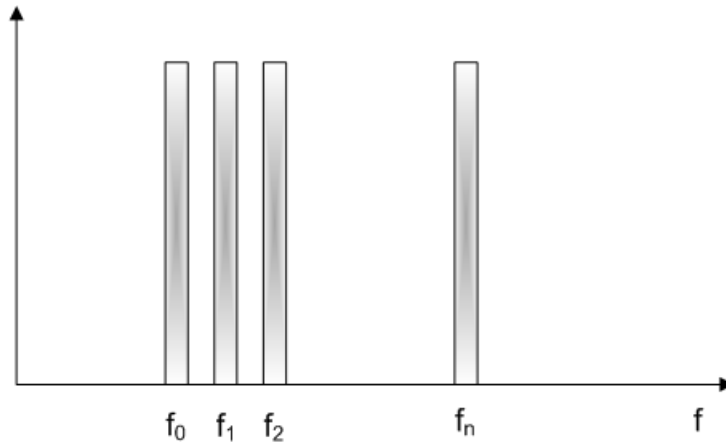
Reference application

Yitran IT800 PLC modem



3rd Generation

OFDM



Multi Carriers

- OFDM
- Robust against narrowband noise
- Higher data rates (>10 kbps)
- High spectral efficiency
- **Some implementations**

Reference application

ADDM-7LM PLC modem



OFDM Benefits

- AMI systems benefits
 - More detailed profiles and energy quality information
 - Online communication with meters
 - Remote meters firmware update via PLC
 - Instant alarms notification
- Integration of end devices into the IP network
 - Routing-only architecture possible
 - Well-defined protocols and services
 - Less interoperability and interconnectivity problems
 - Existing network management systems
- New applications
 - Security systems
 - Control systems
- Future proof
 - Ready for new market demands

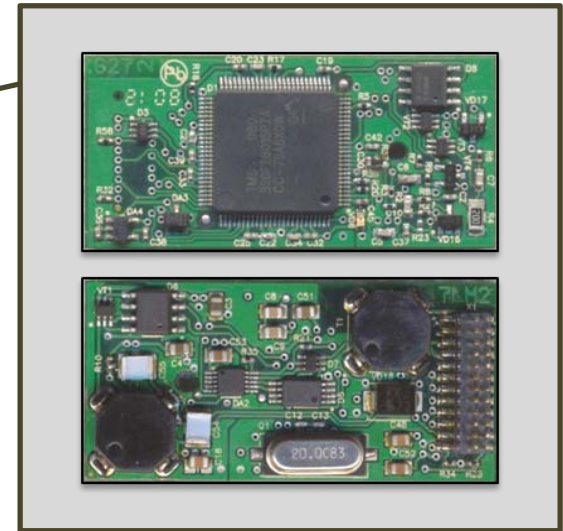
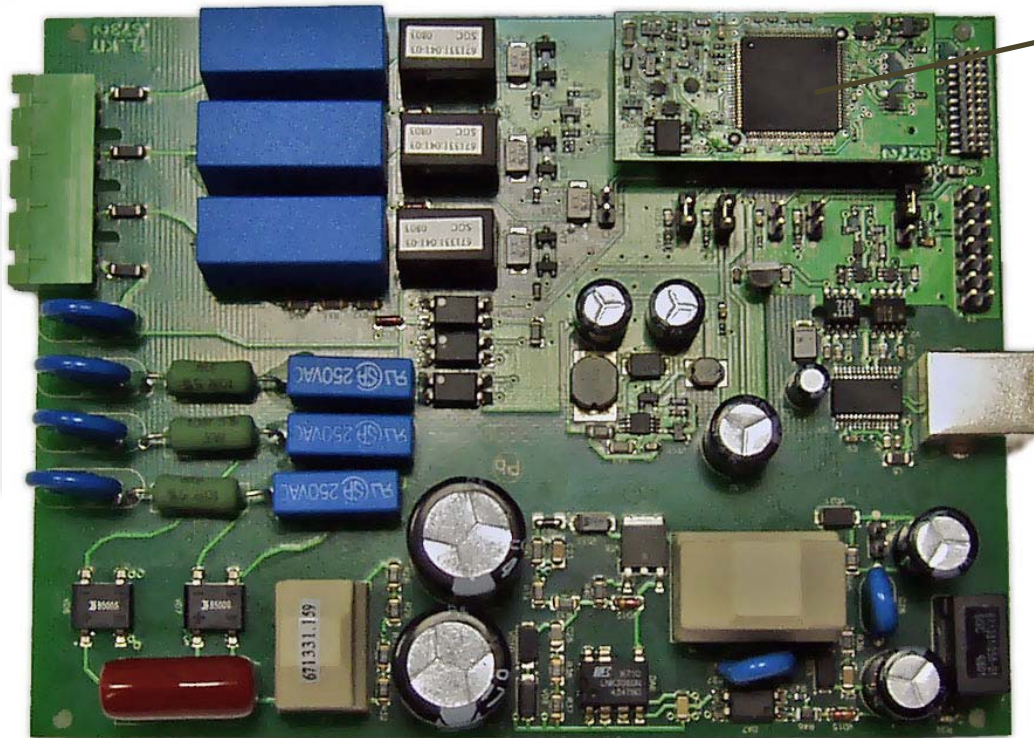
PLC Solution Requirements

- Narrowband (CENELEC limitations: 3 – 148,5 kHz)
- EMC requirements
- Bi-directional communications
- Noise proof
- Repetition technique
- Cross-talk management
- Adaptive to grid topology changes
- 3-phase communications
- High data rates (>10 kbps)
- Auto-discovery services
- Multi-protocol support (TCP/IP, DLMS/COSEM, SML...)
- Secure data transmission
- Low cost

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ADD GRUP Solution



Module Dimensions:
(L x W x H), mm:
46 x 22 x 13



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 TEXAS INSTRUMENTS

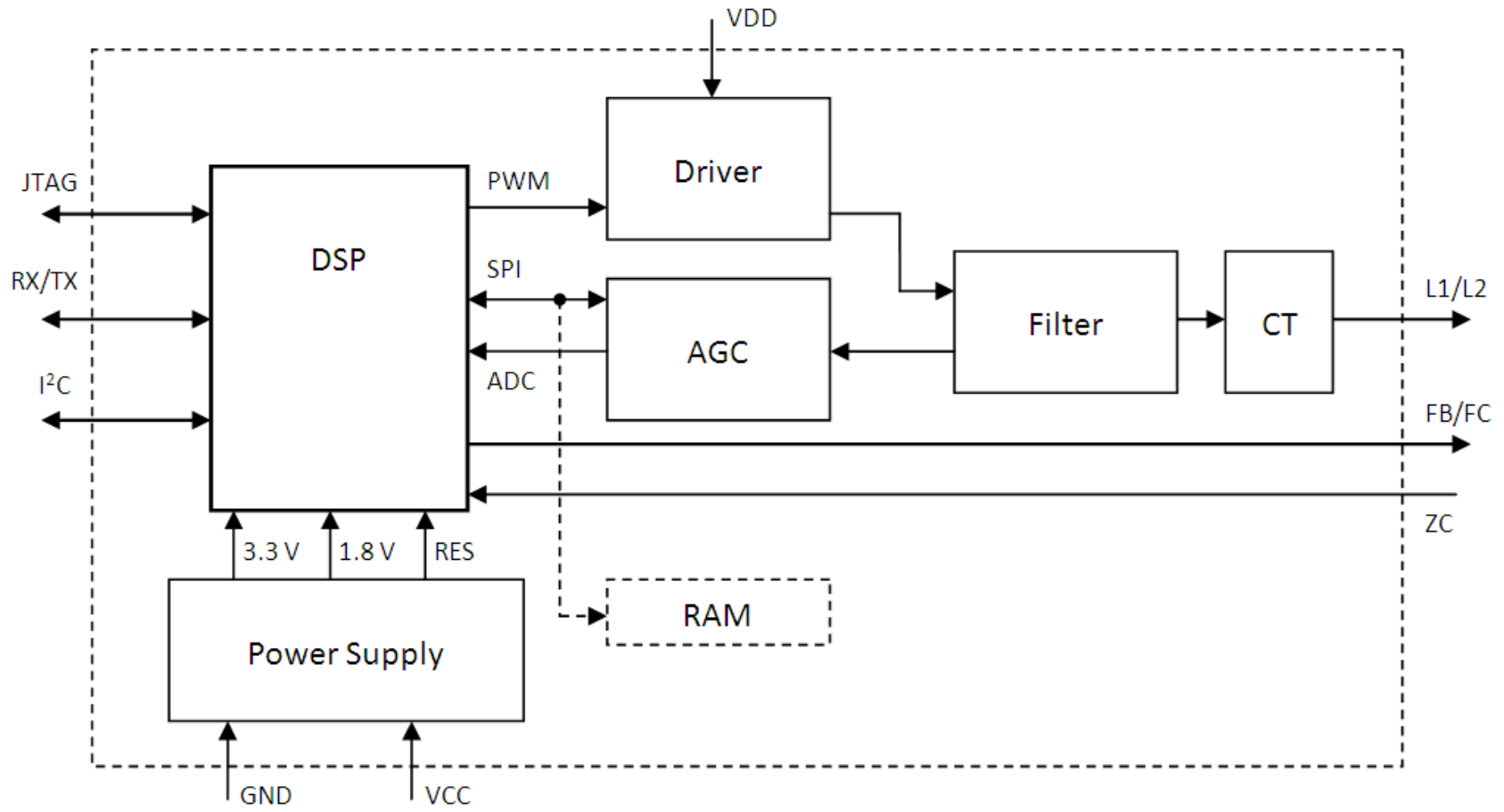
ADDM-7LM Features (1)

- High performance 32-bit DSP (TMS320F28xx)
- Operating frequency range 18 – 90 kHz (CENELEC A-band)
- Data rates up to 76,8 kbps for one mains phase (up to 230 kbps for 3-phase communications)
- Transmission with OFDM and FEC
- OFDM performed by complex FFT (128 points)
- Number of used carriers from 12 to 48
- Freely configurable carriers in the operating frequency range
- Flexible carrier notching
- Carriers interval 1500 Hz
- Differential phase modulation technique (DPSK 2/4/8/16)
- Cyclic prefix as guard interval

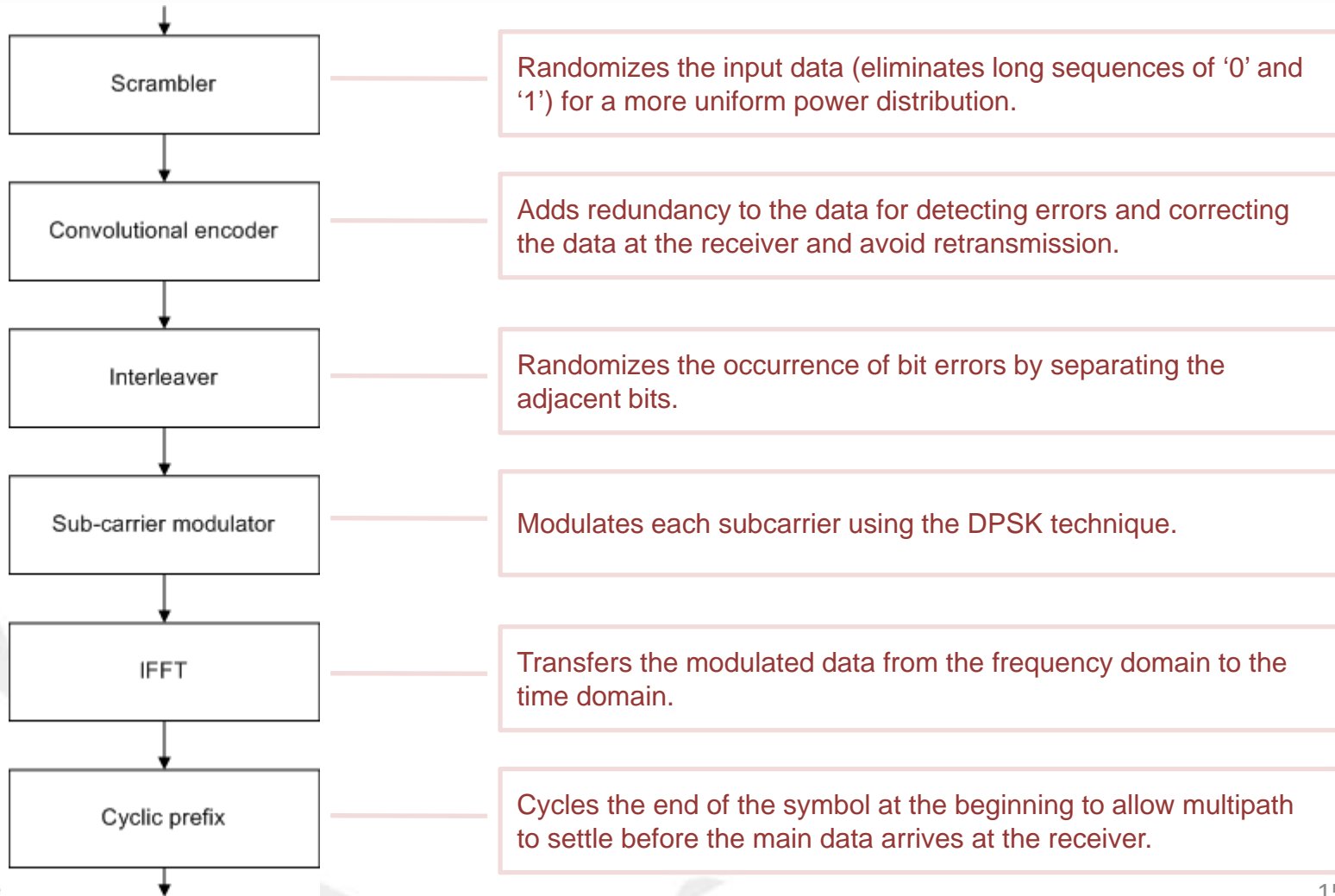
ADDM-7LM Features (2)

- Convolutional encoder / Viterbi decoder (constraint length 5, rates 1/2, 2/3 and 3/4)
- Bit interleaving for noise effects reduction
- 32-bit CRC for error detection
- Data randomization for uniform power distribution
- Automatic Gain Control
- Zero-crossing synchronized transmission
- Integrated MAC layer with auto-discovery and repetition mechanism
- Integrated LLC layer IEEE 802.2 type 1
- Asynchronous serial or I²C host interface
- Easy integration into any devices of the AMM/AMR systems
- Compatible to Standards EN 50065 (CENELEC), IEC 61000-3

ADDM-7LM Block Diagram

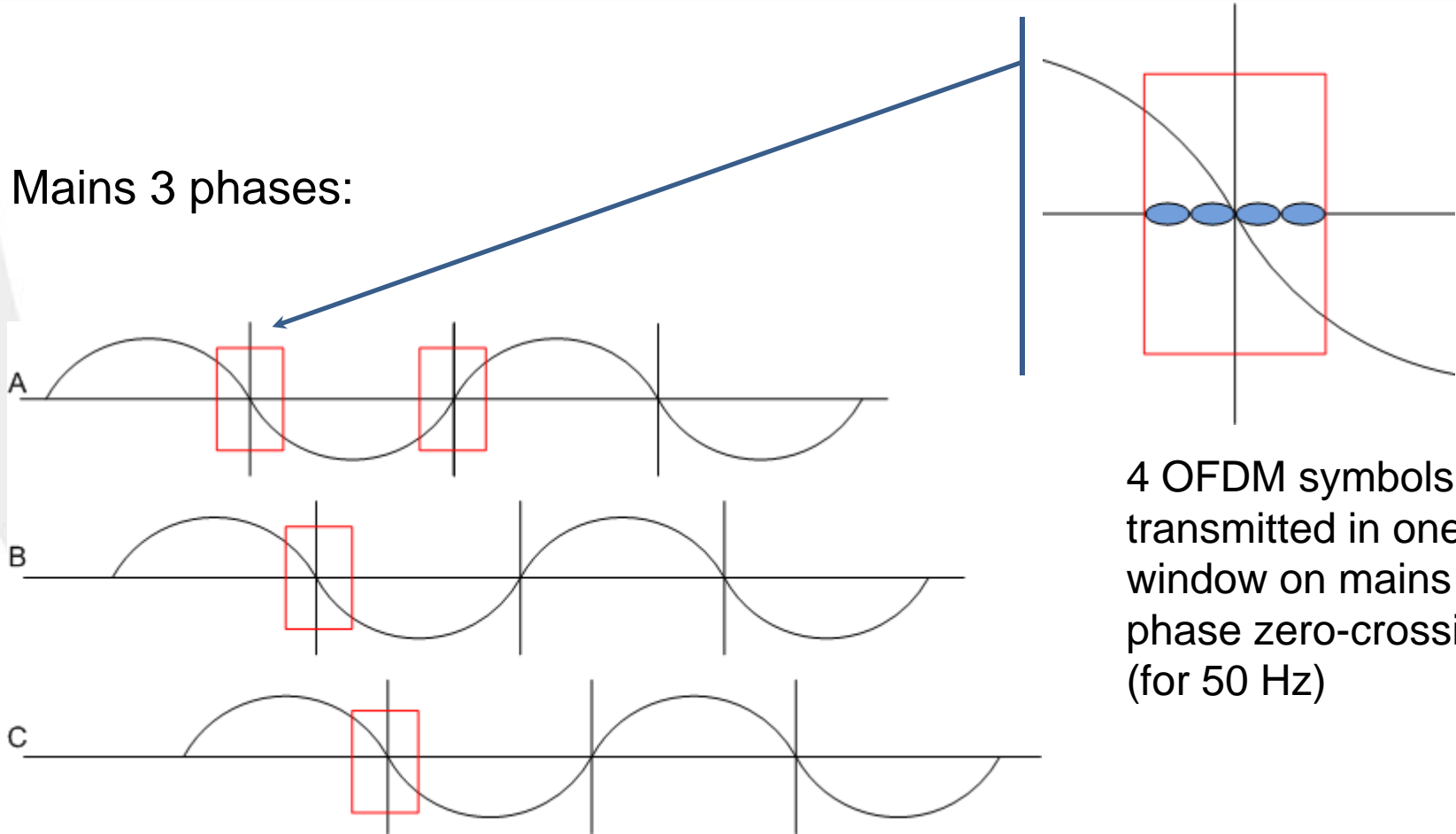


Transmission Technique



Transmission Windows

Mains 3 phases:



4 OFDM symbols transmitted in one window on mains phase zero-crossing (for 50 Hz)

Data Rates

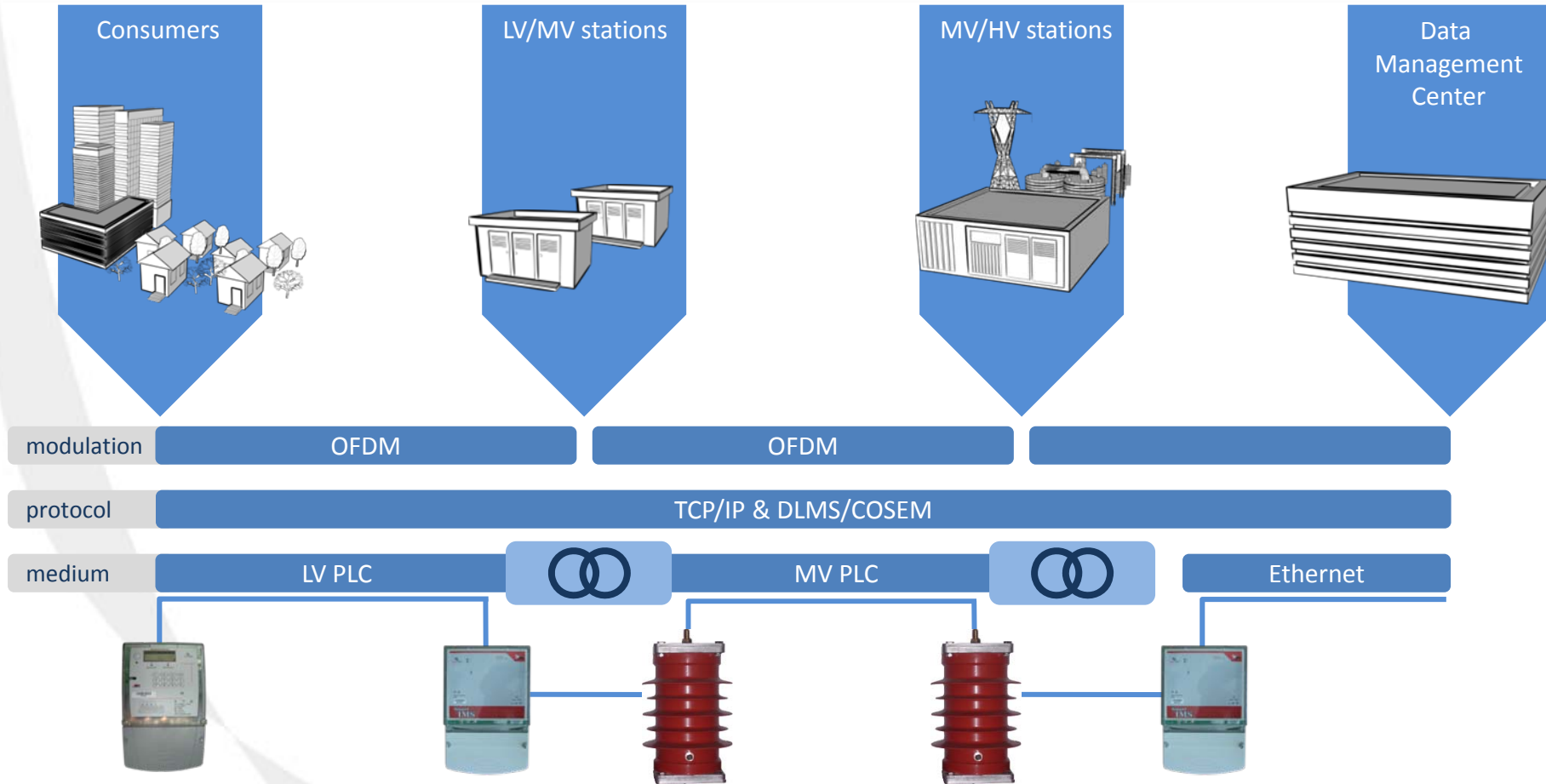
Depending on the modulation scheme and coding options the following calculations may be presented for one LV phase and 48 subcarriers used:

	DBPSK		DQPSK		D8PSK		D16PSK	
	FEC		FEC		FEC		FEC	
Information bits per subcarrier	1/2	-	1/2	-	1/2	-	1/2	-
Information bits per symbol	0,5	1	1	2	1,5	3	2	4
Raw data rate, kbps	24	48	48	96	72	144	96	192
	9,6	19,2	19,2	38,4	28,8	57,6	38,4	76,8

Protocol Stack

Protocol Layers		Standards	
COSEM Application Layer		IEC 62056-53	
Wrapper sub-layer		IEC 62056-47	
UDP	TCP	STD0006 (RFC 768)	STD0007 (RFC 793)
IP		STD0005 (RFC 791, RFC 792, RFC 919, RFC 922, RFC 950, RFC 1112)	
LLC IEEE 802.2, Type 1		IEEE 802.2, RFC 1042	
PLC MAC + PHY		IEEE 802.XX	
PL/LV media	PL/MV media	See, e.g., IEC 61334-1-1, sub-clause 3	

Efficient Communications



Objective Achieved

- All PLC issues addressed:
 - Homogenous techniques and protocols used on LV and MV
 - Robust high speed communication over LV and MV
 - Bi-directional 3-phase communication
 - Auto-discovery mechanisms
 - Repetition technique
 - Cross-talk management
- Convergence with other IEEE 802 standards
- Open standards for all protocol stack layers
- From the shelf implementations for:
 - Addressing and Routing
 - QoS
 - Security
 - Network management
- Low cost and future proof solution

Thank You for attention!

Visit www.addgrup.com for more info.