Embedded Connectivity Summit 2004

Low-Cost Modem Applications and Implementations Using the 56F8300 Family

DSCO

Launched by Motorola

freescale™
semiconductor

Objective

Provide an overview of the hardware and software requirements for implementing full v.22bis Soft Modem. Demonstrate complete hardware and software implementation using the 56F8300 and the CodeWarrior™ and Processor Expert™ software tools. Demonstrate the benefits of these complete solutions for the industrial, security, commercial and other markets.

Soft Modem Application

- **A Soft Modem application implements the functionality required for a complete full-featured ITU compliant Modem. This includes not only the data pumps, protocols, and algorithms but the ancillary functionality required for a complete soft modem such as DTMF dialing, call progress tone detection, and traditional fall back protocol.**

- **Lowers cost of including Modem capability by reusing processor to do Modem as well as main application task**

56800/E Hybrid Controller Roadmap

56850 Series
Telecom/voice, RAM-based, 120 MMACS, 81–144 pins

56F8400 Series
Automotive, industrial, Flash-based,120 MMACS, Flex-Ray, 2xCan, Improved PWM&ADC, low power, 48–160 pins

56F8500 Series
Automotive, industrial, Flash-based,150 MMACS, Flex-Ray, 2xCan, Improved PWM & ADC, low power,48- 160 pins

56F8300 Series
Automotive&Industrial, Flash-based, 60 MMACS, 16-512KB PFlash, 48–160 pins

56F8100 Family
Mid-Range Industrial and General Purpose, Flash Based, 40MMACs 48-144 pins

56F8000 Series
Low end industrial and automotive control, Flash-based, 32 MMACS, 28-32 pins

56F820 Series
General Purpose, Flash-based, 40 MMACS, 100–128 pins

56F80x Series
Industrial controllers, Flash-based, 40 MMACS, 32–160 pins
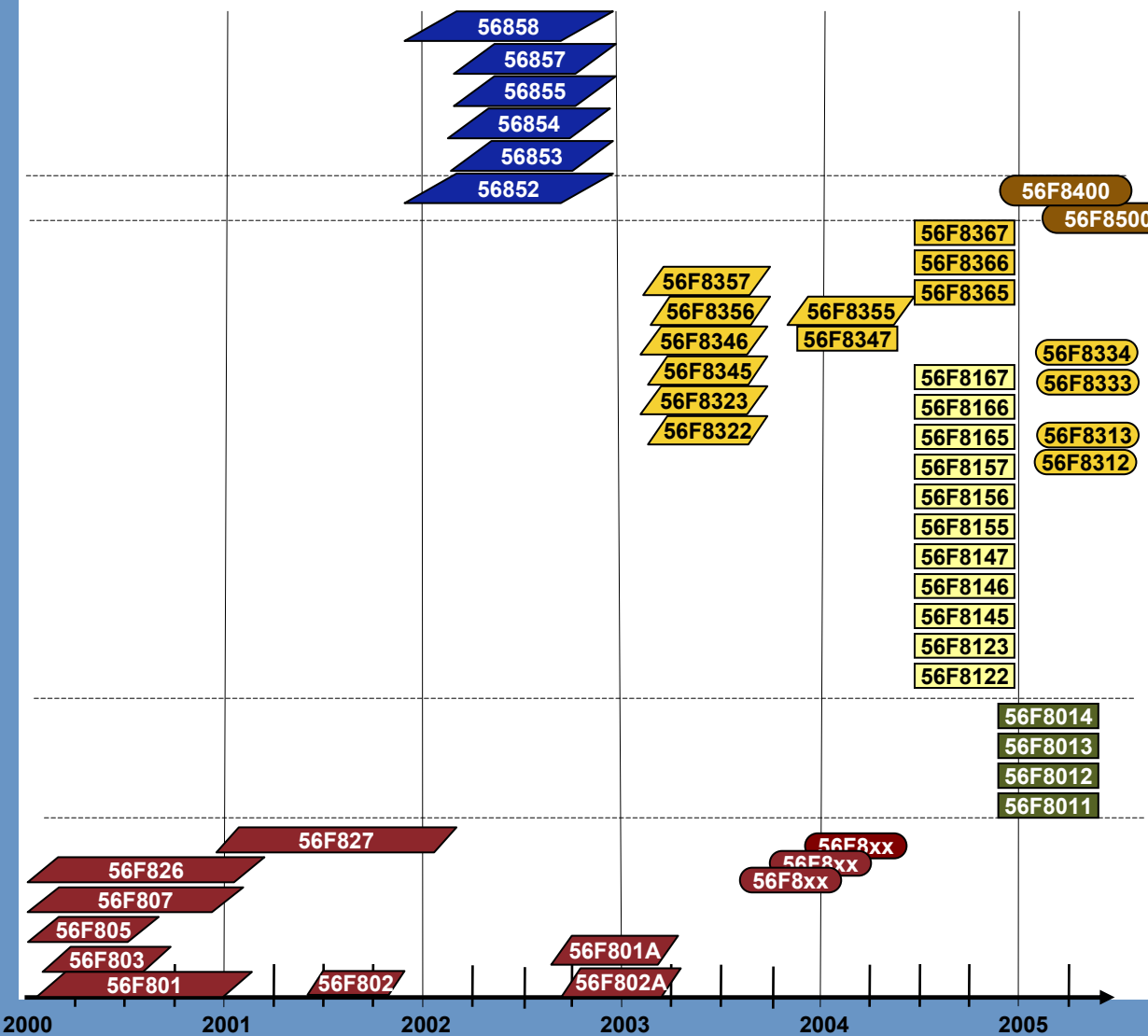
Proposal

Planning

Execution

Production

0.1Xµ, 56F8400 120 MMACS

0.1Xµ, 56F8500 150 MMACS

0.18µ, 56800E 120 MMACS

0.25µ, 56800E 60 MMACS

0.25µ, 56800E 40 MMACS

0.25µ, 56800 30/40 MMACS

0.25µ, 56800E 32 MMACS

56858
56857
56855
56854
56853
56852

56F8400
56F8500

56F8367
56F8366
56F8365

56F8357
56F8356
56F8355
56F8346
56F8347
56F8345
56F8323
56F8322

56F8334
56F8333

56F8167
56F8166
56F8165
56F8313
56F8157
56F8312
56F8156
56F8155
56F8147
56F8146
56F8145
56F8123
56F8122

56F8014
56F8013
56F8012
56F8011

56F827
56F826
56F807
56F805
56F803
56F801

56F8xx
56F8xx
56F8xx

56F801A
56F802A
56F802

2000   2001   2002   2003   2004   2005

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56F82x Series

	56F826	56F827
Performance	80MHz/40MIPS	80MHz/40MIPS
Temp. Range	(-40, +85)°C	(-40, +85)°C
Voltage	2.5 & 3.3V	2.5 & 3.3V
On-Chip Flash	**35.5K x 16**	**67K x 16**
Program Flash	31.5K x 16	63K x 16
Data Flash	2K x 16	4K x 16
Boot Flash	2K x 16	Via Program Flash
On-Chip RAM	**4.5 X 16**	**5K x 16**
Program RAM	512 x 16	1K x 16
Data RAM	4K x 16	4K x 16
Ext. Memory Interface	Yes	Yes
PLL	Yes	Yes
Watchdog Timer	Yes	Yes
Interrupt Controller	Yes	Yes
Time Of Day (TOD)	yes	yes
16-bit Timers	4	4
12-bit ADC	-	10ch
SCI (UART)	2	3
SPI (Synchronous)	2	2
SSI	1	1
GPIO (Ded./Shrd/Tot)	16 / 30 / 46	16 / 48 / 64
JTAG/OnCE	Yes	Yes
Packages	100LQFP	128LQFP
Availability	Now	Now

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Slide 5

56850 Series

	56852	56853	56854	56855	56857	56858
Performance	120MHz/120MIPS	120MHz/120MIPS	120MHz/120MIPS	120MHz/120MIPS	120MHz/120MIPS	120MHz/120MIPS
Temp. Range	(-40, +85)°C	(-40, +85)°C	(-40, +85)°C	(-40, +85)°C	(-40, +85)°C	(-40, +85)°C
I/O Voltage	3.3V	3.3V	3.3V	3.3V	3.3V	3.3V
Core Voltage	1.8V	1.8V	1.8V	1.8V	1.8V	1.8V
On-Chip RAM	**22KB**	**34KB**	**66KB**	**58KB**	**130KB**	**130KB**
Program RAM	12KB	24KB	32KB	48KB	80KB	80KB
Data RAM	8KB	8KB	32KB	48KB	48KB	48KB
Boot RAM	2KB	2KB	2KB	2KB	2KB	2KB
Ext. Memory Expansion	4MB/12MB	4MB/16MB	4MB/16MB	4MB/16MB	-	4MB/16MB
Oscillator	Yes	Yes	Yes	Yes	Yes	Yes
PLL	Yes	Yes	Yes	Yes	Yes	Yes
Watchdog Timer	Yes	Yes	Yes	Yes	Yes	Yes
Interrupt Controller	Yes	Yes	Yes	Yes	Yes	Yes
16-bit Timers	4	4	4	4	4	4
SPI (Synchronous)	1	1	1	-	1	1
SCI	1	2	2	2	2	2
ISSI	1	-	-	-	-	-
ESSI	-	1	1	1	2	2
Parallel Host Interface	-	8-bit	8-bit	-	8-bit	8-bit
DMA	-	6-ch	6-ch	6-ch	6-ch	6-ch
GPIO (Max)	11	41	41	18	47	47
JTAG/EOnCE	Yes	Yes	Yes	Yes	Yes	Yes
Packages	81 MBGA	128 LQFP	128 LQFP	100 LQFP	100 LQFP	144 LQFP 144 MBGA
Availability	Now	Now	Now	Now	Now	Now

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56F8300 Series

	56F8322	56F8323	56F8333	56F8334
Performance	60MHz/MIPS	60MHz/MIPS	60MHz/MIPS	60MHz/MIPS
Temp. Range	(-40, +125)°C	(-40, +125)°C	(-40, +125)°C	(-40, +125)°C
Voltage (Core / I/O)	2.5/3.3V	2.5/3.3V	2.5/3.3V	2.5/3.3V
Program Flash	32KB	32KB	64KB	64KB
Program RAM	4KB	4KB	4KB	4KB
Data Flash	8KB	8KB	8KB	8KB
Data RAM	8KB	8KB	8KB	8KB
Boot Flash	8KB	8KB	8KB	8KB
Flash Security	Yes	Yes	Yes	Yes
Ext. Memory Interface	-	-	-	Yes
Regulator(On/Off-chip)	On-Chip	On/Off-Chip	On/Off-Chip	On/Off-Chip
On-Chip Relaxation Osc.	Yes	Yes	Yes	Yes
16-bit Timers	8	8	16	16
Quadrature Decoder	1 x 4ch	1 x 4ch	1 x 4ch	1 x 4ch
PWM	1 x 6ch	1 x 6ch	1 x 6ch	1 x 6ch
PWM Fault Input	1	3	3	3
PWM Current Sense Pins	0	3	3	3
12-bit ADC	2 x 3ch	2 x 4ch	2 x 4ch	2 x 4ch
Temperature Sensor	YES	Optional	Optional	Optional
CAN	FlexCAN	FlexCAN	FlexCAN	FlexCAN
SCI (UART)	2	2	2	2
SPI (Synchronous)	2	2	2	2
GPIO (Ded./Shrd/Tot)	0 / 21 / 21	0 / 27 / 27	0 / 27 / 27	0/61/61
JTAG/EOnCE	Yes	Yes	Yes	Yes
Package	48LQFP	64LQFP	64LQFP	100LQFP

56F8300 Series

	56F8345	56F8346	56F8347	56F8355	56F8356	56F8357	56F8365	56F8366	56F8367
Performance	60MHz/MIPS	60MHz/MIPS	60MHz/MIPS	60MHz/MIPS	60MHz/MIPS	60MHz/MIPS	60MHz/MIPS	60MHz/MIPS	60MHz/MIPS
Temp. Range	(-40, +125)°C	(-40, +125)°C	(-40, +125)°C	(-40, +125)°C	(-40, +125)°C	(-40, +125)°C	(-40, +125)°C	(-40, +125)°C	(-40, +125)°C
Voltage (Core / I/O)	2.5/3.3V	2.5/3.3V	2.5/3.3V	2.5/3.3V	2.5/3.3V	2.5/3.3V	2.5/3.3V	2.5/3.3V	2.5/3.3V
Program Flash	128KB	128KB	128KB	256KB	256KB	256KB	512KB	512KB	512KB
Program RAM	4KB	4KB	4KB	4KB	4KB	4KB	4KB	4KB	4KB
Data Flash	8KB	8KB	8KB	8KB	8KB	8KB	32KB	32KB	32KB
Data RAM	8KB	8KB	8KB	16KB	16KB	16KB	32KB	32KB	32KB
Boot Flash	8KB	8KB	8KB	16KB	16KB	16KB	16KB	16KB	16KB
Flash Security	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Ext. Memory Interface	-	Yes	Yes	-	Yes	Yes	-	Yes	Yes
Regulator(On/Off-chip)	On/Off-Chip	On/Off-Chip	On/Off-Chip	On/Off-Chip	On/Off-Chip	On/Off-Chip	On/Off-Chip	On/Off-Chip	On/Off-Chip
On-Chip Relaxation Osc.	No	No	No	No	No	No	No	No	No
16-bit Timers	16	16	16	16	16	16	16	16	16
Quadrature Decoder	2 x 4ch	2 x 4ch	2 x 4ch	2 x 4ch	2 x 4ch	2 x 4ch	2 x 4ch	2 x 4ch	2 x 4ch
PWM	2 x 6ch	2 x 6ch	2 x 6ch	2 x 6ch	2 x 6ch	2 x 6ch	2 x 6ch	2 x 6ch	2 x 6ch
PWM Fault Input	4 + 4	3 + 4	3 + 4	4 + 4	3 + 4	3 + 4	4 + 4	3 + 4	4 + 4
PWM Current Sense Pins	3 + 3	3 + 3	3 + 3	3 + 3	3 + 3	3 + 3	3 + 3	3 + 3	3 + 3
12-bit ADC	4 x 4 ch	4 x 4 ch	4 x 4 ch	4 x 4ch	4 x 4ch	4 x 4ch	4 x 4 ch	4 x 4ch	4 x 4ch
Temperature Sensor	Optional	Optional	Optional	Optional	Optional	Optional	Optional	Optional	Optional
CAN	FlexCAN	FlexCAN	FlexCAN	FlexCAN	FlexCAN	FlexCAN	FlexCAN (2)	FlexCAN (2)	FlexCAN (2)
SCI (UART)	2	2	2	2	2	2	2	2	2
SPI (Synchronous)	2	2	2	2	2	2	2	2	2
GPIO (Ded./Shrd/Tot)	21/ 28 / 49	0 / 62 / 62	0 / 76 / 76	21 / 28 / 49	0 / 62 / 62	0 / 76 / 76	21 / 28 / 49	0 / 62 / 62	0 / 76 / 76
JTAG/EOnCE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Package	128LQFP	144LQFP	160LQFP	128LQFP	144LQFP	160LQFP	128LQFP	144LQFP	160LQFP

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Slide 8

DSP56F82x, DSP5685x Modem - *Components*
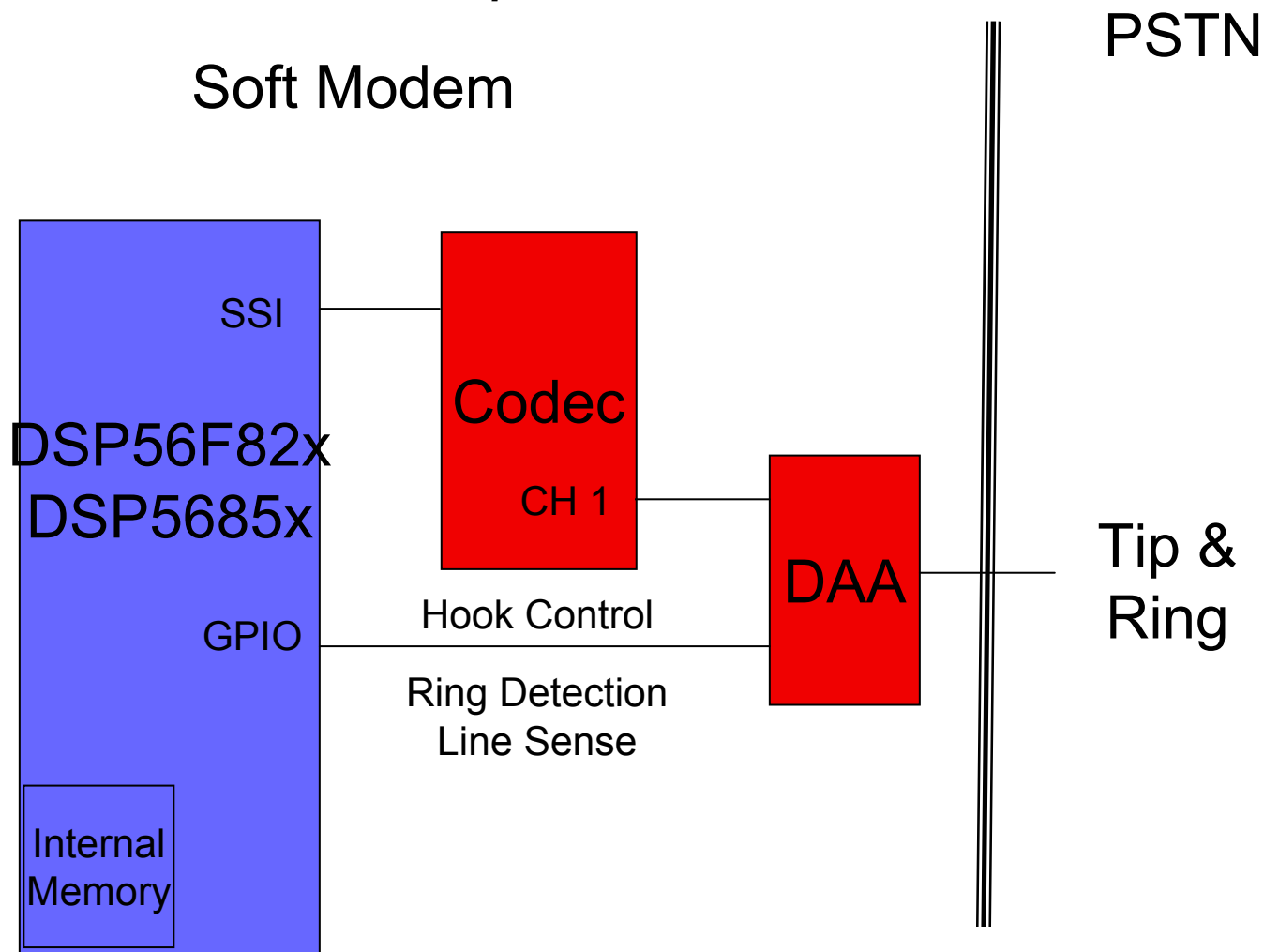
56F8300 Modem - *Components*

Soft Modem

PSTN

56F8300

Timer
ADC

GPIO

Flash
Memory

Low
Cost
Codec
CH 1

Hook Control

Ring Detection
Line Sense

DAA

Tip &
Ring
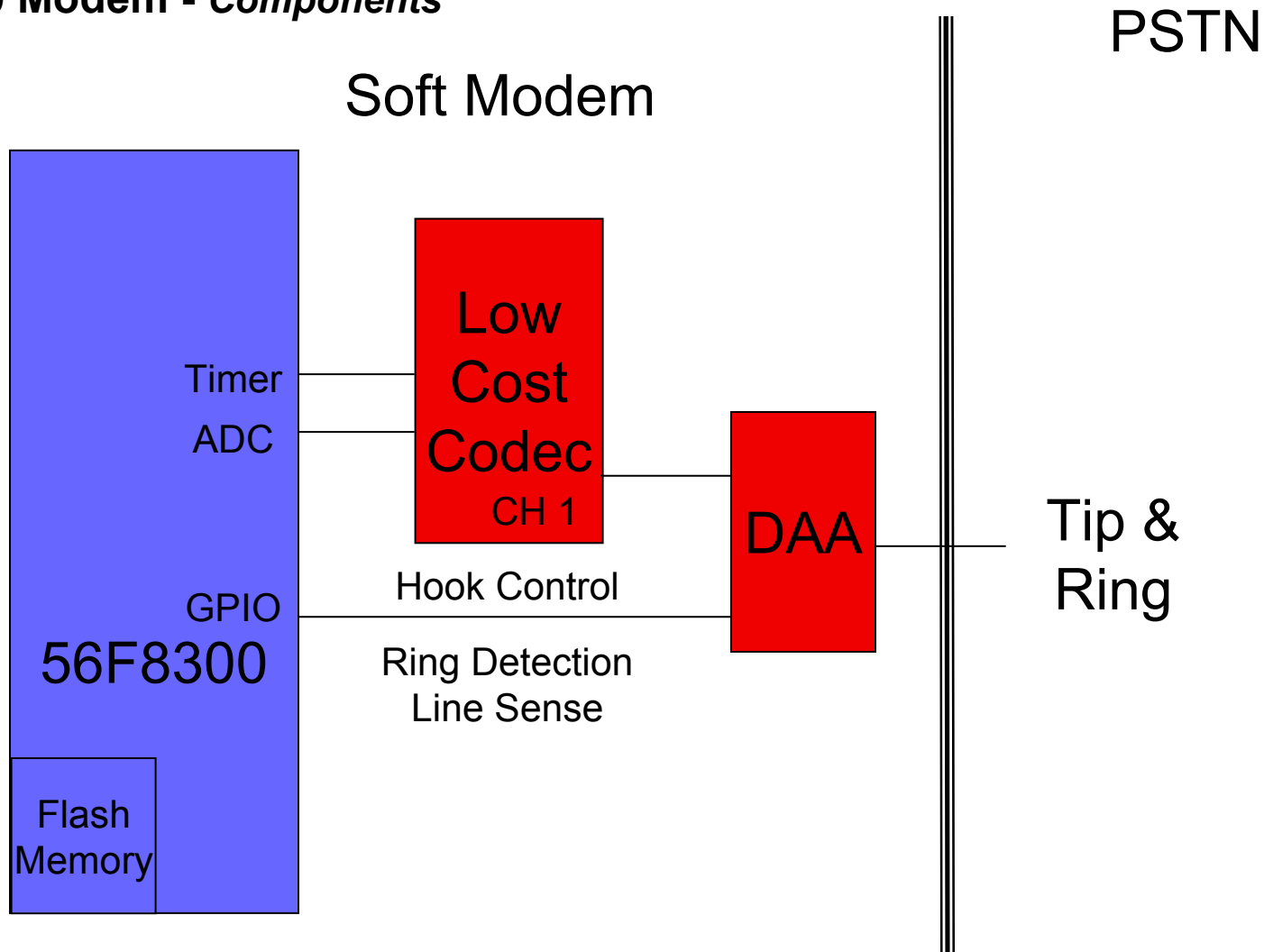
56F8300 Low Cost Codec
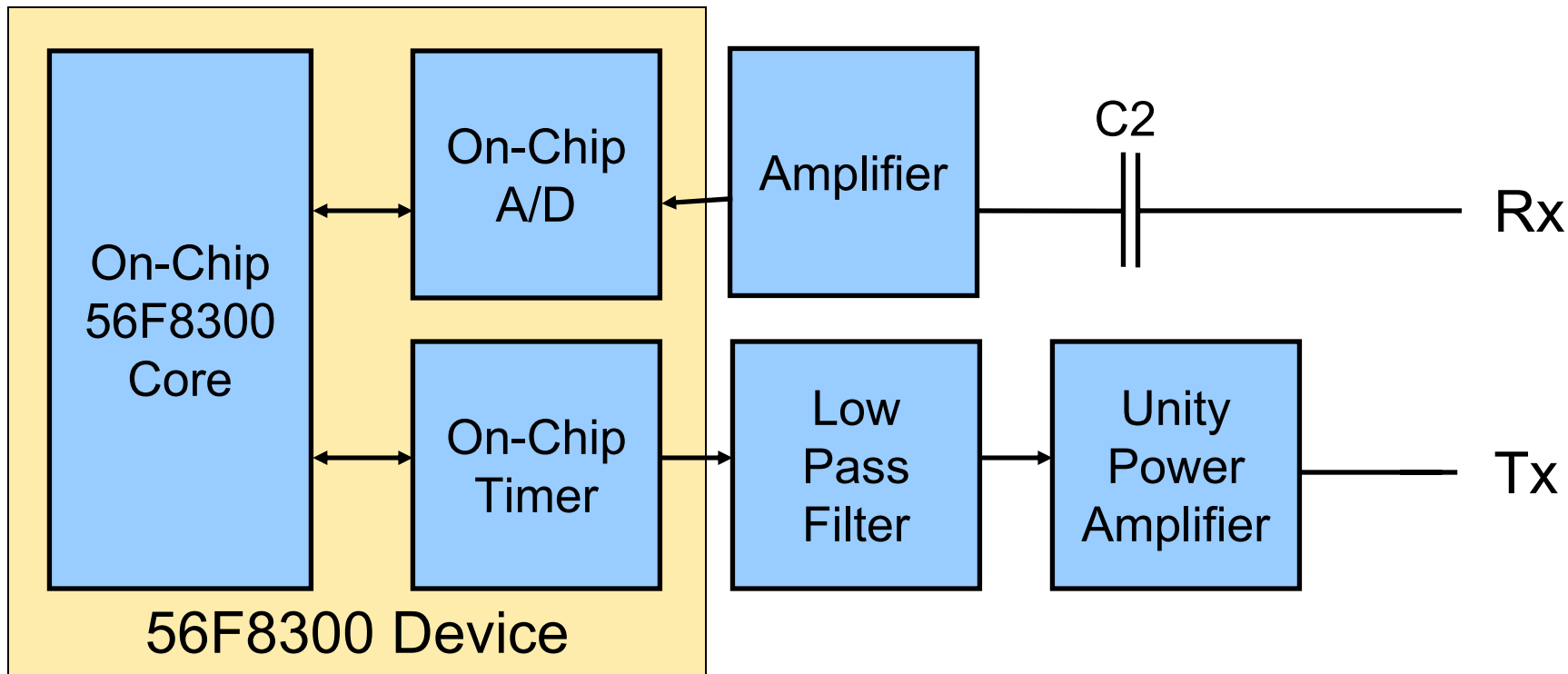
Modem Software Basics

Software Component	Description
DTMF generation	The DTMF signal, also known as a Touch Tone signal, is comprised of two frequencies which represent a single digit on the telephone keypad. The generation of DTMF signals is used in the telephone network.
Call Progress Tone Detection	CPT is a set of tones which are used to indicate the current status of a call.
v.22bis	The ITU-T standard for 2400 bits per second split-band modem for use on the General Switched Telephone Network and on Point-to-Point two wire leased telephone-type circuits.
v.8bis	Two modems, Initiating and Responding, can have different capabilities, some of which are common. A common mode of communication must be agreed upon by both sides, depending on the priorities on each side. This is facilitated by V.8bis.
v.21	Higher speed modems like v.22bis might require a fallback to lower data-rate modes (e.g., 300bps, 75bps). V.21 provides a solution to this requirement by allowing a data rate of 300bps.

Session Establishment

Fallback

2400 bps

1200 bps

300 bps

Down speed
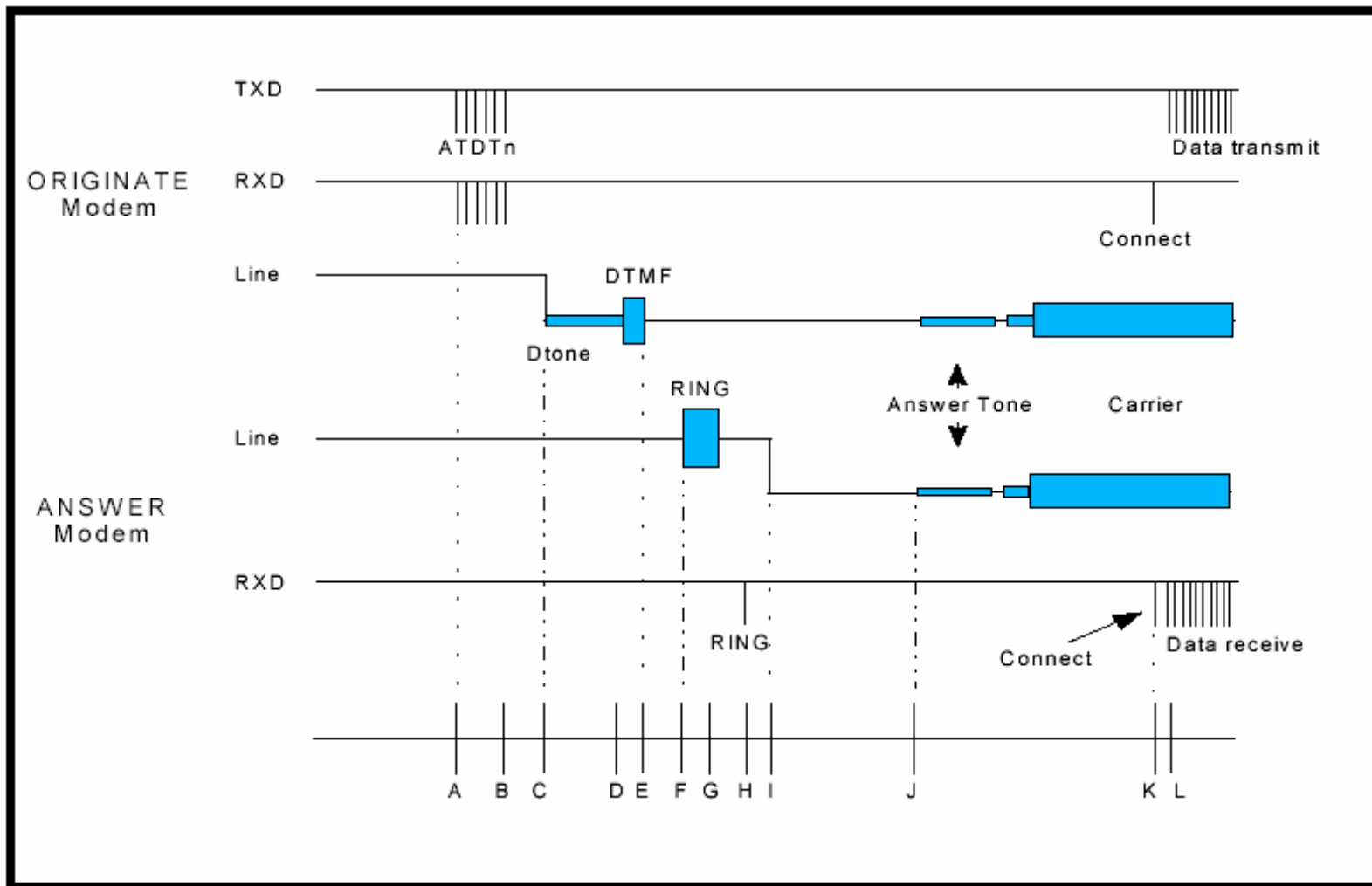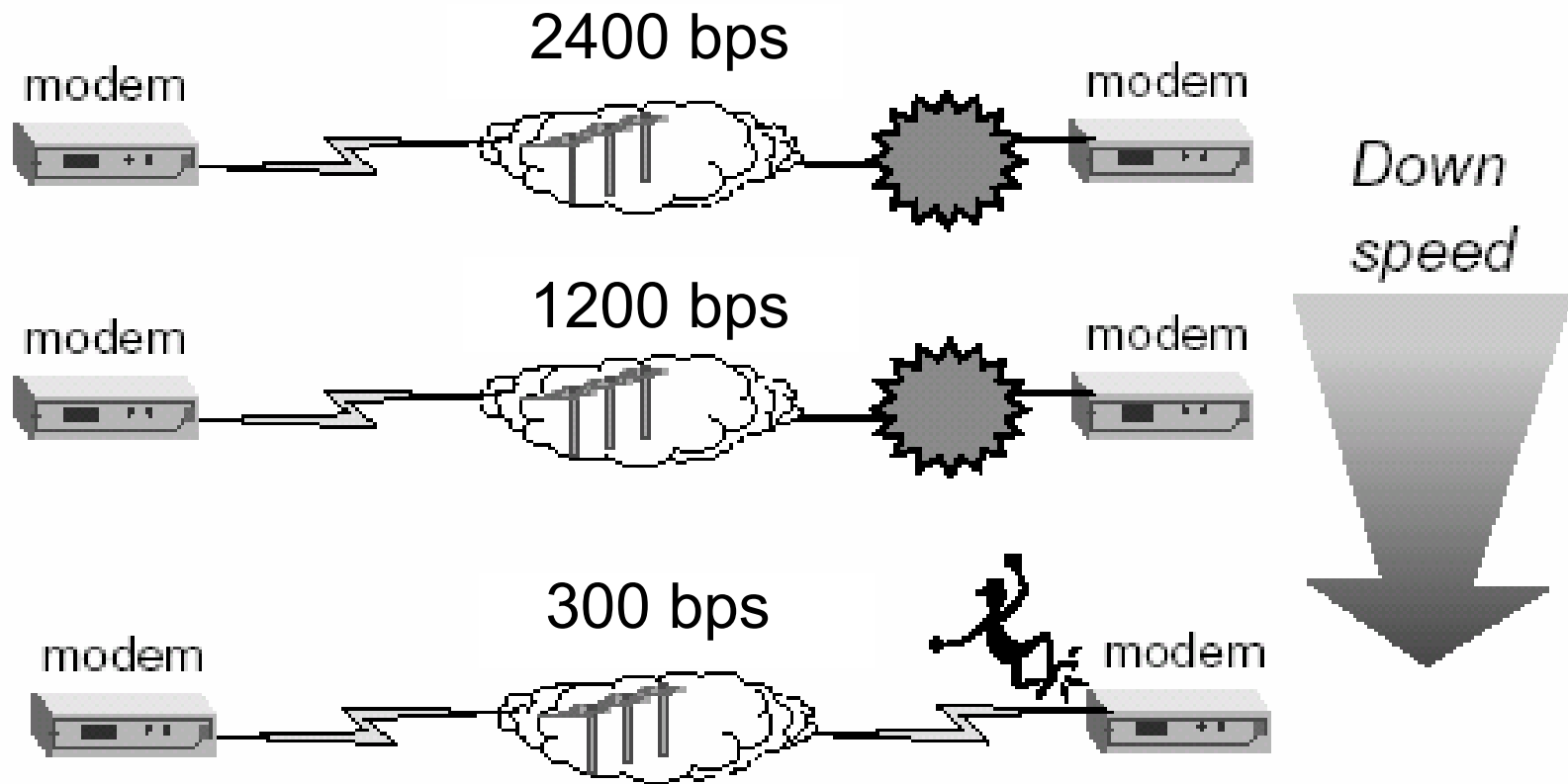
DTMF Generate

DTMF signaling is used to set up a call, as well as to control other features such as call forwarding or conference calling. The tones are divided into two groups; one tone from each group is selected to represent a digit. The following tones are valid for equipment in North America only:
• Low Group: 697 Hz, 770 Hz, 852 Hz & 941 Hz.
• High Group: 1209 Hz, 1336 Hz, 1477 Hz & 1633 Hz.
To minimize the chances of spurious signals being accepted as DTMF tones, neither these frequencies' harmonics nor their intermodulation products fall into any of the tone bands. Separation between tones is typically 10%.
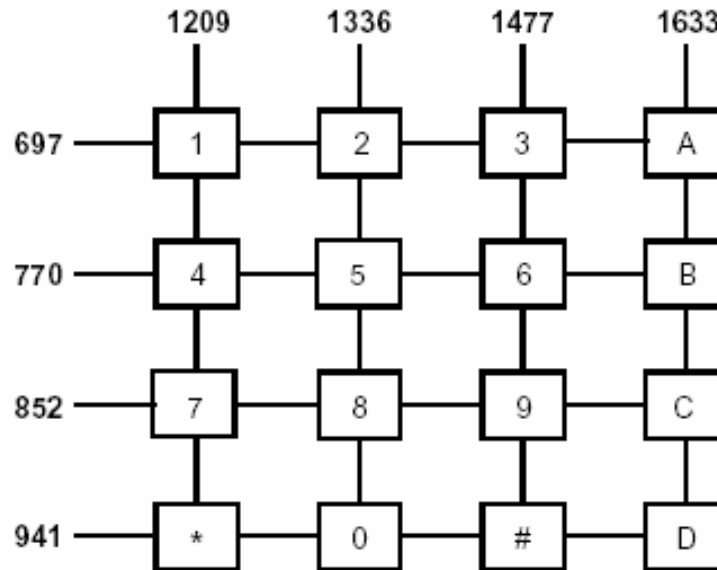
Call Progress Tone Detect

CPT is a set of tones which are used to indicate the current status of a call. Each tone consists of two frequencies and a specific temporal pattern, (ON & OFF periods). The specifications of each tone are listed below.

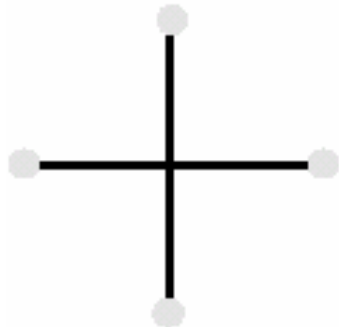| Signal Name	Frequency (Hz)	Temporal Pattern	Amplitude
Dial Tone	350+440 (+/- 0.7%)	Steady on	-29 to -10 dBm
Message Waiting Indicator Tone	350+440 (+/- 0.7%)	10 Bursts (0.1Sec on, 0.1 Sec off) then steady on	-29 to -10 dBm
Recall Dial Tone/ Confirmation Tone	350+440 (+/- 0.7%)	3 Bursts (0.1 Sec on, 0.1 Sec off) then steady on	-29 to -10 dBm
Line Busy	480+620 (+/- 1.5%)	0.5 Sec on, 0.5 Sec off; repeating	-52 to -21 dBm
Re-order	480+620 (+/- 1.5%)	0.25 Sec on, 0.25 Sec off; repeating	-52 to -21 dBm
Audible Ringing	440+480 (+/- 1.6%)	2 Sec on, 4 Sec off; repeating	-47 to -16 dBm

Modulation Methods

- **FSK**
  - **1 bit per baud. max speed =2400 bps**

- **PSK, DPSK**
  - **up 3 bit per baud**

- **QAM**
  - **combines ASK and PSK, encoding 4-7 bits per baud**

- **TCM**
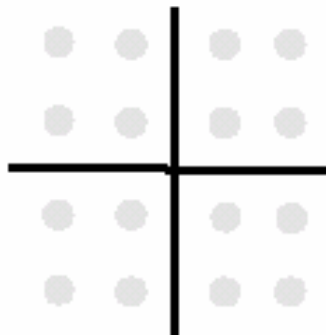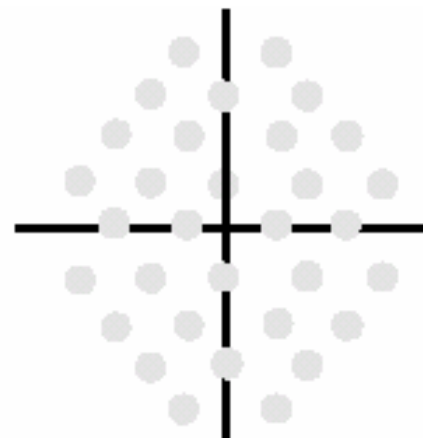 - **same as QAM, but adds extra bits for error correction**

Signal Constellation

distance = sqrt(C^2+D^2)

point defines a legimate signal change

angle = sin^{-1} $\dfrac{C}{\text{sqrt}(C^2+D^2)}$

C

D

- distance defines signal's amplitude
- angle defines phase shift
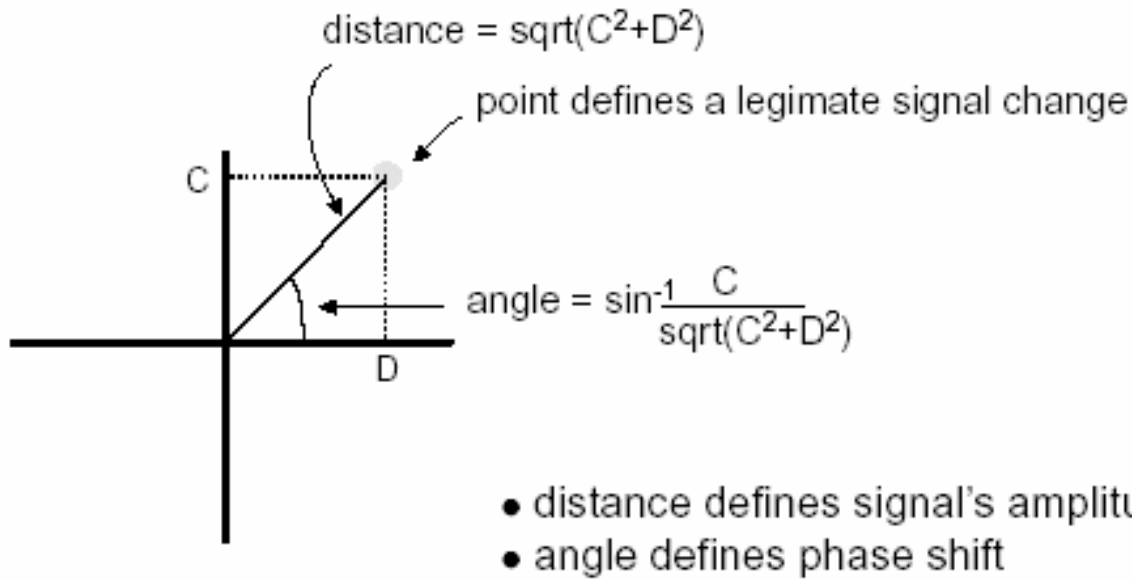
Constellation Samples

V.22
600 baud 1200 bps
PSK

V.22bis
600 baud 2400 bps
QAM

V.32
2400 baud 9600 bps
TCM

v.22bis

A v.22bis split-band modem is characterized by transmission and reception on two spectral bands which do not overlap. The standard defines:

• Calling modem to:
— transmit with a carrier frequency of 1200 Hz and
— receive with a carrier frequency of 2400 Hz
• Answering modem to:
— transmit with a carrier frequency of 2400 Hz and
— receive with a carrier frequency of 1200 Hz

Quadrature amplitude modulation technique is used for each channel with synchronous line transmission at 600 baud. The constellation could be either 16 point, 4 bits/baud supporting an input bit rate of 2400bps, or 4 point, 2 bits/baud supporting 1200bps. A scrambler is included in the input to the transmitter and a descrambler at the output of the receiver. The modem should have both an adaptive equalizer and a compromise equalizer. A guard tone of 1800 ±20 Hz or 550 ±20 Hz may be used while transmitting only in the high channel (transmitter of the answering modem).

v.8bis

The V.8bis allows DCEs and DTEs with multiple modes of operation over the PSTN and on leased telephone-type circuits, to perform these functions:

- Selection of the desired mode of operation at automatic call establishment on the PSTN, controlled by either the calling or answering station
- Selection of the desired mode of operation while in telephony mode on an already-established connection, controlled by either station
- Determination by either station of whether the remote station supports V.8bis, with minimum disturbance to a voice caller
- Exchange of available capabilities between stations on a connection at call establishment or while in telephony mode
- Graceful recovery in the event of transmission of errors or selection of an unavailable mode of operation

The Complete Development Environment
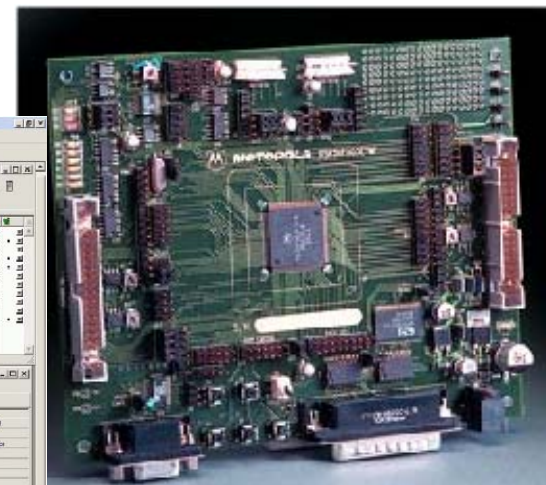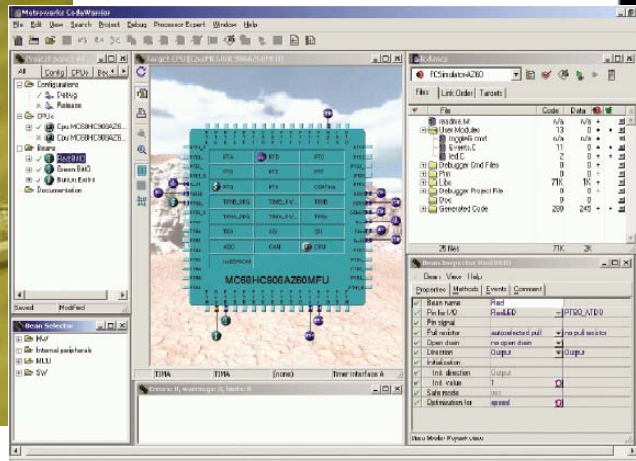
CodeWarrior for 56800/E

CodeWarrior for Motorola 56800/E is a windows based visual IDE that includes an optimizing C compiler, assembler and linker, project management system, editor and code navigation system, debugger, simulator, scripting, source control, and third party plug in interface.

Processor Expert

Processor Expert (PE) provides a Rapid Application Design (RAD) tool that combines easy-to-use component-based software application creation with an expert knowledge system. PE is fully integrated with the CodeWarrior for 56800/E.

Hardware Tools

The 56800/E solutions are supported with a complete set of evaluation modules which supply all required items for rapid evaluation and software and hardware development. In addition several command converter options exist for customer target system debugger connection.

Processor Expert™ Overview
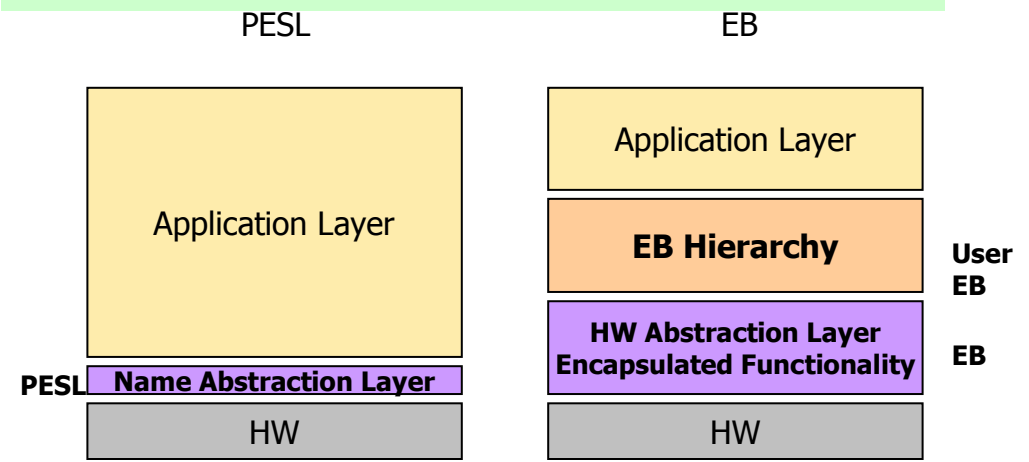
Processor Expert™

- Supports rapid application development
- Enables component oriented programming
- Provides expert advice if necessary
- Delivers instant functionality of generated code
- Provides tested ready-to-use code

Key Abstraction Technologies

- **PESL**
  - Processor Expert System Library
  - Peripheral oriented
- **EB – an abstraction provider**
  - Embedded Beans
  - Functionality oriented
  - Real *components* for building of an application

PESL   EB

How Features of PE are Achieved

- Developed by experienced programmers of embedded systems
- Expert knowledge system is working on the background of PE and checks all the settings
- Provides context help and access to CPU/MCU vendor documentation
- All EB delivered by UNIS are tested according to ISO testing procedures (UNIS is ISO certified company)

Processor Expert Features

Available across 8/16 bit product lines

Rapid application development

Expert configuration system
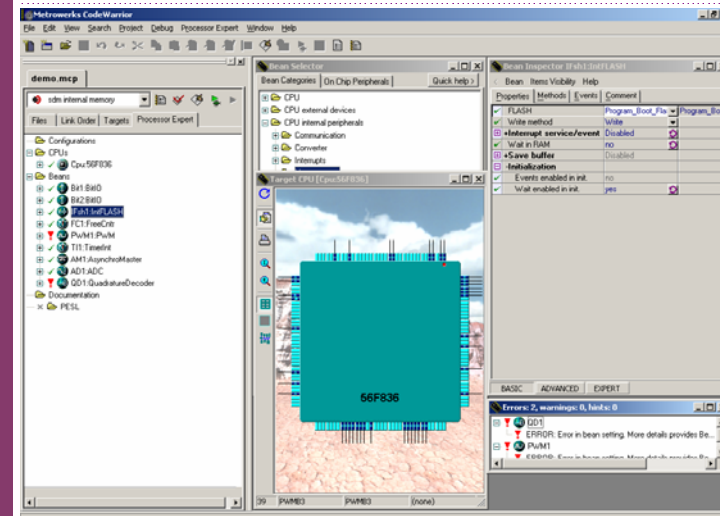
Instant functionality of generated code

Two Peripheral programming levels
- Embedded Beans
- PESL

Application Specific Algorithm Libraries
- All SDK algorithm libraries ported

Tested and ready-to-use code

Application Specific Algorithm Libraries

Memory Manager

- Dynamic allocation

Feature Phone Library

- CallerID type 1&2, CallerID Parser, Generic Echo Cancellor

DSP Library

- FIR, IIR, FFT, Auto Correlation, Bit Reversal

Telephony Libraries

- AEC, AGC, Caller ID,
- CAS, CPT, CTG, DTMF
- G165, G168, G711
- G723, G726, G729

Modem Libraries

- V.8bis, V.21, V.22bis, V.42bis

Security Libraries

- RSA, DES, 3DES,

Motor Control

- BLDC, ACIM, SR motor specific algorithms
- General purpose algorithms

Math Libraries

- Matrix, Fractional, Vector
- Trigonometric

Tools Library

- Cycle Count, FIFO, FileIO, Test

Bean Selector

Bean Categories | On Chip Peripherals | Quick help >

- CPU
- CPU external devices
- CPU internal peripherals
- SW
  - Array Function Library
  - Data
  - Digital Signal Processing Library
  - DSP
  - Feature Phone Library
  - Fractional Math Library
  - Matrix Math Library
  - Memory manager
  - Modem Library
  - Motor Control
  - OS configuration
  - Security Library
  - Speech Library
  - Telephony Library
  - Tools Library
  - Trigonometric Function Library
  - Tutorials and demonstrations
  - Vector Math Library

Filter: all/CPU | Licensed

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Conclusion

- **56800/E Hybrid controllers are well suited to a broad range of modem applications**

- **Complete set of soft modem algorithms available**

- **Example hardware available for 56F82x, 5685x, and 56F8300 available**

- **Very powerful CodeWarrior and Processor Expert development environment accelerates development cycle**

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