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A Low-Cost Soft Modem Using the Freescale Digital Signal Controller MC56F802x/3x Series

Using On-Chip ADC and DAC

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The hardware and software design of a low cost V.22/V.22bis soft modem is presented. The design does not include a traditional telecommunications PCM CODEC (pulse code modulation coder/decoder), but rather, uses the ADC and DAC of the Freescale 56F802x/3x series to implement a less complex solution. An optional serial port with AT command set is included as a test fixture. Included for reference are modem performance figures measured on the implementation, as well as complete implementation details.

Contents

1 System Specification and Design 2
2 Processor Expert Bean Use in the Soft Modem 9
3 Software Design Details 35
4 Conclusion - System Performance 83
5 Layout and Governmental Certifications 109
6 References 110
Appendix ALow-Cost Modem Daughter Card Schematics . 110

1 System Specification and Design

This section describes the system used to implement the soft modem, as well as the motivation for such a system. Then the system specification is followed by a block diagram and discussion of implementation.

1.1 Soft Modem System Concept

To begin with, it will help to define the term soft modem. A soft modem is one that can be used to modulate/demodulate data to be sent serially over an analog channel directly, without the need for a serial data path to another entity to supply data or control signals. It includes a simple way to dial phone numbers; detect ringing signals; control the hook relay of the DAA; control input and output analog data; connect to remote modems; and communicate with remote modems. Complete control of the modem is embedded within the same host computer performing other system functions, such as alarm monitoring or motion control. A soft modem is the enabling ingredient that allows combining the data terminal equipment (DTE) and data communication equipment (DCE) into one entity.

This differs from traditional communication systems in which the DTE and DCE are two separate parts. Traditionally, the DTE and DCE communicated via a 25-pin serial interface that carries signals such as those described in the V.14, V.25, and V.22bis (and many other) specifications. These signals were used for flow control, and complex signalling between the DTE and DCE as to what respective states they might be in. With the advent of the AT command set in the 1980s many of these signals fell into disuse, and the 25-pin DTE/DCE interface is now more typically found as a 9-pin interface. The difference is made up by providing a complex set of commands and responses that attempt to keep the DTE and DCE in sync. This is depicted in Figure 1.

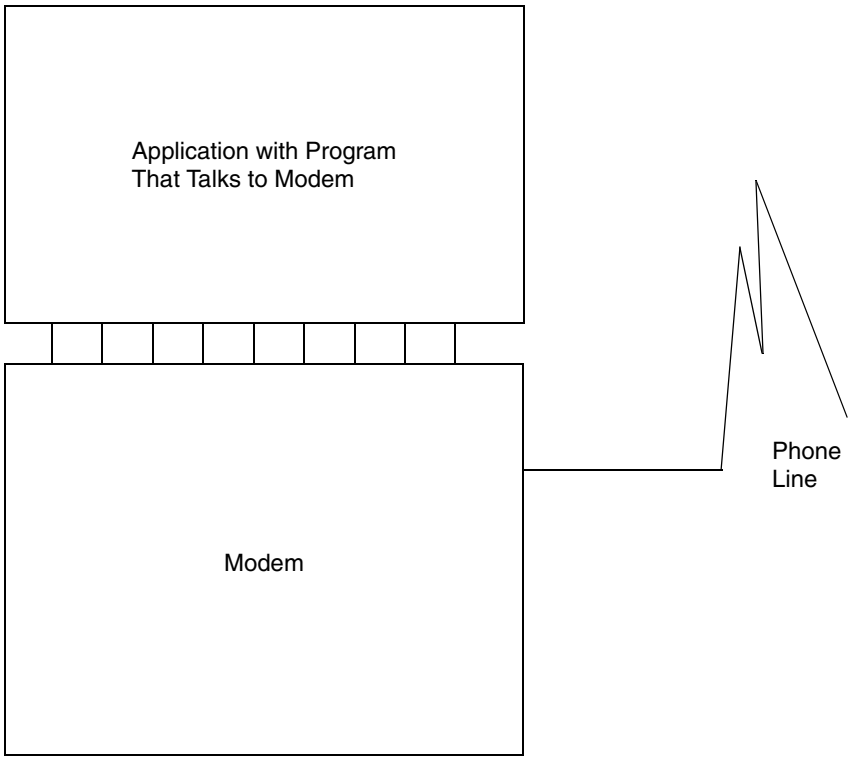


Figure 1. DTE/DCE 9-Pin Configuration

In the 1990s this interface all but disappeared, when the modem designed to be used only with the most common personal computer operating system was developed. This spoofed the serial communications to the DCE, actually performing much of the modem function on the host processor. Only the digital signal processing was done on another processor, which was closely coupled to the personal computer on its bus. The DTE and DCE continued to be two intelligent processors, but the old serial interface was gone.

When the DTE and DCE were merged into one processor around the turn of the century, the need for such a cable or even bus vanished, as well as the need for a “serial port.” This is in fact how modems in PCs are implemented today. The host processor is powerful enough to implement the modem algorithms and the DCE as a separate intelligent device does not exist. All that is needed is a way to send and receive analog signals over the phone line, and to protect telephone equipment, using the DAA. The serial ports, used only for PC communication software compatibility, are complete spoofs.

Now it is easy for this same elegant architecture, shown in Figure 2, to exist in embedded systems.

In this document we will show how simple such a design is, how few resources of the processor it takes, and how well it performs on USA average lines. This design even omits the standard telecommunications CODEC, using instead a DAC (digital-to-analog convertor) for output and ADC (analog-to-digital converter) for input. Because both of these peripherals are readily available from the many peripherals on one 56F802x/3x series device, along with more than the digital signal processing power required from the single core, the design is a true one-chip, one-core system that includes telecommunications ability while leaving room for much more system functionality.

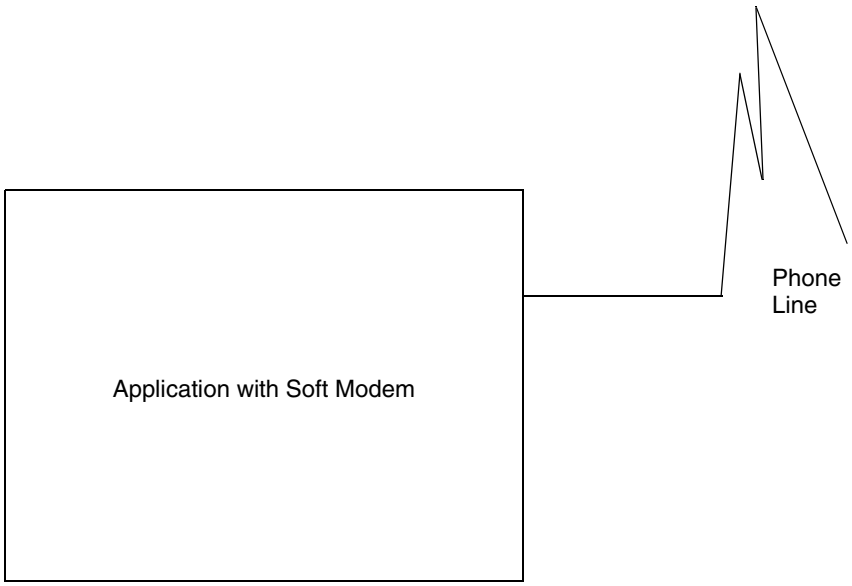


Figure 2. Soft Modem Configuration

This approach has many applications in embedded systems. One example would be a security system that consists of a single processor, which is charged with both monitoring local security sensors and communicating directly over phone lines to a central reporting location.

Another application would be a portable medical device, such as a heart monitor, that could periodically interface directly to a phone line without the need for an external modem (or costly modem chip onboard) of any kind. Without the DCE/DTE split such a device would be more reliable, less expensive, and consume less power.

While it would be possible to split the design into a DCE and a DTE, this would add cost due to several factors:

- the additional processor
- the two serial ports required to connect the DCE and DTE
- software in both the DCE and DTE needed for communication between the two
- the interrupts and context saving/restoring that such communication requires

It would also add a potential failure scenario when the DCE and DTE fail to observe each other's states in a timely manner.

1.2 Soft Modem Specification and Design

Figure 3 shows how the basic modem, DTMF, and call progress detection are implemented. Not shown are the DAA control signal, the ring-detect signal, the flow control signal (for testing only), and the serial port (for testing only).

The modem incorporates portions of the following standards as they apply to a soft modem: V.25, V.22, and V.22bis, all implemented on the host digital signal controller (DSC). The portions of these standards related to the DTE/DCE interface are simply not required for a soft modem. DAC and ADC peripherals

on the DSC pass digital samples at a rate of 7200 samples per second (SPS) for the modems and the DTMF generation software. For the call progress software, used to detect dial tone, a sampling rate of 8000 SPS is used. The smaller the sampling rate, the less work for the processor, and subsequently the less power used. The rate of 7200 SPS is ideal for these modems. Fixed rate codecs, commonly used in other solutions, may require the use of sample rate conversion algorithms; these are not needed to interface this modem, because complete control over the codec (which is a soft codec) is intrinsic to the design.

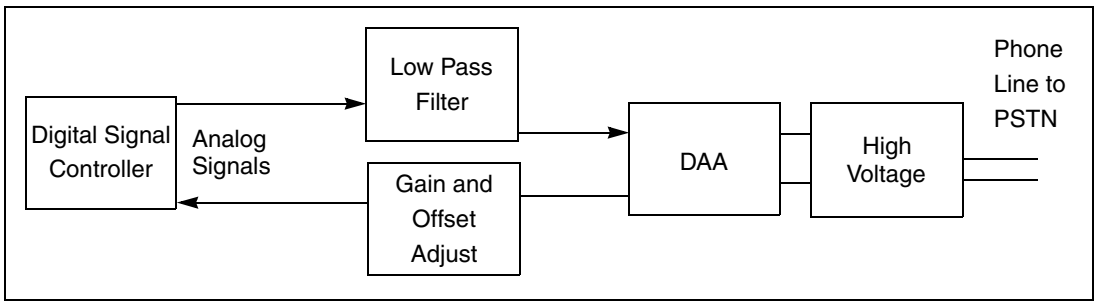


Figure 3. Basic Modem, DTMF, and Call Progress Detection Implementation

1.3 Test Harness Specification and Design

The test harness for the soft modem application, as depicted in Figure 4, consists of some of the resources of the MC56F8037 and some external test equipment. The DSC and the telco connection to the DSC are the only parts of this figure that are not purely test equipment.

The resources of the MC56F8037 DSC used for testing consist of an asynchronous serial communication port and associated beans and software. This port is used to support an AT command set that is used only for testing — it is not an essential element of the soft modem design. Data and commands are communicated alternately through this test channel. There are two kinds of AT commands supported: online commands and offline commands. The online commands may be issued after the escape sequence puts the test fixture into the online command state. The offline commands may be issued when no connection is in progress.

The online commands supported are:

- ato — return to online data state
- ath — hang up the phone
- atz — hang up the phone and soft reset the modem
- the +++ escape sequence, with three second pre- and post-guard times

The offline commands supported are:

- ata — causes the modem to go off-hook and answer (this command is not required, because the test fixture will automatically answer two seconds after the first ring).
- atd<string> — sets the number to dial string. When this string is set to a non-empty condition, it causes the soft modem to dial that number in the string and attempt a connection. (A production program interfacing to the soft modem would simply set this string to achieve a dialed connection from the soft modem.)
- ati — issues the modem test fixture model and version number.

- atq1 — puts the AT command set into quiet mode, where it will operate without responding.
- atq0 — undoes the atq1 command.
- atz — performs a soft reset of the soft modem. This hangs up the phone and frees RAM resources.
- at+0 — puts the modem into V.21 mode (if it is conditioned in), where it will attempt to force all subsequent connections. A modem soft reset is also performed.
- at+2 — puts the modem into V.22/V.22bis mode, where the modem will attempt to force all subsequent connections. A modem soft reset is also performed.

The online data state of the test fixture is attained with the industry standard escape sequence, which consists of:

- a delay period of three seconds with no traffic on the serial test channel
- three “plus” characters (+++)
- another three seconds of no activity on the serial test channel

Connect messages are issued indicating the line speed. The serial test channel operates at a fixed 2400 baud.

Characters are buffered into the test fixture for transmission and reception to and from the test fixture queues.

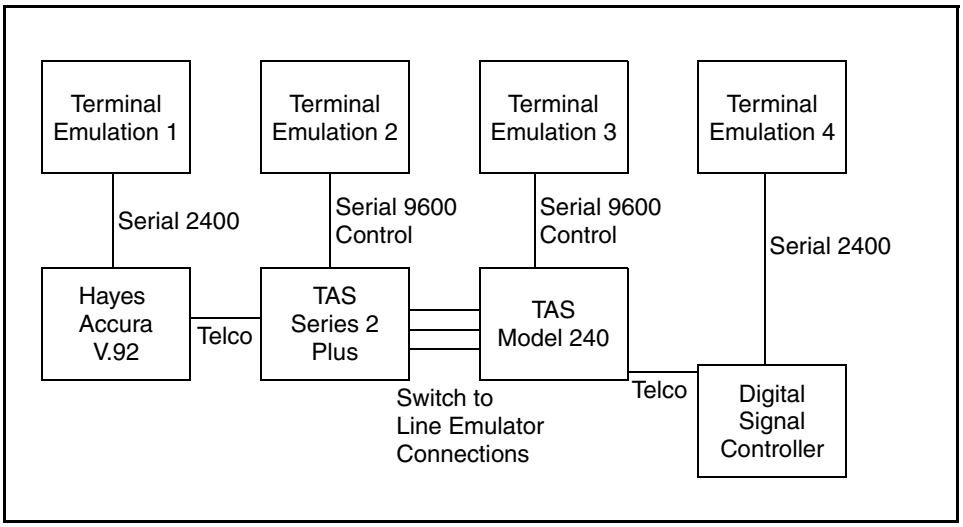


Figure 4. Test Harness for Soft Modem Application

The external test equipment consists of two types: one is connected to the RJ11 telco jack of the soft modem, and the other is connected to a USB async serial port on the EVM. The telco jack is connected to equipment that simulates the USA average public switched telephone network (PSTN) connection to an off-the-shelf modem, a Hayes Accura V.92 modem. This PSTN simulation equipment consists of the TAS Series 2 Plus unit and the TAS model 240 unit.

1.3.1 Terminal Emulation One

Terminal emulation one runs HyperTerminal on a PC at 2400 BPS, eight bits data, no parity, one stop bit on a communication port. It runs a binary file transfer using one of the protocols included with

HyperTerminal. It is connected to a Hayes Accura modem where the AT command set is used to directly control the modem.

1.3.2 Terminal Emulation Two

Terminal emulation number two is a HyperTerminal session at 9600 baud used to control the TAS Series 2 Plus unit. This unit is programmed to simulate USA average lines.

1.3.3 Terminal Emulation Three

Terminal emulation three controls the TAS model 240, which in these tests is used to supply the NULL line. The use of the TAS model 240 is optional, because all functions are available with the series 2 unit.

1.3.4 Terminal Emulation Four

Terminal emulation four is HyperTerminal on a PC at 2400 BPS eight bits data, no parity, one stop bit, no flow control. It is the peer of terminal emulation one. It runs the other end of the binary file transfer. The active signals supplied to the serial-to-USB converter on the EVM include tx data, rx data, and no hardware flow control signal.

1.4 Hardware Implementation, Setup, and Operation

A standard off-the-shelf Freescale MC56F8037EVM is used for this project. A Freescale Low Cost Modem Daughter Card (LCMDC) is also used, together with a peripheral expansion card to allow easy access to each signal on the LCMDC. The two boards are cross-wired together.

Power is conveyed from the EVM in the form of digital 3.3 V power. It is used for both digital and analog power on the LCMDC. Twisted-pair wiring is used to convey the analog signal from the LCMDC to an ADC input on the MC56F8037EVM, and another twisted pair is used to take one of the DAC outputs from the EVM to the LCMDC card. Ring-indicate and hook-control signals are single wires connecting the LCMDC and the EVM.

Five-volt power is brought from a bench supply to the LCMDC. It is needed only for the DAA circuit. (Other DAA circuits are available that will run on 3.3 V, such as the XE0092 available from Xecom, but the LCMDC card was readily available for this project. A model with the Xecom unit is under construction.)

1.4.1 DAC Application to Telephony Baseband Transmission

The DAC is used to develop the analog signal in this project. The DAC updates the voltage output at a rate four times the sample rate of 7200 SPS, or 28800 updates per second. The software only needs to calculate a new delta each 1/7200th second. This allows us to combine the DAC and ADC interrupts into one interrupt, that runs at 1/7200 interrupts per second, on the same clock derived from 3x the IPBUS clock. Other designs might require five times the interrupts per second.

The output of the DAC is a piece-wise approximation of the desired analog signal. Some filtering is needed to limit its bandwidth.

This DAC signal enters from the left of Figure 5 where it is limited to 4 kHz by a 4th order active low-pass filter. The filtered signal is then passed on to the left of Figure 6 for level setting.

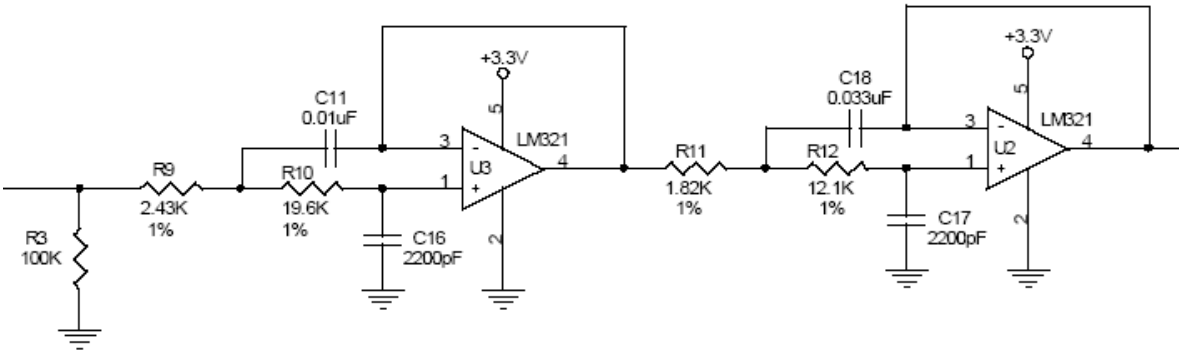


Figure 5. TD1 into Active 4 kHz 4th Order Filter to TP7

The output, XMIT, from Figure 6 is then passed to the XMIT input of a Cermetek CH 1837A DAA whose output level is set to –10 dBm via adjustment of R17. R18 is not populated.

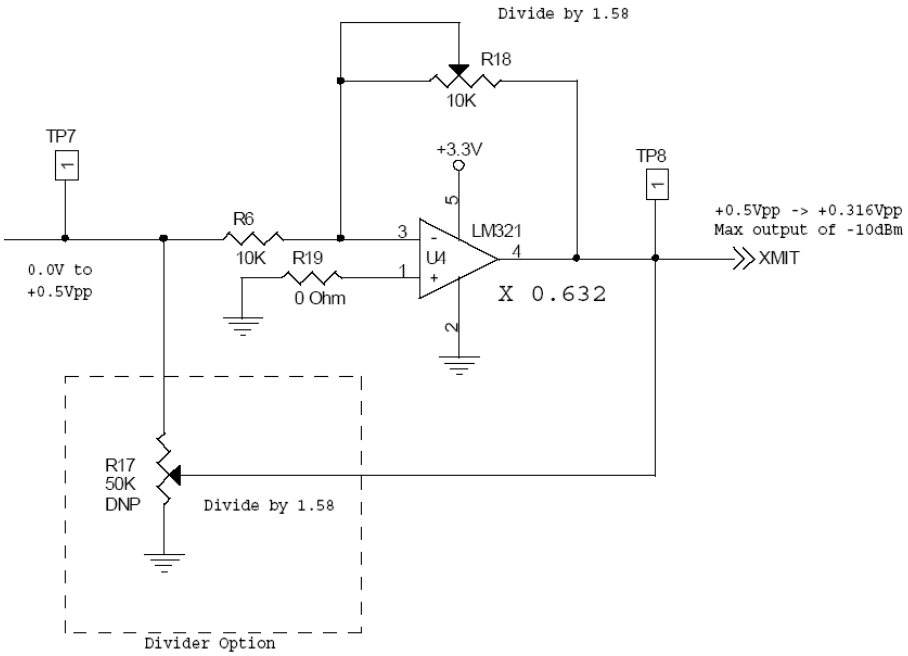


Figure 6. TP7 to Level Set to XMIT

1.4.2 Telephony Baseband Reception to Analog/Digital Convertor

Level adjustment and signal offset calibration are achieved with the circuit shown in Figure 7. The REC signal is from the DAA, the received telephony signal. After level adjustment and offset adjustment, the signal is passed directly to the ADC of the MC56F8037, where it is sampled per the bean configuration

shown in Figure 13 through Figure 15. The gain of R16 is set to its maximum, allowing communication over null lines at –51dBm at V.22bis speed.

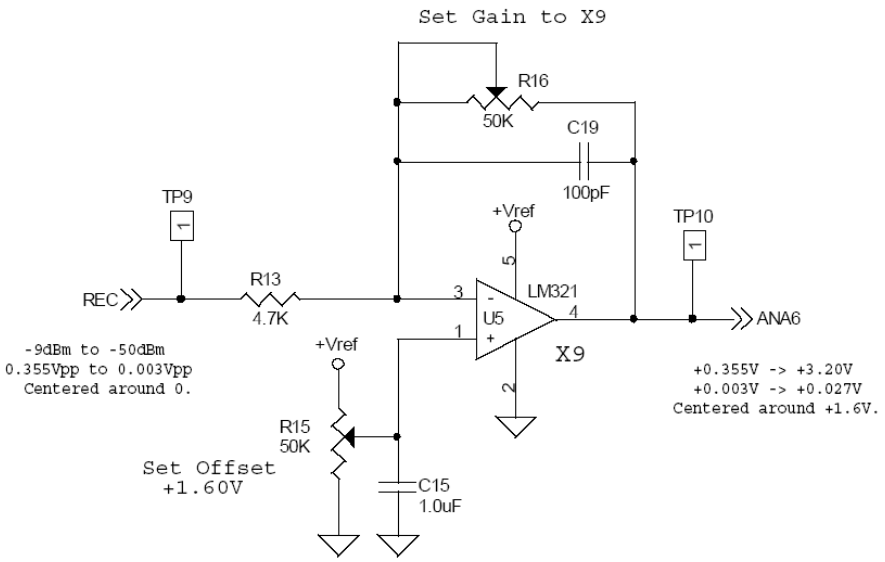


Figure 7. REC to Offset and Gain to ANA6

Complete schematics for the Low Cost Modem Daughter Card are included in Appendix A, "Low-Cost Modem Daughter Card Schematics."

2 Processor Expert Bean Use in the Soft Modem

Version 8.2 of Metrowerks CodeWarrior for the Freescale DSC family was used to develop all of the code. Much of the code was generated automatically from GUI selections made from simple menus, after the basic system building blocks (software/hardware combinations) were selected. Processor Expert beans encapsulate these basic system blocks.

All of the beans are documented in this section, so that the modem may be constructed directly from these beans together with the code supplied in the next section. (The Processor Expert modem library will also be needed, to supply the modem beans.) A bean has properties, methods, and events. After a bean is added to a project, it must be configured in these three areas. For each bean in the project the complete list of properties, methods, and events is illustrated, along with a commentary on the bean's usage. When Processor Expert is then called upon to generate code, it will use the configured beans to generate most of the code required for the Soft Modem. The user-written code that must be added to complete the project is documented in 3, "Software Design Details."

Processor Expert simplified the construction of the software by encapsulating peripheral support into beans. For example, there is a bean for an asynchronous serial port, used to form a test channel over which the AT commands are interfaced to the modem. The properties include such items as baud rate, in this case chosen to be 2400 baud. Another property is used to associate the bean with a particular set of pins on the device. The methods are ways to interface your main program with the peripheral. Code for methods can be drag-and-dropped into your program. Events of the bean facilitate installing user-defined functions to

be performed by an interrupt service routine (ISR) used with the bean. The modem data pumps are also added as beans.

The software project is formed by first selecting blank Processor Expert Stationery, adding the beans, and then configuring them. Then the user-written software programs are added as a final step. Pop-up help on the methods for using the beans, along with the drag-and-drop feature, makes using the processor simple.

The bean name (given at the time the bean is added to a project by the designer) is followed by a colon and then the generic bean type. The soft modem software project consists of the beans depicted in Figure 8.

The soft modem has been implemented on several members of the DSC family, including 56F8323, 56F8346, 56F8357, 56F8367, and now on the MC56F8037 as in this project.

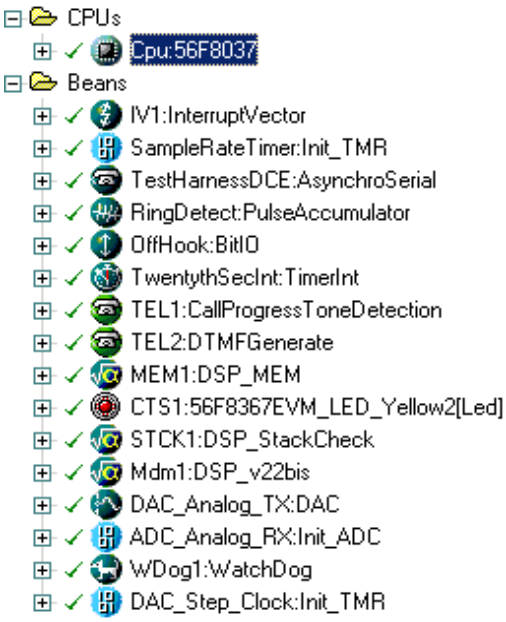


Figure 8. Modem Project Bean List

2.1 CPU Bean

Under CPUs in Figure 8, there is just one CPU listed. The CPU bean has the check mark. This is the one used in the active target, sdm pROM xRAM, or small memory model wherein the constants in data xRAM are initialized from program flash (pROM). The CPU bean has the default settings with the external crystal option. Double-clicking on the CPU bean shows its properties as in Figure 9.

One of the important tabs of the CPU bean is the build-options tab. Note the dynamic memory allocation at the bottom of the build-options list. This allows most of the memory for the soft modem to be deallocated when the soft modem is not in use.

Bean name	Cpu	
CPU type	56F8037	
Oscillator frequency [MHz]	8	8 MHz
Clock source	External crystal	
Initialization priority	minimal priority	0
Saturation mode	Disabled	
Initialize shadow registers	no	
Initialize unused I/O pins	no initialization	
Internal peripherals		
SIM module		
Wait disable mode	Enabled	
Stop disable mode	Enabled	
OnCE clock to core	Enabled when core TAP is enabled	
CLKO select	3X system clock	
CLKOUT mode	Disabled	
Flash security & protection	Disabled	
Peripheral clocks		
Peripheral clock rates		
I/O module		
CPU interrupts		
Enabled speed modes		
High speed mode	Enabled	
System clock (IP Bus)	32.0	32.0 MHz
PLL clock	Enabled	
PLL clock frequency	192.0	Xtal * 24 / 1
Enable PLL after reset	yes	
Low speed mode	Disabled	
Slow speed mode	Disabled	

Compiler	CodeWarrior DSP C Compiler
PESL support	yes
Unhandled interrupts	One handler for all
User initialization	
User data declarations	(string list)
User code before PE initialization	(string list)
User code after PE initialization	(string list)
Generate linker file	yes
pROM-xRAM mode	yes
Stack size	0100
Heap size	0020
ROM/RAM Areas	4
MemoryArea0	
ROM/RAM Area	Enabled
Name	.p_Interrupts
Address	0
Size	80
Qualifier	RWX
MemoryArea1	
ROM/RAM Area	Enabled
Name	.p_Code
Address	80
Size	7F80
Qualifier	RWX
MemoryArea2	
ROM/RAM Area	Enabled
Name	.x_Data
Address	1
Size	CFF
Qualifier	RW
MemoryArea3	
ROM/RAM Area	Enabled
Name	.x_DynMem
Address	D00
Size	300
Qualifier	INTERNAL_DYNAMIC
System paths	0
User paths	0

Figure 9. Cpu:56F8037 on sdm pROM-xRAM Target

2.2 MEM1:DSP_MEM Bean

This bean defines internal xRAM for use by the other DSP-related beans. Internal memory is much faster than external memory. The most notable feature on this configuration is the x_Dynmem at the bottom of Figure 10. This must be present to provide dynamic memory services for the soft modem. Because the modem is not the only function in a real application, it is good for it to give back all of its RAM memory when it is not in operation. This can be most easily accomplished with the help of the dynamic memory services provided by Processor Expert.

Bean name	MEM1
Internal dynamic memory size in byte	300
External dynamic memory size in byte	0
ROM/RAM Areas	4
MemoryArea0	
ROM/RAM Area	Enabled
Name	.p_Interrupts
Address	0
Size	80
Qualifier	RWX
MemoryArea1	
ROM/RAM Area	Enabled
Name	.p_Code
Address	80
Size	7F80
Qualifier	RWX
MemoryArea2	
ROM/RAM Area	Enabled
Name	.x_Data
Address	1
Size	CFF
Qualifier	RW
MemoryArea3	
ROM/RAM Area	Enabled
Name	.x_DynMem
Address	D00
Size	300
Qualifier	INTERNAL_DYNAMIC

Figure 10. MEM1:DSP_MEM Properties

☑	memCallocEM	generate code
☑	memCallocIM	generate code
☑	memFreeEM	generate code
☑	memFreeIM	generate code
☑	memIsAligned	generate code
☑	memIsEM	generate code
☑	memIsIM	generate code
☑	memMallocAlignedEM	generate code
☑	memMallocAlignedIM	generate code
☑	memMallocEM	generate code
☑	memMallocIM	generate code
☑	memReallocEM	generate code
☑	memReallocIM	generate code
☑	memMemcpy	generate code
☑	memMemset	generate code
☑	memMemsetP	generate code
☑	memCopyPtoX	generate code
☑	memCopyXtoP	generate code
☑	memCopyPtoP	generate code
☑	memReadP16	generate code
☑	memReadP32	generate code
☑	memWriteP16	generate code
☑	memWriteP32	generate code

Figure 11. MEM1:DSP_MEM Methods

These are the various methods available for the DSP algorithms to allocate memory. A major advantage of having so many classes of memory available is that it is possible to allow the algorithm to specify the arrangement of operands in memory, which minimizes wait states.

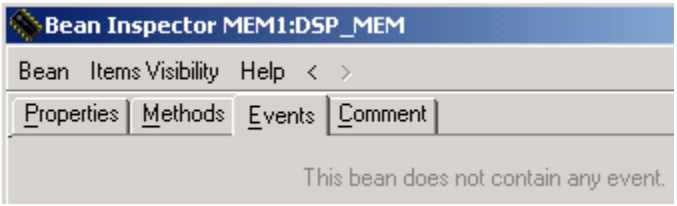


Figure 12. MEM1:DSP_MEM Events

2.3 ADC1:ADC Bean

Note the InputTimer is used to trigger the ADC conversion. After it is triggered, it takes eight rapid fire samples. The fifth sample is used. A special low-level bean is used just to initialize the ADC peripheral. This results in more efficient code, especially because no events are used and the ISR is directed to the user code with no intermediate processing. Also, the only method is to initialize.

The fifth sample is used because it was observed to have the least noise in this application. Averaging the eight samples resulted in more noise, resulting in poor mode performance.

Bean name	ADC_Analog_RX
Device	ADC
Settings	
Clock setting	
Clock divisor select value	3
A/D Frequency	5.333333333333 MHz
Stop mode (0)	no
Stop mode 1	yes
ADC mode	Triggered Sequential
Parallel mode	simultaneous
Trigger mode (0)	SYNC input or START bit
Trigger mode 1	SYNC input or START bit
Power savings mode	Disabled
Power-up delay	13
Auto standby	Disabled
High volt. ref. source 0	external
Low volt. ref. source 0	internal
High volt. ref. source 1	internal
Low volt. ref. source 1	internal
A/D Channels	
Channels configuration	
ANA0-ANA1	Single ended mode
ANA2-ANA3	Single ended mode
ANB0-ANB1	Single ended mode
ANB2-ANB3	Single ended mode
ANA4-ANA5	Single ended mode
ANA6-ANA7	Single ended mode
ANB4-ANB5	Single ended mode
ANB6-ANB7	Single ended mode

Sample 0	Enabled	
Channel	GPIOC13_ANB5	GPIOC13_ANB5
Channel signal		
Sample 1	Enabled	
Channel	GPIOC13_ANB5	GPIOC13_ANB5
Channel signal		
Sample 2	Enabled	
Channel	GPIOC13_ANB5	GPIOC13_ANB5
Channel signal		
Sample 3	Enabled	
Channel	GPIOC13_ANB5	GPIOC13_ANB5
Channel signal		
Sample 4	Enabled	
Channel	GPIOC13_ANB5	GPIOC13_ANB5
Channel signal		
Sample 5	Enabled	
Channel	GPIOC13_ANB5	GPIOC13_ANB5
Channel signal		
Sample 6	Enabled	
Channel	GPIOC13_ANB5	GPIOC13_ANB5
Channel signal		
Sample 7	Enabled	
Channel	GPIOC13_ANB5	GPIOC13_ANB5
Channel signal		
Sample 8	Disabled	
Sample 9	Disabled	
Sample 10	Disabled	
Sample 11	Disabled	
Sample 12	Disabled	
Sample 13	Disabled	
Sample 14	Disabled	
Sample 15	Disabled	

Zero crossing		
Sample 0	disabled	
Sample 1	disabled	
Sample 2	disabled	
Sample 3	disabled	
Sample 4	disabled	
Sample 5	disabled	
Sample 6	disabled	
Sample 7	disabled	
Interrupts		
Conversion complete (0)		
Interrupt	INT_ADCA_Complete	INT_ADCA_Complete
End of scan interrupt	Enabled	
Interrupt priority	medium priority	1
ISR name	ADC_EOS_INT	
Conversion complete 1		
Interrupt	INT_ADCB_Complete	INT_ADCB_Complete
End of scan interrupt	Disabled	
Interrupt priority	medium priority	1
ISR name		

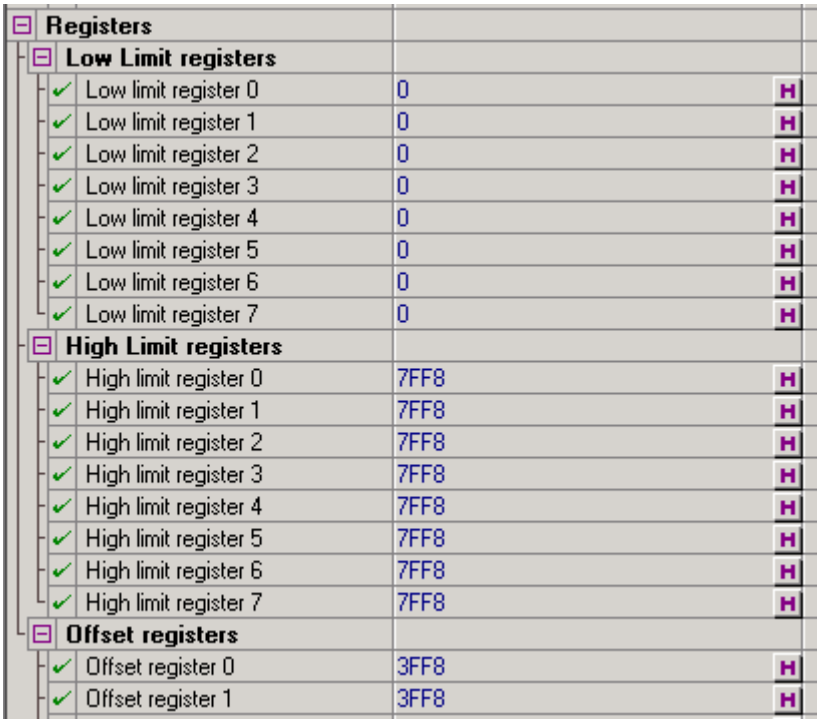


Figure 13. AD1:ADC Properties (Four Parts)

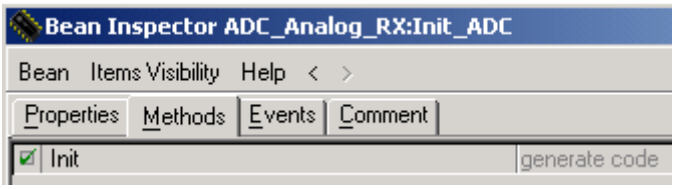


Figure 14. AD1:ADC Methods

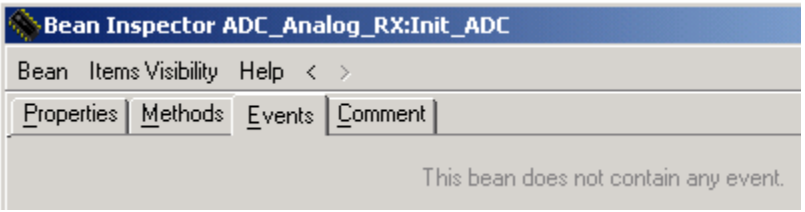


Figure 15. AD1:ADC Events

2.4 DAC_Step_Clock:Init_TMR Bean

This clock runs at a frequency of 4 times 7200, or 28800 cycles per second. The V.22bis implementation uses 7200 samples per second, for both input and output processing.

This is the bean that supplies the clock signal that causes the DAC to increment or decrement by its assigned delta step. This results in the signal construction of the TX modem signal. This is the signal that is next taken by the low-pass filter, then passed to the DAA and on to the telephone circuit.

The frequency of this clock is four times the sample rate, because it has been shown in the previous modem project that a linear interpolation into four line segments is enough to construct a good modem signal for the low-pass filter to process. Thus, between each of the 7200 samples per second, four equal steps are taken by the DAC to connect between two adjacent output samples.

The advantage of this is that the DAC can do this on its own, and needs to be adjusted with a new delta only once each sample period. This clock is divided down by four to produce the sample rate clock. Because the DAC and ADC are running off the same time base, it is possible to use one ISR to handle both the ADC and the DAC function, once per 7200 samples per second.

So, once each sample time, a new delta is calculated for the DAC, and the ADC sample is obtained, both in the same ISR.

The new delta is calculated based on where the DAC will end up from the previous application four times of the previous delta, versus where the DAC needs to go. This process keeps the DAC tracking the desired signal. The full range of the DAC is used.

Note that the time base for this clock is three times the IPBus clock rate. These frequencies allow the system to run at its maximum rate of 32 MHz.

This bean has a pin output for diagnostic purposes only. Also, it is not required to run any function at the rate of this timer, because only the DAC needs to step its output when the timer runs down. The output of this timer feeds the sample rate timer.

Bean name	DAC_Step_Clock	
Device	TMRA1	TMRA1
Settings		
Clock settings		
TMRA clock rate	TMRA_3x_System_clock	TMRA_3x_System_clock
Primary source		
Primary source	prescaler (IP BUS clock)	
Secondary source		
Secondary source	counter 0 input pin	
Operation mode	Count mode	
Count once	count repeatedly	
Count length	count till compare, then reinitialize	
Count direction	up	
Master mode	Enabled	
External OFLAG force	Disabled	
Forced OFLAG value	0	
Force OFLAG output	no	
Output enable	yes	
Output polarity	true	
Input polarity	true	
Co-channel initialization	Disabled	
Input capture mode	Disabled	
Load capture register	on rising edge of input	
OutputMode	toggle OFLAG output on successful cor	
Compare load control 1	Enabled	
Load upon successful compare	with the value in TMRx_CMP1	
Compare load control 2	Disabled	
Debug mode action	Halt TMR counter	
Input filter	Disabled	
Pins	1	
TMR pin		
Pin name	GPIOA12_TB1_SCLK1_TA1	GPIOA12_TB1_SCLK1_TA1
Pin direction	Output	
Pin signal		

Interrupts		
Timer Channel		
Interrupt	INT_TMRA1	INT_TMRA1
Timer compare interrupt	Disabled	
Timer overflow interrupt	Disabled	
Input edge interrupt	Disabled	
Timer compare 1 interrupt	Disabled	
Timer compare 2 interrupt	Disabled	
Interrupt priority	medium priority	1
ISR name		
Registers		
Timer Compare register 1	1667	
Timer Compare register 2	0000	
Timer Capture register	0000	
Timer Load register	0000	
Timer Counter register	0000	
Timer Comparator Load register 1	1667	
Timer Comparator Load register 2	0000	
Initialization		
Call Init method	yes	
Enable peripheral clock	yes	
Enable channel	yes	

Figure 16. DAC_Step_Timer:Init_TMR Properties (two parts)

Figure 17. DAC_Step_Clock:Init_TMR Methods

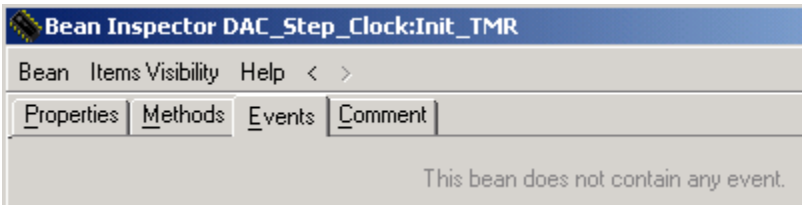


Figure 18. DAC_Step_Clock:Init_TMR Events

2.5 IV1:InterruptVector Bean

The misaligned LongWordISR is supplied only to detect a misaligned LongWord interrupt. This does not occur in the project as provided, but is useful to illustrate how to hook an ISR. Also, should any bugs be introduced into the project, they may be trapped, in some cases, by this ISR.

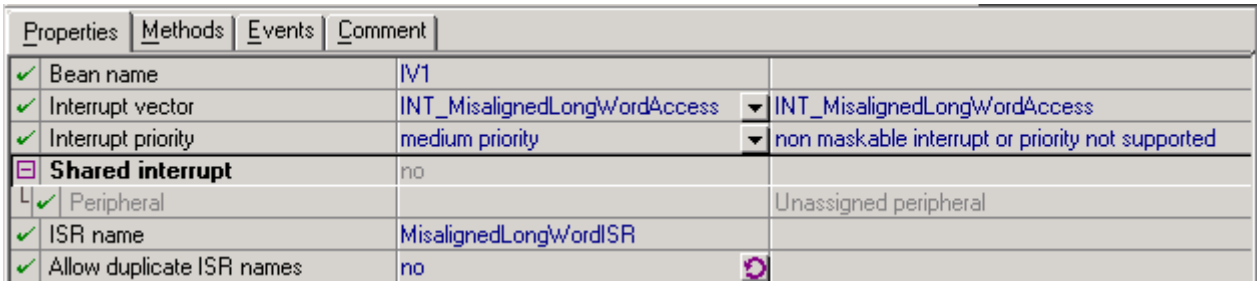


Figure 19. IV1:InterruptVector Properties

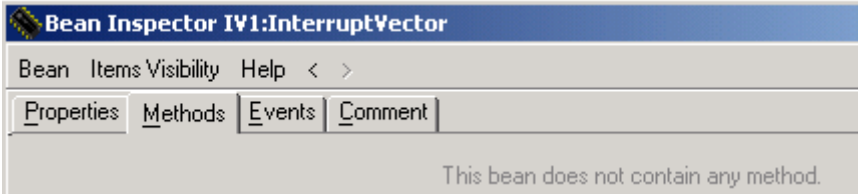


Figure 20. IV1:InterruptVector Methods

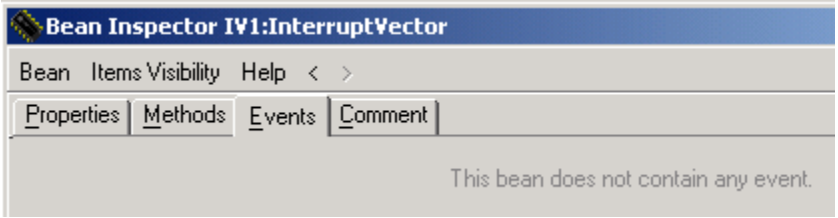


Figure 21. IV1:InterruptVector Events

This bean does not generate any place to put event code in Events.c. Instead, it is up to the programmer to locate his ISR code.

2.6 Mdm1:DSP_v22bis Bean

This software bean generates the modem code for the V22bis/V22 modem data pump. Most of the code is written in optimized assembly language. The API in C is also generated. The memory management makes it possible to set up the modem on a per-call basis.When no call is active, no modem is taking RAM resources. That is why the Memory Management feature is used.

Rather than the AT command set, the API of this bean is used to control the V.22bis modem.

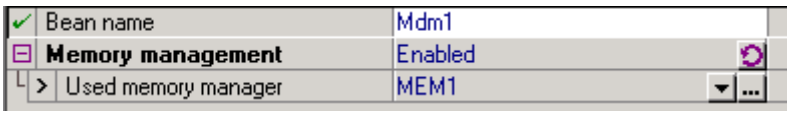


Figure 22. Mdm1:DSP_v22bis Properties

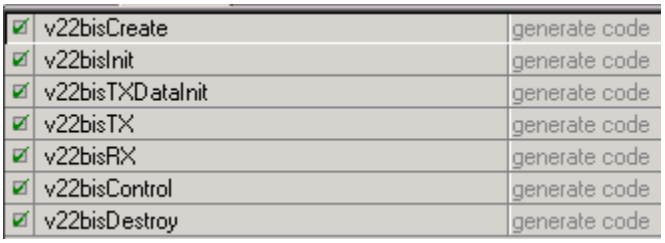


Figure 23. Mdm1:DSP_v22bis Methods

The v22bisControl method is for future expansion of the data pump. The other methods used are illustrated in the next section. They are also documented as part of Processor Expert documentation included with the IDE.

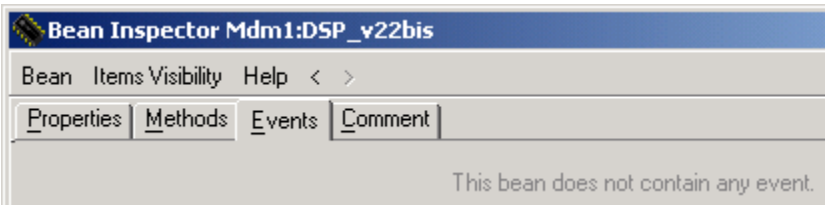


Figure 24. Mdm1:DSP_v22bis Events

No events are needed. The modem is called. When it has data or needs data, it calls the application program back at a designated function to deliver or collect data. Because no event is needed, there is no context switch and the code is more efficient. The modem code operation is gated by the collection of samples for the receiver.

When twelve samples are available, the modem code must be called (or task released if using OS).

The codec (ADC and DAC) code is designed so that it will not have to wait to transmit samples, only for the reception. Because the DAC and ADC are in sync, this is not only possible, but simple to achieve.

It is also arranged in such a way that only 12 samples are obtained, and no more, prior to calling the modem code. This assures that any handshaking between modems is completed in a timely manner, assuring robust connection.

The modem bean code itself is very robust, adapting quickly to changing line signal levels, for example. The main thrust of this note is to show how best to use this modem bean.

2.7 SampleRateTimer:Init_TMR Bean

This bean is responsible for timing the ADC sample reads. It normally operates at 7200 samples per second. Using the PESL commands, the peripheral is modified to sample at 8000 samples per second during call progress. This dynamic sampling rate avoids the use of any sample rate conversion code.

Bean name	SampleRateTimer	
Device	TMRA3	TMRA3
Settings		
Clock settings		
TMRA clock rate	TMRA_3x_System_clock	TMRA_3x_System_clock
Primary source		
Primary source	counter 1 output pin	
Secondary source		
Secondary source	counter 0 input pin	
Operation mode	Count mode	
Count once	count repeatedly	
Count length	count till compare, then reinitialize	
Count direction	up	
Master mode	Disabled	
External OFLAG force	Disabled	
Forced OFLAG value	0	
Force OFLAG output	no	
Output enable	yes	
Output polarity	true	
Input polarity	true	
Co-channel initialization	Disabled	
Input capture mode	Disabled	
OutputMode	toggle OFLAG output on successful	
Compare load control 1	Enabled	
Load upon successful compare	with the value in TMRx_CMP1	
Compare load control 2	Disabled	
Debug mode action	Halt TMR counter	
Input filter	Disabled	
Pins	1	
TMR pin		
Pin name	GPIOB3_MOSI0_TA3_PSRC1	GPIOB3_MOSI0_TA3_PSRC1
Pin direction	Output	
Pin signal		

Interrupts		
Timer Channel		
Interrupt	INT_TMRA3	INT_TMRA3
Timer compare interrupt	Disabled	
Timer overflow interrupt	Disabled	
Input edge interrupt	Disabled	
Timer compare 1 interrupt	Disabled	
Timer compare 2 interrupt	Disabled	
Interrupt priority	medium priority	1
ISR name		
Registers		
Timer Compare register 1	1	
Timer Compare register 2	0000	
Timer Capture register	0000	
Timer Load register	0	
Timer Counter register	0000	
Timer Comparator Load register 1	1	
Timer Comparator Load register 2	0000	
Initialization		
Call Init method	yes	
Enable peripheral clock	yes	
Enable channel	yes	

Figure 25. SampleRateTimer:Init_TMR Properties (Two Parts)

To alter the sampling rate without having to execute a stop or a reset, the Timer Compare register 1 is changed to a smaller number on the fly, achieving 8000 samples per second with PESL commands during call progress detection. Be sure to enable the PESL commands in the project, because the soft modem uses these. The compiler will report no prototype if this is not enabled.

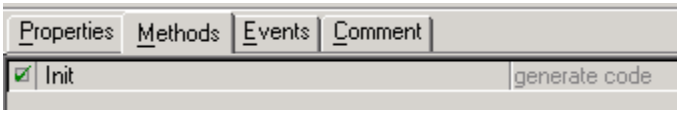


Figure 26. SampleRateTimer:Init_TMR Methods

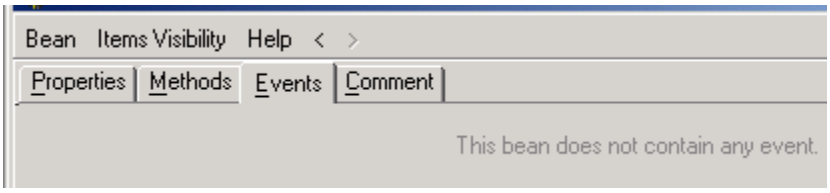


Figure 27. SampleRateTimer:Init_TMR Events

2.8 TestHarnessDCE:AsynchroSerial Bean

This bean was set up for 2400 baud. It actually does not matter what baud rate is used as long as it is at least 2400 baud. The buffering is done in the modem. One of the SCI ports on the device is used for this purpose. It connects to a chip that converts this signal to USB, so that computers without serial ports may

easily interface (and power the EVM) via USB cable here. Such a device is transparent to applications, other than that a special device driver is needed on the PC (acting as the DTE) to allow a terminal emulation program to assign a virtual device driver to this phantom port presented on the USB. On my computer it showed up as COMM 5, but results may vary on different PC configurations.

Remember, it is intended that this interface be removed for the actual application (such as calling a pre-programmed number to report a voltage change on a sensor). The embedded modem may be accessed directly with the APIs illustrated here, rather than resort to an external DTE.

Bean name	TestHarnessDCE	
Channel	QSCI0	QSCI0
Interrupt service/event	Enabled	
Interrupt RxD	INT_QSCI0_RxFull	INT_QSCI0_RxFull
Interrupt RxD priority	medium priority	1
Interrupt RxD preserve registers	yes	
Interrupt TxD	INT_QSCI0_TxEmpty	INT_QSCI0_TxEmpty
Interrupt TxD priority	medium priority	1
Interrupt TxD preserve registers	yes	
Interrupt Error	INT_QSCI0_RxError	INT_QSCI0_RxError
Interrupt Error priority	medium priority	1
Interrupt Error preserve registers	yes	
Interrupt Idle	INT_QSCI0_TxIdle	INT_QSCI0_TxIdle
Interrupt Idle priority	medium priority	1
Interrupt Idle preserve registers	yes	
Input buffer size	100	
Output buffer size	100	
Handshake		
CTS	Disabled	
RTS	Disabled	
Settings		
Parity	none	none
Width	8 bits	8 bits
Stop bit	1	1
SCI output mode	Normal	
LIN slave mode	Disabled	
Receiver	Enabled	

Transmitter	Enabled	
TxD	GPIOB7_TXD0_SCL	GPIOB7_TXD0_SCL
TxD pin signal		
Baud rate	2400 baud	high: 2399.880 baud
Break signal	Disabled	
Wakeup condition	Idle line wakeup	
Transmitter output	Not inverted	
Stop in wait mode	no	
Initialization		
Enabled in init. code	yes	
Events enabled in init.	yes	
CPU clock/speed selection		
High speed mode	This bean enabled	This bean is enabled
Low speed mode	This bean disabled	This bean is disabled
Slow speed mode	This bean disabled	This bean is disabled

Figure 28. TestHarnessDCE:AsynchroSerial Properties (Two Parts)

Notice that block, not character, input/output is used. All interrupts are at the same priority throughout the project.

Enable	don't generate code
Disable	don't generate code
EnableEvent	don't generate code
DisableEvent	don't generate code
RecvChar	generate code
SendChar	generate code
RecvBlock	generate code
SendBlock	generate code
ClearRxBuf	generate code
ClearTxBuf	generate code
CharsInRxBuf	don't generate code
GetCharsInRxBuf	generate code
CharsInTxBuf	don't generate code
GetCharsInTxBuf	generate code
SetBaudRateMode	don't generate code
GetError	generate code
GetBreak	don't generate code
SetBreak	don't generate code
TurnTxOn	don't generate code
TurnTxOff	don't generate code
TurnRxOn	don't generate code
TurnRxOff	don't generate code
SetIdle	don't generate code
LoopMode	don't generate code
ConnectPin	don't generate code
GetRxIdle	don't generate code
GetTxComplete	don't generate code

Figure 29. TestHarnessDCE:AsynchroSerial Methods

To send a block of characters to the serial port, use SendBlock. To receive a block of characters, use RecvBlock.

These methods were simply drag-and-dropped into the application code as required.

Event module name	Events	
BeforeNewSpeed	don't generate code	
AfterNewSpeed	don't generate code	
OnError	generate code	
Event procedure name	TestHarnessDCE_OnError	
Priority	same as interrupt	2
OnRxChar	generate code	
Event procedure name	TestHarnessDCE_OnRxChar	
Priority	same as interrupt	2
OnRxCharExt	don't generate code	
OnTxChar	generate code	
Event procedure name	TestHarnessDCE_OnTxChar	
Priority	same as interrupt	2
OnFullRxBuf	generate code	
Event procedure name	TestHarnessDCE_OnFullRxBuf	
Priority	same as interrupt	2
OnFreeTxBuf	generate code	
Event procedure name	TestHarnessDCE_OnFreeTxBuf	
Priority	same as interrupt	2
OnBreak	don't generate code	
OnTxComplete	don't generate code	

Figure 30. TestHarnessDCE:AsynchroSerial Events

2.9 RingDetect:PulseAccumulator Bean

The ring detect uses timer hardware to pre-process the ring signal. This reduces the MIP load when processing it, and filters out spurious ring signals.

Bean name	RingDetect	
Counter	TMRA0_PACNT	TMRA0_PACNT
Interrupt service/event	Enabled	
Interrupt	INT_TMRA0	INT_TMRA0
Interrupt priority	low priority	1
Interrupt preserve registers	yes	
Mode	Count	
Input filter	Disabled	
Sample count	10	
Sample period	01	
Primary input		
Input pin	GPIOA6_FAULT0_TA0	GPIOA6_FAULT0_TA0
Input pin signal	RingIndicateUnconditioned	
Pull resistor	pull up	pull up
Edge	rising edge	rising edge
Input source	external	
Source bean		Bean is not selected
Initialization		
Enabled in init. code	no	
Events enabled in init.	yes	

Figure 31. RingDetect:PulseAccumulator Properties

Enable	generate code
Disable	generate code
EnableEvent	don't generate code
DisableEvent	don't generate code
ResetCounter	generate code
SetCounter	don't generate code
GetCounterValue	generate code
SetCompare1	don't generate code
SetCompare2	don't generate code
GetCompare1Value	don't generate code
GetCompare2Value	don't generate code
ConnectPin	don't generate code

Figure 32. RingDetect:PulseAccumulator Methods

Event module name	Events
BeforeNewSpeed	don't generate code
AfterNewSpeed	don't generate code
OnOverflow	don't generate code
OnEnd	don't generate code
OnCompare1	don't generate code
OnCompare2	don't generate code

Figure 33. RingDetect:PulseAccumulator Events

2.10 OffHook:BitIO Bean

This bitIO is used to control the on-hook/off-hook status of the DAA. Never take the phone from the on-hook to the off-hook condition while the phone is ringing, as this may damage the DAA circuits. The auto-answer feature of the soft modem assures that this will not happen.

Bean name	OffHook	
Pin for I/O	GPIOA10_CINA2_TB2	GPIOA10_CINA2_TB2
Pin signal	OFFHK	
Pull resistor	no pull resistor	no pull resistor
Open drain	no open drain	no open drain
Drive strength for GPIOA10	High	
Direction	Output	Output
Initialization		
Init. direction	Output	
Init. value	0	
Safe mode	yes	
Optimization for	code size	

Figure 34. OffHook:BitIO Properties

GetDir	don't generate code
SetDir	don't generate code
SetInput	don't generate code
SetOutput	don't generate code
GetVal	don't generate code
PutVal	don't generate code
ClrVal	generate code
SetVal	generate code
NegVal	don't generate code
ConnectPin	don't generate code
GetRawVal	don't generate code

Figure 35. OffHook:BitIO Methods

ClrVal and SetVal are methods used to take the modem on and off the hook. When on hook, the modem is not connected to the phone line. When off hook, it is connected. This term goes back to the antique telephone design.

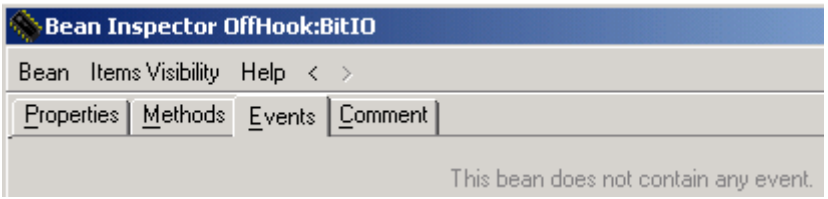


Figure 36. OffHook:BitIO Events

2.11 TwentythSecInt:TimerInt Bean

This bean is used to generate an interrupt once every twentieth second for the ring-detection and AT command set state machines. Also, the AT command set needs to run a three-second timer when it is online, connected to another modem, to prevent data of +++ being construed as a request to enter the online command state.

Bean name	TwentythSecInt	
Timer	TMRB1_Compare	TMRB1_Compare
Counter	TMRB1	TMRB1
Interrupt service/event	Enabled	
Interrupt	INT_TMRB1	INT_TMRB1
Interrupt priority	medium priority	1
Interrupt preserve registers	yes	
Prescaler	Auto select	high: 128
Interrupt period	50 ms	high: 50 ms
Same period in modes	yes	
Bean uses entire timer	no	
Initialization		
Enabled in init. code	yes	
Events enabled in init.	yes	
CPU clock/speed selection		
High speed mode	This bean enabled	This bean is enabled
Low speed mode	This bean disabled	This bean is disabled
Slow speed mode	This bean disabled	This bean is disabled

Figure 37. TwentythSecInt:TimerInt Properties

Enable	generate code
Disable	generate code
EnableEvent	don't generate code
DisableEvent	don't generate code
SetPeriodMode	don't generate code
SetPeriodTicks16	don't generate code
SetPeriodTicks32	don't generate code
SetPeriodUS	don't generate code
SetPeriodMS	don't generate code
SetPeriodSec	don't generate code
SetPeriodReal	don't generate code
SetFreqHz	don't generate code
SetFreqkHz	don't generate code
SetFreqMHz	don't generate code

Figure 38. TwentythSecInt:TimerInt Methods

Figure 39. TwentythSecInt:TimerInt Events

2.12 TEL1:CallProgressToneDetection Bean

This is a software bean that generates the Call Progress Tone Detection code used to detect dial tone. Note the available methods. When they are moused over in the project window, each method's documentation pops up.

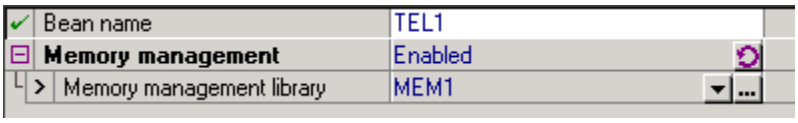


Figure 40. TEL1:CallProgressToneDetection Properties

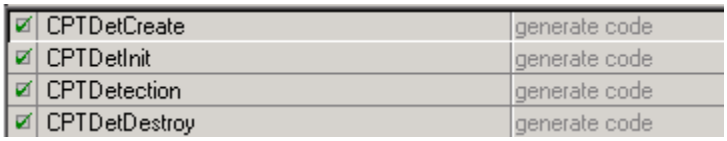


Figure 41. TEL1:CallProgressToneDetection Methods

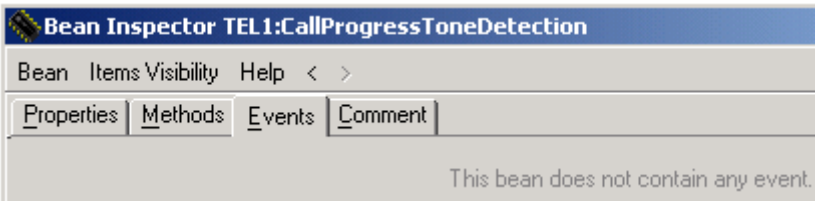


Figure 42. TEL1:CallProgressToneDetection Events

2.13 TEL2:DTMFGenerate Bean

This bean generates the software to generate the samples needed for DTMF dialing. This bean supports both 7200 and 8000 samples per second. The soft modem uses 7200 SPS. This consumes fewer cycles and less energy. Also, no sample rate convertor is needed to interface to the codec. This is really a soft codec included with the MC56F8037 in the form of its ADC and DAC, and their timing may be reconfigured on the fly.

The resources of this bean are used (RAM allocated) only while the bean is in use, due to the use of Memory Management.

Figure 43. TEL2:DTMFGenerate Properties

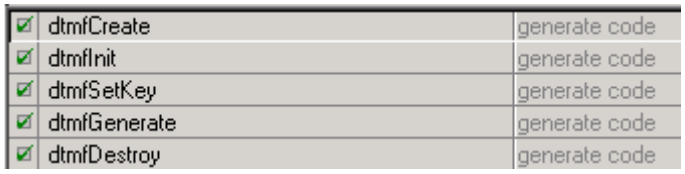


Figure 44. TEL2:DTMFGenerate Methods

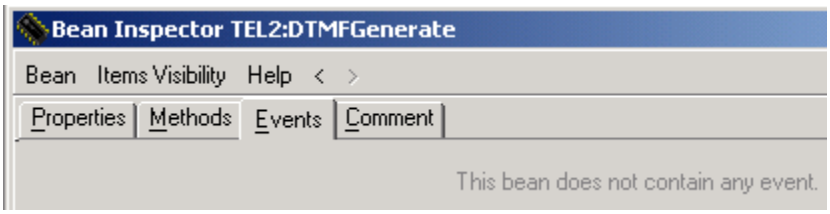


Figure 45. TEL2:DTMFGenerate Events

2.14 Mdm2 DSP_v21 Modem Software Bean

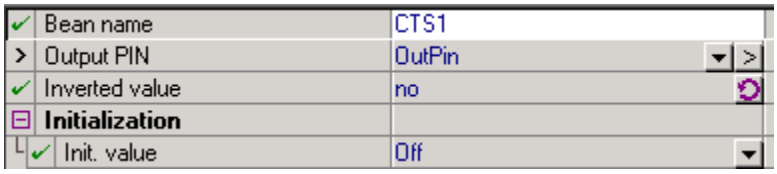
One of the two modem beans available for this project, Mdm2, generates the V.21 modem data pump code. V.21 is not the subject of this note, but the code is conditionally assembled into the project.

2.15 CTS1:56F8367EVM_LED_Yellow2 Bean

This Clear-to-Send (of hardware flow control application) bean takes a bit IO and employs it for the Clear-to-Send signal to the USB device on the EVM, which is not pinned out to this signal.

It is included as a hook for the user who may want to use this signal.

Without this hardware flow control mechanism, the PC could overrun the modem during binary file transfers using XMODEM, or YMODEM, or ZMODEM binary file transfer protocols with HyperTerminal.



Bean name	Inhr1	
Pin for I/O	GPIOA1_PWM1	GPIOA1_PWM1
Pin signal		
Pull resistor	no pull resistor	no pull resistor
Open drain	no open drain	no open drain
Drive strength for GPIOA1	Low	
Direction	Output	Output
Initialization		
Init. direction	Output	
Init. value	0	
Safe mode	no	
Optimization for	speed	

Figure 46. CTS1:56F8367EVM_LED_Yellow2 Properties (Two Parts)

Note the right angle bracket on the Output PIN on the top element of Figure 46. This indicates that this bean encapsulates another bean. By clicking on the right angle bracket, another screen is presented. That is shown on the second part (of two) of Figure 46 and shows the actual pin used for the Clear-to-Send signal which is sent to the PC serial port.

This on initial value actually means that flow is restricted initially.

On	generate code
Off	generate code
Toggle	generate code
Set	don't generate code
Status	don't generate code
ConnectPin	don't generate code

Figure 47. CTS1:56F8367EVM_LED_Yellow2 Methods

The on method would stop the flow from the PC, whereas the off method would allow it to resume.

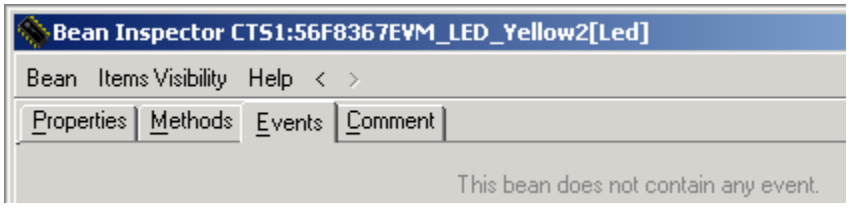


Figure 48. CTS1:56F8367EVM_LED_Yellow2 Events

2.16 DAC_Analog_TX Bean

The DAC can generate user-defined waveforms. We define the waveform to be the V.22bis TX signal. To do this, we have to keep giving the updated delta to the DAC at exactly the required time.

Bean name	DAC_Analog_TX	
D/A converter	DAC0	DAC0
D/A channels	1	
Channel0		
Channel output pin	Enabled	
D/A channel (pin)	GPIOD6_DAC0	GPIOD6_DAC0
D/A channel (pin) signal	Analog_TX	
Init value	000000000000	
D/A resolution	12 bits	
Data mode	Left justified	
Glitch filter	Enabled	
Filter value	7	
Synchronous mode	Enabled	
SYNC input pin	TA1_output	TA1_output
SYNC input pin signal		
SYNC input source	internal	
Source bean	DAC_Step_Clock	
Automatic waveform generatio	Enabled	
Generated shape	User	
Counting up	yes	
Counting down	yes	
Maximum value	FFF	
Minimum value	000	
Step size	000	
Initialization		
Enabled in init. code	yes	

Figure 49. DAC_Analog_TX Bean Properties

Enable	don't generate code
Disable	don't generate code
SetValue	generate code
SetValue8	don't generate code
SetValue16	don't generate code
SetMaxValue	generate code
SetMinValue	generate code
SetStep	generate code
ConnectPin	don't generate code

Figure 50. DAC_Analog_TX Bean Methods

Properties | Methods | Events | Comment

This bean does not contain any event.

Figure 51. DAC_Analog_TX Bean Events

3 Software Design Details

All of the code described here is readily available by downloading the modem project from the Freescale website. However, it is included here for ease of reference, explanation of function, and discussion. The actual modem code for the V.22bis and the V.21 is not published here.

This section includes the actual code written to implement the modem, which is separate from any code generated by the beans. The actual code and the discussion of design details are included together. The following sections relate to the following list of files written during the implementation of this project:

1. Modem.C
2. modem.h
3. Events.c
4. V21_processA.c (included in case the V.21 option is desired)

Modem.C is a file containing C code — the main program as well as most of the top level functionality of the modem.

The modem.h header file contains mainly state machines for the ring detection and AT command set.

The Events.c program is generated by Processor Expert and is used to connect functions with ISRs that are associated with beans. These are called events in Processor Expert terminology.

The V21_processA.c file is a customized version of the V21_process.c file automatically generated for the V.21 modem bean. This is required because the bean only supports synchronous communications with V.21. By replicating this file and making modifications to its contents, and then calling the methods that are in V21_processA.c rather than the ones in V21_process.c, an async interface is implemented. The previous method names are retained with the simple addition of a capital A suffix. The effect of this is a new, customized API for the V.21 modem.

3.1 Modem.C

Modem.C contains the functions required to use the beans which will implement both the V.22bis/V.22 modem and the V.21 modem (although the V.21 is optioned out for this note).

The sections that follow describe these functions and are interspersed with the code from main.c that implements them.

3.1.1 main.c Preamble

The preamble is largely generated by the various beans that add the include file references. It also contains static RAM variables needed for global access and state definition for the modem.

```
/** ###################################################################
**     Filename  : modem.C
**     Project   : modem
**     Processor : 56F8367
**     Version   : Driver 01.09
**     Compiler  : Metrowerks DSP C Compiler
**     Date/Time : 4/5/2005, 2:52 PM
**     Abstract  :
```

```
**         Main module.
**         Here is to be placed user's code.
**     Settings  :
**     Contents  :
**         No public methods
**
**     (c) Copyright UNIS, spol. s r.o. 1997-2004
**     UNIS, spol. s r.o.
**     Jundrovska 33
**     624 00 Brno
**     Czech Republic
**     http      : www.processorexpert.com
**     mail      : info@processorexpert.com
** ###################################################################*/
/* MODULE Modem */

//#define SAMPLE_RATE 8000
//#define ANALOG_LOOPBACK
//#define FORCE_DATA_MODE
/* Including used modules for compilling procedure */
#include "Cpu.h"
#include "Events.h"
#include "MEM1.h"
#include "CTS1.h"
#include "IV1.h"
#include "SampleRateTimer.h"
#include "TestHarnessDCE.h"
#include "RingDetect.h"
#include "OffHook.h"
#include "TwentythSecInt.h"
#include "TEL1.h"
#include "TEL2.h"
#include "Inhr1.h"
#include "STCK1.h"
#include "Mdm1.h"
#include "DAC_Analog_TX.h"
#include "ADC_Analog_RX.h"
#include "WDog1.h"
#include "DAC_Step_Clock.h"
/* Include shared modules, which are used for whole project */
#include "PE_Types.h"
#include "PE_Error.h"
#include "PE_Const.h"
#include "IO_Map.h"
#include "v22bis_app.h"
#include "modem.h"
//#define V21LOOPBACK

extern  int CountTime ;
extern Result dtmfGenerate (dtmf_sHandle *pDTMF,
                            Int16 *pData, /* Pointer to output buffer */
                            UWord16 NumSamples);extern  void TXCallbackRoutine (void *
pCallbackArg, v22bis_eStatus Status,
                                Word16 * pSamples, UWord16 NumberSamples);
extern  void RXCallbackRoutine (void * pCallbackArg, v22bis_eStatus Status,
                                char * pBits, UWord16 NumberBits);
UWord16 ReadAnalogRxData(Word16 * pRxBuffer, UWord16 Size);
```

```
UWord16 WriteAnalogTxData(Word16 * pTxBuffer, UWord16 Size);
void InitAnalogRxChannel(void);
void InitAnalogTxChannel(void);
void InitPoorMansCodec(void);
void CPTDetCallback (void *, UWord16 );
UWord16  v22bis_connection_established, connection_lost;
UWord16  rate_negotiated;
v22bis_sTXCallback  v22bis_TXCallback;
v22bis_sRXCallback  v22bis_RXCallback;


word Connecting_v21,Caller_Modem,call_phone_number,AT_z_flag,AT_q_flag,
V21_Mode,Ans_Tone_Start,Ans_Tone_Detect ;
#define AC0tr 0x3ffff     // energy threshold for ANS detection
#define NUM_ANS_SAMPLESd4 12
#define NUM_ANS_SAMPLESd2 24
#define NUM_ANS_SAMPLES 48 // number of samples to collect integral number of periods of
ANS
                           // based on 2100 hertz tone sampled at 7200 SPS.
                           // 2100/7200 * 7 , seven samples in 24 cycles.
                           // twice that to calculate autocorrellation
                           // function number 24, as well as 0 and 12 to compare.
/* Number of samples to be collected before calling the V22bis
   receiver */
#define  NUMRX_SAMPLES_V22bis   12 // v22 bis modem
#define NUM_SAMPLES_V21 24
/* Number of samples to be collected before calling the Call Progress Detect
   receiver */
#define  NUM_SAMPLES    100 // call progress
Word16   CodecTxBuffer[NUMSAMPLES];   /* Samples generated by the transmitter */
Word16   CodecRxBuffer[NUM_SAMPLES];  /* Samples for the receiver */
unsigned char     tty_in[100] ;
unsigned char     modem_in[100] ;  // modem has private buffer, cannot share.
byte  tty_in_status ;
unsigned char     ModemRxBuffer[MODEM_RX_BUFF_SIZE];
volatile unsigned char    *pModemRxWrt = ModemRxBuffer;
volatile unsigned char    *pModemRxRead = ModemRxBuffer;
volatile UWord16  is_time_to_shake = FALSE ; // between rings
int      AnalogRxBuffer[RX_BUFFER_SIZE];
volatile int     *pAnalogRxWrite=0;
volatile int     *pAnalogRxRead=0;
volatile  unsigned int      AnalogTxBuffer[TX_BUFFER_SIZE];
volatile  unsigned int     *pAnalogTxWrite = 0;
volatile  unsigned int     *pAnalogTxRead = 0;
Word16 PreviousSample = 0;
word CumCnt = 0 ;
word SaveCnt = 0 ;
/* Number of bytes transmitted at a time */
extern word ring_pulse_count ;
extern RING_STATE ring_state ;
volatile UWord16 Line_Tones;  // call progress detected
signed long        ACa,AC0,AC12,AC24;  // autocorrelation function accumulators for ANS
detect.
#ifdef CALIBRATE
signed long  DCavg ;
#endif
int h_parm ;
```

```
byte *p_phone_number ;
byte phone_number[41]; //ascii characters.. terminated with 0x00 as in a string.
                                //the phone number to call is stored here.. up to 40
digits.  Calling is activated via "call_phone_number".
AT_OFF_STATES AT_off_state ;
AT_ON_STATES AT_on_state ;
ESCAPEMENT_STATES state_of_escape ;
word Last_Dac_Value = 0;
long CombinedAnalogRxSample ;
// V.21

#ifdef __V21_H
v21_sHandle *pV21;
v21_sConfigure ConfigV21;
void TxCallbackV21 (void *pCallbackArg, Word16 *pSamples, UWord16 NumberSamples);
void RxCallbackV21 (void *pCallbackArg, char *pChars, UWord16 NumberBits);
Result v21TxProcessA (v21_sHandle *pV21, unsigned char *pBytes,UWord16 NumBytes);
Result v21RxProcessA (v21_sHandle *pV21, Word16 *pSamples, UWord16 NumSamples);
Result resTx=V21_TX_FREE;
Result resRx=V21_RX_PASS;
#endif
word TestTone[4] =
{
 0xC471, // don't make it too regular or too easy
 0x7876,
 0x8763,
 0x79f
};
Frac16 V25ansTone[24] =
{
0,
3967,
-2054,
-2904,
3557,
1063,
-4107,
1063,
3557,
-2904,
-2054,
3967,
0,
-3967,
2054,
2904,
-3557,
-1063,
4107,
-1063,
-3557,
2904,
2054,
-3967
};
unsigned int Blue_DAC_Scale ;
word This_Dac_Value ;
```

```
word This_Delta_Value ;
```

3.1.2 main()

The main() function is the control code for the modem. It is organized around the sequence of events needed to form one data connection to another modem connected over the PSTN. The initialization block that is executed only at system reset or power-up is first. This is followed by the start of a large loop that represents the establishment and disestablishment of a call to another modem.

One time through this large loop represents one call. The modem is re-initialized to the extent necessary after each call, retaining no information about the previous call. Various stages of the process differ depending on how the call is originated. The process begins, after initializing the per-call variables, with waiting for one of two events to happen:

- the phone rings
- there is a command to do one of these:
  - establish a call
  - adjust one of the command-configurable parameters
  - display product information

The main program can be broken conceptually into several parts that flow in sequence within this large loop.

3.1.2.1 “On Stack” Main Data Definitions

These definitions are allocated on the stack portion reserved when the main.c program is called. Because main() never returns by design, the variables herein may be considered to be static, but not global.

```
void main(void)
{
#ifdef CALIBRATE
 int DCcount = 0 ;
 signed long DC=0   ;
#endif
 v22bis_sHandle     *V22bisInstance=0;
 CPTDet_sHandle     *pCPTDet=0;
 dtmf_sHandle       DTMFhandle;
 v22bis_sConfigure  *pConfig=0;
 CPTDet_sConfigure  *pCPTDet_Config=0;
 dtmf_sConfigure    ConfigDTMFg;
 int resultv22,i;
 int resultcpd;
 int resultDTMFg;
 UWord16 modem_config;
 // there is no public configuration flag word for the call progress bean's structures
 UWord16 num_words;
 UWord16 message_transmitted;
 int numtxbytes ;
```

3.1.2.2 Actual Entry Point to Main and One-Time-Only Initialization Block

The Processor Expert adds the following line to initialize the beans, as directed in the properties in the GUI bean interfaces. Following that is the one-time initialization for the modem itself.

```
/*** Processor Expert internal initialization. DON'T REMOVE THIS CODE!!! ***/
 PE_low_level_init();
 WDog1_Disable();  // make sure none of this
 PESL(DAC0, DAC_WRITE_MAXVAL_REG_LEFT, 0xfff0); // PE uses 0xffff!
 numtxbytes = 0 ;
 /*** End of Processor Expert internal initialization.                    ***/
 pModemRxWrt = ModemRxBuffer;
 pModemRxRead = ModemRxBuffer;
 PreviousSample = 0;
 V21_Mode = FALSE ;
```

3.1.2.3 Call Establishment/Disestablishment while Loop Runs Once Per Call

This loop consists of the various stages of call establishment and disestablishment. The various stages are delineated and described in the sub-sections that follow.

```
while (1)  // start / restart modem.
           // the modem must return to this loop top when it restarts.  The modem restarts
             // after a call is lost.
 {
  byte Key;
```

3.1.2.3.1 Per-Call Initialization

Prior to the first and subsequent calls, variables are initialized. No record of prior calls is maintained. By clearing the call_phone_number flag, the modem is prevented from repeatedly calling the stored phone number until a connection is established.

```
OffHook_ClrVal();
  for (i = 0; i< NUM_SAMPLES ; i++)  CodecRxBuffer[i] = 0;
  AT_q_flag = AT_z_flag = FALSE ;
  AT_off_state = AT_off_idle ;
  AT_on_state = AT_on_idle ;
  is_time_to_shake = FALSE;
  call_phone_number = FALSE;
  //CTS1_On();          // no data flow yet.  CTS.. Clear To Send.. used to throttle the
DTE, which is
                     // most often a PC used for testing.  When CTS1_On is called, it has
                        // the effect of stopping the
                        // the DTE from sending further data.  This is commonly known as
hardware flow control
                      // such as is found in the hyperterminal program of Windows.  This
program does not implement
                        // flow control in the other direction.. towards the DTE, which
is assumed to be capable of
                        // recieving the data without pause.
  CumCnt = 0 ;         // This is the accumulation of characters in this programs buffer
of data from the DTE.
                        // It is monitored for the purposes of flow control which is
effected thru the CTS1 bean.
```

```
  Caller_Modem = FALSE ; // When the modem bean is initialized, it must be initialized
in caller or callee mode.
                         // We start with the assumption that we are not making a call,
so we define the boolean
                         // variable, Caller_Modem, to be FALSE.


  pCPTDet_Config = (CPTDet_sConfigure *) memMallocEM (sizeof (CPTDet_sConfigure)); // In
order to use call progress
                         // tone detection, memory must be allocated in advance.

  if (pCPTDet_Config == NULL) // Once debugging is complete, this check may perhaps be
removed.
  {
   asm(debughlt);
   while(1){};
  }
  pCPTDet_Config->CPTDetCallback.pCallback = CPTDetCallback; // The call progress
detection will call us back when
                               // call progress tones are detected.
  pCPTDet = CPTDetCreate (pCPTDet_Config); // Prepare to use the Call Progress Detection
API with this creation.
  if (pCPTDet == NULL) // Once debugging is complete, this check may perhaps be removed.
  {
   asm(debughlt);
   while(1){};
  }
  // Initialize and start the ring detection state machine:
  ring_state = ring_idle ; // The ring detector is a state machine in conjuction with the
RingDetectPulseAccumlator
                           // bean.  The initial or reset state of the ring detector is
"ring_idle".
  ring_pulse_count = 0;    // The ring detector
  OffHook_ClrVal();                      // ONHOOK, or not offhook.. rest condition of
DAA.. not connected.
  RingDetect_Disable();
  RingDetect_Enable();
  RingDetect_ResetCounter();
  archEnableInt();
#ifdef FORCE_DATA_MODE          // force data mode ... handshake even if no ring and no
number to dial.
  is_time_to_shake = TRUE;
#endif
  // CTS1_Off();   // allow flow to modem from DTE for commands.
```

3.1.2.3.2 Connection Establishment Loop

This loop waits for a ring or command to establish a connection. Origination is triggered via the call_phone_number flag, which is set by the offline AT command function, called at the top of the loop. As characters come in, the command is assembled and executed to set this flag. Or, the ATA command can force the modem into answer mode. Other commands can change the modem to operate in V.21 mode, to display the version of the code, or to suppress output of response to commands and connection status changes.

```
while ((is_time_to_shake == FALSE)&&(AT_z_flag == FALSE))   // stay in this loop untill
modem goes off hook and completes a connection.
  {
   AT_offline();
   if(call_phone_number)
```

3.1.2.3.3 Search for Dial Tone

The modem is now off-hook to dial and must find dial tone. The call progress bean is used to search for dial tone. In addition to the methods defined for the beans, PESL commands allow the selection of particular useful commands for direct manipulation of the peripherals. In this case, QTIMER_A1 is associated with the sample rate. This bean is used to time the samples on the ADC to achieve a net sample rate of 7200 samples per second. However, for the dial tone search, a bean is used that needs to be provided samples at 8000 samples per second. By changing the starting point of the timer up a few positions, the time is reduced and the number of samples is increased. The following PESL command changes the sample rate (of just the input, because the output is not used during dial tone search):

```
PESL(QTIMER_A1, QT_WRITE_LOAD_REG, 168);  // 802x set for 8000 sps output
```

When the bean is re-initialized, this value is reset to zero. That is why there is no PESL command to put the value back to zero. The bean is simply re-initialized when a return to 7200 samples per second is required.

```
// Start monitoring call progress.
    int Time_left_to_ANS, Time_left_to_DIALTONE ;
    byte * pKey;
    OffHook_SetVal();
    InitPoorMansCodec();
    PESL(QTIMER_A1, QT_WRITE_LOAD_REG, 168);  // 802x set for 8000 sps output
    Line_Tones = 0;
    Time_left_to_DIALTONE = (7200/NUM_SAMPLES) * 10; // 10 seconds
```

3.1.2.3.4 Wait-for-Dial-Tone Loop is Timed and User-Abortable

This complex while statement looks for dial tone, a timer expiration (nine second sledge-hammer timer), or any character to be entered from the test fixture, to abort the attempt to obtain dial tone. The sledge-hammer timer times the entire process of dialing, including the dial tone search, up to the point of answer tone detection.

```
while ((Line_Tones != DIAL_TONE_DETECTED) && Time_left_to_DIALTONE-- &&
(TestHarnessDCE_GetCharsInRxBuf() == 0))
    {
     num_words = 0 ;
     do
     {
     num_words += ReadAnalogRxData((CodecRxBuffer + num_words),NUM_SAMPLES - num_words);
     }
     while (num_words < NUM_SAMPLES);  // 100 for Call Progress Detect
```

3.1.2.3.5 CALIBRATE — For Calibration of the Daughter Cards

Normally, CALIBRATE is not defined. When it is, the code will calculate the energy in the dial tone. This value may be observed directly with CodeWarrior using the Data Visualization feature of the IDE. Then

the value of the potentiometer on the LCMDC (low cost modem daughter card) may be adjusted and real-time feedback obtained on the offset of the signal.

```
    #ifdef CALIBRATE // try to adjust LCMDC R15 for zero offset.
    {Word16 *pCodecB ;
     int i;
     pCodecB = CodecRxBuffer ;
     for (i = 0 ; i < NUMRX_SAMPLES_V22bis ; i++) DC += *pCodecB++ ;
     DCcount += NUMRX_SAMPLES_V22bis ;
     if (DCcount > 500) // can be larger if desired smoother.
     {
      DCcount = 0;
      DCavg = DC ;  // no need to divide, just show the number.  Use data visualization!
      DC = 0     ;
     }
    }
    #else  // if calibrating (above), holds on dialtone or what ever tone is incomming.
    resultcpd = CPTDetection (pCPTDet, CodecRxBuffer, NUM_SAMPLES);
    #endif
   }
   CPTDetDestroy(pCPTDet);
   free (pCPTDet_Config);
   if ((Time_left_to_DIALTONE <= 0) || TestHarnessDCEGetCharsInRxBuf() )
   { unsigned int n;
           call_phone_number = FALSE ; // don't keep trying to call the number forever..
automatically ;) .
        AT_off_state = AT_off_idle ; // allow new commands.
        if (!AT_q_flag) TestHarnessDCESendBlock((byte *)"\nNO DIALTONE\r\n", 14, &n); //
indicate to the DTE the problem.
        goto RESTART ;   // K&R approve use of goto in cases where break is not effective.
   }
```

3.1.2.3.6 After Dial Tone is Obtained, Rapid DTMF Dialing Ensues

The dialer parameters are set for the fastest dialing that should be recognized by standard telephony equipment. To slow down this rate of dialing by a factor of two, increase ConfigDTMFg.OnDuration and ConfigDTMFg.OffDuration contents by a factor of two.

The phone number to dial is simply a string pointed to by phone_number. This dialer can dial the digits 0 through 9 as well as the letters A through D, not normally provided on telephone handsets.

Note below the presence of additional diagnostics that are conditionally available when bringing the modem up on hardware. These diagnostics will output various tones and DTMF digits.

```
// dial-tone detected .. dial as fast as possible
    InitPoorMansCodec();
    CPTDetDestroy(pCPTDet); pCPTDet = 0 ;
    free (pCPTDet_Config);  pCPTDet_Config = 0 ;
    if ((Time_left_to_DIALTONE <= 0) || TestHarnessDCE_GetCharsInRxBuf() )
    {
     unsigned int n;
     call_phone_number = FALSE ; // don't keep trying to call the number forever..
automatically ;) .
    AT_off_state = AT_off_idle ; // allow new commands.
    if (!AT_q_flag) TestHarnessDCE_SendBlock((byte *)"\nNO DIALTONE\r\n", 14, &n); //
indicate to the DTE the problem.
    goto RESTART ;   // K&R approve use of goto in cases where break is not effective.
```

```
        }
        Blue_DAC_Scale = BLUE_DAC_SCALE_DTMF;
        ConfigDTMFg.OnDuration  = 288;      /* No. of samples for on duration */
        ConfigDTMFg.OffDuration = 252;    /* No. of samples for off duration */
        ConfigDTMFg.SampleRate  = 7200;   /* Sampling Frequency */
        ConfigDTMFg.amp         = 0x1fff; /* Amplitude, should be less than 0.5 */
        /* Call dtmfCreate */
        TEL2_dtmfInit ( &DTMFhandle, &ConfigDTMFg);
        pKey = phone_number ;
    //#define OUTPUT_TEST_TONE
    #ifdef OUTPUT_TEST_TONE
        for (;;)
        {
         num_words = 0;
         do
         {
         num_words += WriteAnalogTxData(((short *) &TestTone[0] + num_words), 4 - num_words);
         }
         while (num_words < 4);
        }
    #endif
    //#define OUTPUT_ANS_TEST_TONE
    #ifdef OUTPUT_ANS_TEST_TONE
        for (;;)
        {
         num_words = 0;
         do
         {
          num_words += WriteAnalogTxData((&V25ansTone[0] + num_words), 24 - num_words);
         }
         while (num_words < 24);
        }
    #endif
    //#define DIAL_FIRST_REPEAT_DEBUG
    // good place to set tx level out
    // do fft to check freqs on scope
    #ifdef DIAL_FIRST_REPEAT_DEBUG
        Key = *pKey;  // dial first digit repeatedly
        for (;;)
    #else
        while (0 != (Key = *pKey++))
    #endif
        {
         TEL2_dtmfSetKey(&DTMFhandle, (char)Key);
         resultDTMFg = PASS;
         while (resultDTMFg == PASS)
         {
          resultDTMFg = dtmfGenerate(&DTMFhandle, (Int16 *) CodecTxBuffer, NUMSAMPLES);
          num_words = 0;
          do
          {
         num_words += WriteAnalogTxData((CodecTxBuffer + num_words), NUMSAMPLES - num_words);
          }
          while (num_words < NUMSAMPLES);
         };
        }; // number dialed.
```

3.1.2.3.7 Search for Answer Tone

To achieve the best possible results, the timing of the hand-off to the V.22bis bean is critical. The V.22bis bean should take over as soon as answer tone is detected. This provides the largest connect percentage.

In the case of V.21, the entire answer tone should be detected all the way to the end, prior to handing control of the line to the V.21 code.

For the application program to determine this, a simple autocorrelation function is used. Due to the sampling rate and frequency being detected, the following code will quickly detect the answer tone or any periodic function with the same period as the answer tone. Prior to doing the autocorrelation, a dc offset correction is performed.

The modem code itself contains a similar function to detect answer tone in a similar way.

Again, any key typed at the async interface will abort the attempt to find answer tone and connect.

```
InitPoorMansCodec();
//#define MODEM_DET_ANS_TONE  // give the modem a chance to see if it can do it bettor
than this code can.
#ifndef MODEM_DET_ANS_TONE
    Time_left_to_ANS = (7200/NUM_ANS_SAMPLES) * 30; // 30 seconds
    Ans_Tone_Start = FALSE ;
    Ans_Tone_Detect = FALSE ;
    while
    ((   (TestHarnessDCE_GetCharsInRxBuf() == 0)       &&   // until this is false
         (Time_left_to_ANS > 0)             &&   // or this is false
         ( V21_Mode || !Ans_Tone_Start)     &&   // or this is all false
         (!V21_Mode ||!Ans_Tone_Start || Ans_Tone_Detect ) // or all this false
      )
    )
    {
     Time_left_to_ANS--;
     num_words = 0;
     // we stay in this do loop a long time perhaps..ReadAnalogRxData may give zero..
     do
     {
      num_words += ReadAnalogRxData((CodecRxBuffer + num_words),NUM_ANS_SAMPLES -
num_words);
     }
     while (num_words < NUM_ANS_SAMPLES);
     // Detect ANS
     // autocorellation function 0 should equal autocorellation function 24.
     // autocorellation function 12 should be the negative of both for 2100 hertz at
7200SPS.
     // scaling by shift right 5 (32) will allow use of long for accumulation without
overflow.
     ACa=AC0=AC12=AC24 = 0;
     for (i=0; i < NUM_ANS_SAMPLESd2; i++)
     {
      ACa += (long) CodecRxBuffer[i];            // note, ACa will be small for well
adjusted offset on RX
     }
     ACa /= NUM_ANS_SAMPLESd2 ;
     for (i=0; i < NUM_ANS_SAMPLESd2; i++)
     {
      AC0    += (((long)(CodecRxBuffer[i   ]-ACa) *
```

```
                    (long)(CodecRxBuffer[i   ]-ACa)))    / NUM_ANS_SAMPLESd2;
        AC12   += (((long)(CodecRxBuffer[i   ]-ACa) *
                   (long)(CodecRxBuffer[i+NUM_ANS_SAMPLESd4]-ACa)))    / NUM_ANS_SAMPLESd2;
        AC24   += (((long)(CodecRxBuffer[i   ]-ACa) *
                   (long)(CodecRxBuffer[i+NUM_ANS_SAMPLESd2]-ACa)))    / NUM_ANS_SAMPLESd2;
       }
       if ((AC0  >=  AC0tr) &&
           (AC24 >=  AC0tr) &&
           (AC12 <= -AC0tr) &&
           ((-50  * (AC0+AC12)) < AC0) &&
           ( (50  * (AC0+AC12)) < AC0) &&
           ((-50  * (AC0-AC24)) < AC0) &&
           ( (50  * (AC0-AC24)) < AC0)
           )
       {
       Ans_Tone_Start= TRUE ;
       Ans_Tone_Detect = TRUE ;
       }
       else
       {
        Ans_Tone_Detect = FALSE ;
       }
      }
      if ((Time_left_to_ANS <= 0) || TestHarnessDCE_GetCharsInRxBuf() )
      {
       unsigned int n;
       call_phone_number = FALSE ; // don't keep trying to call the number forever..
automatically ;) .
      AT_off_state = AT_off_idle ; // allow new commands.
      if (!AT_q_flag) TestHarnessDCE_SendBlock((byte *)"\nNO CARRIER\r\n", 13, &n); //
indicate to the DTE the problem.
      goto RESTART ;   // K&R approve use of goto in cases where break is not effective.
      }
#endif
      Caller_Modem = TRUE ;
      // launch originate modem here.
      is_time_to_shake = TRUE ;  // ANS detected, originate mode selected, go to V.xx
protocol.
      } // end (if call_phone_number)
     }; // End check for phone ringing to answer
     is_time_to_shake = FALSE ;
     if (AT_z_flag)
     {
      goto RESTART ;
     }
     OffHook_SetVal();
```

3.1.2.3.8 Modem Handshake — V.21 Case — Provide ANS Tone if Answering

Now that the number has been dialed and answer tone has been detected, or we have answered the phone and must provide answer tone, first we check for the case of V_21. In this case, the answer tone must be provided by the application. This is done very easily in the small loop below, which illustrates well the technique for outputting samples to the telephone interface.

```
// DATA PUMPING STARTS HERE
   Blue_DAC_Scale = BLUE_DAC_SCALE_V22bis ;  //0 also works
```

```
   // CTS1_On();
   // V.21
#ifdef __V21_H
   if (V21_Mode)
  {
   if (FALSE == call_phone_number)           // provide 2 seconds ans tone
                                            // because V.21 module does not do it.
   {
    InitPoorMansCodec();  // prior to interrupts checking in!
    for (i = 0 ; i < 300*2 ; i++)            // 300 bauds is one second.
    {
     num_words = 0;                 // 24 words per baud at 7200 SPS.
     do
     {
      num_words += WriteAnalogTxData((&V25ansTone[num_words]), 24 - num_words);
     }
     while (num_words < 24);
    }
   }
   Connecting_v21 = TRUE ;
   resTx = V21_TX_FREE ;                    // can't be busy yet!
   ConfigV21.v21Flag = V21_LOOPBACK_DISABLE ;
#ifdef V21LOOPBACK
   ConfigV21.v21Flag = 3 ;
#endifV21 Modem instantiation
```

The V.21 modem is dynamically instantiated here based on the calling mode, which is either answer or originate. Note the callback routines. These are routines that are provided by the application programmer and are called back by the modem data pump code when the modulation or demodulation of a “chunk” of data is obtained. In the case of the V.21 modem, a chunk is just one bit. The application program is called back for each received bit. This makes it a task of the application program to put the received characters together. The final else statement below is “if not V.21.” The #endif is the demarcation of the end of the V.21 code that is not compiled because it is conditioned off.

```
if (Caller_Modem) ConfigV21.Station = V21_CALL_MODEM; else ConfigV21.Station =
V21_ANS_MODEM ;
   ConfigV21.Gain = 0x07ff;            // EXPERIMENT WITH THIS!
   // ConfigV21.Gain = 0x01ff;            // original
   ConfigV21.TxCallback.pCallback = TxCallbackV21;
   ConfigV21.TxCallback.pCallbackArg = NULL;
   ConfigV21.RxCallback.pCallback = RxCallbackV21;
   ConfigV21.RxCallback.pCallbackArg = NULL;
   pV21 = v21Create (&ConfigV21);
   if (pV21 == NULL)
   {
    asm(debughlt);
    while(1){}
   }
   // assert (!"Out of memory");
  }
  else
#endif
```

3.1.2.3.9 V.22bis Dynamic Instantiation on a Per-Call Basis

In this case the V.22bis data pump is activated, not the V.21 data pump. If required, it will generate the answer tone. It also looks for answer tone, so if we are calling, the loop above has dropped us here while the majority of the answer tone is yet to be heard.

```
{
   /* Initialize the flow control parameters for the demo */
   v22bis_connection_established = FALSE;      // Will be set in the TX Callback routine
   connection_lost = FALSE;            // Will be set in the RX Callback routine if there
is an error
   message_transmitted = (unsigned short)FAIL;
   /* Set the rate_negotiated flag to none (-1) before starting
   V22bis / V22 transaction. The flag "rate_negotiated will
   take either V22BIS_1200BPS_CONNECTION_ESTABLISHED or
   V22BIS_2400BPS_CONNECTION_ESTABLISHED which are a part of
   "v22bis_eStatus" enum defined in "v22bis.h" file
   */
   rate_negotiated = (unsigned short)-1;
```

This code manages the initialization for the V.22bis modem, the parameters that are used to control flow to and from the actual V.22bis data pump bean. Next, depending on whether the call has been originated or is being answered, the modem parameters for the data pump itself are determined. The boolean flag Caller_Modem is true if we have dialed or otherwise originated this call.

```
/* Modem configuration parameters */
   if (Caller_Modem)
   {
    modem_config = (V22BIS_CALL_MODEM |   V22BIS_GUARD_TONE_DISABLE |
V22BIS_SELF_RETRAIN_ENABLE | V22BIS_V14_ENABLE_ASYNC_MODE);
   }
   else
   {
#ifdef DISABLE_2100_ANSWERTONE
    modem_config = (V22BIS_ANSWER_MODEM | V22BIS_GUARD_TONE_DISABLE |
V22BIS_SELF_RETRAIN_ENABLE | V22BIS_V14_ENABLE_ASYNC_MODE |
V22BIS_DISABLE_2100_ANSWERTONE);
#else
    modem_config = (V22BIS_ANSWER_MODEM | V22BIS_GUARD_TONE_DISABLE |
V22BIS_SELF_RETRAIN_ENABLE | V22BIS_V14_ENABLE_ASYNC_MODE);
#endif
   }
   /* Allocate memory for the init structure */
   pConfig = memMallocEM( sizeof(v22bis_sConfigure));
   if (pConfig == NULL)
   {
    asm(debughlt);
    while(1){}
   }
```

The callback routines are called when, in the course of the data pump either handling samples it has received or else generating samples to transmit, it determines that characters have been received or that characters may be given for transmission. Other status may also be conveyed in a callback routine. Note that the CTS functions are commented out because they were not used with this test fixture. In an embedded modem such a signal is not even needed, because there is no interface with a DTE.

```
v22bis_TXCallback.pCallback = TXCallbackRoutine;
```

```
    v22bis_RXCallback.pCallback = RXCallbackRoutine;
    /* Initialize the MODEM init structure */
    pConfig ->Flags = modem_config;
    pConfig ->TXCallback = v22bis_TXCallback;
    pConfig ->RXCallback = v22bis_RXCallback;
    /* Call Init routine */
    V22bisInstance = v22bisCreate (pConfig);
    if (V22bisInstance == NULL)
    {
     asm(debughlt);
     while(1){}
    }
   }
   InitPoorMansCodec();    // again?
  /*********************************************************/
#ifndef ANALOG_LOOPBACK
   //   CTS1_Off(); // take data from DTE
#endif
```

3.1.2.3.10 Online Data Loop

After the connection, V.21 or V.22bis/V.22 is established, the code simply loops back to this point. When the call is over, it falls through this loop and back up to the outermost loop in the program. The AS1 bean is tied to the serial port, which is connected to HyperTerminal for testing. AT commands and data come from that source. The online command mode escapement machine follows, as well as the normal data input point. Data flow is similar for V.21 and V.22bis, but not identical, because V.21 is more of a bit-oriented device. This V.21 operates at a fixed 300 bits per second. However, even when V.21 is operating, the AS1 bean, or async terminal connection, remains at 2400 baud. The data is buffered. Flow control signaling from the EVM to the PC assures that the PC will not overrun the modem with data.

The ATZ command will set a flag that will cause the online loop to terminate and the modem to perform a soft reset.

```
/*********************************************************/
  /* THIS IS THE MAIN Modem ONLINE LOOP                                  */
  /*********************************************************/
  CountTime = 0 ;
  state_of_escape = Escape_idle_zero;
  while (AT_z_flag == FALSE)
  {
   int i ;
   unsigned int n;
   word RcvCnt ;
   RcvCnt = 0 ;
   //   if ((TestHarnessDCE_GetCharsInRxBuf() > 5) || (CumCnt > 5)) CTS1_On();
   //   else CTS1_Off();
   if (state_of_escape != Escape_post_idle)
   {
    tty_in_status = TestHarnessDCE_RecvBlock(&tty_in[CumCnt],100-CumCnt, &RcvCnt) ;
    CumCnt += RcvCnt ;
   }
   if (CumCnt)
   {
    CountTime = 0;
   }
```

This code implements flow control. The PC test fixture would possibly overrun the serial port interface during binary file transfers if there were no flow control mechanism. Data from the serial port is buffered in tty_in, with the cumulative count, CumCnt, recorded up to a maximum of 100.

The following code checks for escape from the online data mode (entered after a connection is established) to the online command mode. The operator can type “+++” to leave the online data mode and enter the online command mode. The data passes into the serial port, and even to the other modem. There is a guard time before the +++ and another guard time after it, to ensure that it has not been entered by mistake. A state machine implemented with a simple case statement keeps track of this feature’s state.

```
switch (state_of_escape)
   {
    case Escape_idle_zero:
    if (CountTime >= 30) state_of_escape = Escape_pre_idle_1;
     break;
    case Escape_pre_idle_1:      // no data for a while.. look for plus
     if (CumCnt > 3) state_of_escape = Escape_idle_zero ;
     else if (CumCnt == 1) {if (tty_in[0]=='+') state_of_escape = Escape_p1 ; else
state_of_escape = Escape_idle_zero ;}
     else if (CumCnt == 2) {if ((tty_in[0]=='+') && (tty_in[1]=='+')) state_of_escape =
Escape_p2; else state_of_escape = Escape_idle_zero ;}
    else if (CumCnt == 3) {if ((tty_in[0]=='+') && (tty_in[1]=='+') && (tty_in[2]=='+'))
state_of_escape = Escape_p3; else state_of_escape = Escape_idle_zero ;}
     break;
    case Escape_p1:              // the first + is received.
     if (CumCnt > 2) state_of_escape = Escape_idle_zero ;
     else if (CumCnt == 1) {if (tty_in[0]=='+') state_of_escape = Escape_p2 ; else
state_of_escape = Escape_idle_zero ;}
     else if (CumCnt == 2) {if ((tty_in[0]=='+') && (tty_in[1]=='+')) state_of_escape =
Escape_p3; else state_of_escape = Escape_idle_zero ;}
    break;
    case Escape_p2:              // the second + is received.
     if (CumCnt > 1) state_of_escape = Escape_idle_zero ;
     else if (CumCnt == 1) {if (tty_in[0]=='+') state_of_escape = Escape_p3 ; else
state_of_escape = Escape_idle_zero ;}
    break;
    case Escape_p3:             // the third + is received.  Wait to make sure not data.
     if (CountTime >=30)
     {
      state_of_escape = Escape_post_idle;
      if (!AT_q_flag) TestHarnessDCE_SendBlock((byte *)"\r\nOK\r\n", 6, &n);
      CumCnt =0 ;
     }
     break;
    case Escape_post_idle:        // Escape is in effect.. process online AT commands.
     AT_online() ;
   } // end switch
```

The data flow for the V.21 beans and the V.22bis beans differ. First, the V.21 bean case is coded.

```
#ifdef __V21_H
   if (V21_Mode)
   {
    if (Connecting_v21)
    {
     if (!AT_q_flag) TestHarnessDCE_SendBlock((byte *)"\n\rCONNECT 300\r\n", 15, &n);
     Connecting_v21 = FALSE ;
```

```
    }
    num_words = 0;
    do
    {
     num_words += ReadAnalogRxData((CodecRxBuffer + num_words),NUM_SAMPLES_V21 -
num_words);
    }
    while (num_words < NUM_SAMPLES_V21);  // 24 at least for v.21
    if (resTx == V21_TX_FREE )
    {
     if ((CumCnt >= 1) && (resRx != V21_RX_CARRIER_LOST) )   // can't use tty_in_status
which comes back empty after draining chars
     {
      for (i=0;i<CumCnt;i++) modem_in[i] = tty_in[i] ;
      SaveCnt = CumCnt ;
      resTx = v21TxProcessA (pV21, (unsigned char *) &modem_in[0], CumCnt);
      CumCnt = 0 ;
     }
     else resTx = v21TxProcessA (pV21, (unsigned char *) NULL, 0); // mark some time..
one bit.
    }
    else resTx = v21TxProcessA (pV21, (unsigned char *) &modem_in[0], SaveCnt);
    if (pModemRxRead != pModemRxWrt)
    {
     unsigned char RxChar = *pModemRxRead++;
     TestHarnessDCE_SendChar(RxChar);   // if no analog loopback.
     if (pModemRxRead >= &ModemRxBuffer[MODEM_RX_BUFF_SIZE])
     {
      pModemRxRead = ModemRxBuffer;
     }
    }
#ifdef V21LOOPBACK
    for (i = 0; i < NUM_SAMPLES_V21; i++)
    {
     CodecRxBuffer[i] = CodecTxBuffer[i];
    }
#endif
    resRx = v21RxProcessA (pV21, CodecRxBuffer, NUM_SAMPLES_V21);
    if (resRx == V21_RX_CARRIER_LOST)
     if (!AT_q_flag) TestHarnessDCE_SendBlock((byte *)"\r\nNO CARRIER\r\n", 14, &n);
    if (resRx == V21_RX_CARRIER_LOST)
    break;
   }
```

The other case would be V.22bis, because only these two modes are implemented.

```
else                      // if not V21, then V.22bis..or V.22
#endif
   {
    num_words = 0;
    do
    {
     num_words += ReadAnalogRxData((CodecRxBuffer + num_words),NUMRX_SAMPLES_V22bis -
num_words);
    }
    while (num_words < NUMRX_SAMPLES_V22bis);  // twelve at least for v.22bis
    if (v22bis_connection_established == TRUE)
    {
```

```
      if (message_transmitted == FAIL)
      {
       if (CumCnt >= 1)   // can't use tty_in_status which comes back empty after draining
chars
       {
        for (i=0;i<CumCnt;i++) modem_in[i] = tty_in[i] ;
        v22bisTXDataInit ( V22bisInstance, (char *) &modem_in[0], CumCnt);
        CumCnt = 0 ;
       }
      }
      message_transmitted = (unsigned short) v22bisTX (V22bisInstance);
      if (pModemRxRead != pModemRxWrt)
      {
       unsigned char RxChar = *pModemRxRead++;
       TestHarnessDCE_SendChar(RxChar);   // if no analog loopback.
       if (pModemRxRead >= &ModemRxBuffer[MODEM_RX_BUFF_SIZE])
       {
        pModemRxRead = ModemRxBuffer;
       }
      }
     }
     /* Call V22bis receiver */
     resultv22 = v22bisRX ( V22bisInstance, CodecRxBuffer, NUMRX_SAMPLES_V22bis);
     if (resultv22 == FAIL)
     {
      connection_lost = TRUE;            /* Terminate the loop */
     }
     if (connection_lost == TRUE)
     {
      if (!AT_q_flag) TestHarnessDCE_SendBlock((byte *)"\r\nNO CARRIER\r\n", 14, &n);
      break;
     }
    }  // end block
   }  // end while atz flag is false
```

3.1.2.3.11 Call Disestablishment and Modem Recycling to Re-Initialize for Next Call

There is only one tag used in this program, because a call can be aborted from within several of the loops that have been described. Resources incidental to a particular call setup are freed.

```
RESTART:{}
  InitPoorMansCodec() ;
  if (pCPTDet) CPTDetDestroy(pCPTDet);
  if (pCPTDet_Config) free (pCPTDet_Config);
  if (V22bisInstance) resultv22 = v22bisDestroy (V22bisInstance);
  if (pConfig) free (pConfig);
#ifdef __V21_H
  if (pV21) v21Destroy (pV21);
#endif
  pCPTDet =NULL;
  pCPTDet_Config = NULL;
  V22bisInstance =NULL ;
  pConfig =NULL;
#ifdef __V21_H
  pV21 = NULL ;
#endif
 } // restart modem
```

```
} // end of main
```

3.1.3 AT_offline()

This routine parses and executes the AT commands that are directed from the test fixture, the AS1 bean, to the modem when it is not connected to another modem. Commands can be used to dial or change the options of the modem. A simple state machine is used to parse the commands one character at a time in real time. Because this is just a test harness, no command editing features are included.

```
/*****************************************************************************
*
* Module: AT_offline
*
* Description: Converse with serial port to effect calling.
*              This routine is designed only for the "offline" command mode.
*              Simply call this routine about 2400 times per second or perhaps
*              more often when the modem has nothing to do.
*              Dialing is accomplished by filling phone_number, then setting
*              call_phone_number true.  The OK reponse is always produced.
*
* Returns: None
*
* Arguments: None
*
*****************************************************************************/

void AT_offline (void)
{
 unsigned int n ;
 byte c;
 if (TestHarnessDCE_GetCharsInRxBuf())
 {
  tty_in_status = TestHarnessDCE_RecvBlock(&c,1,&n) ;
  switch (AT_off_state)
  {
   case AT_off_idle:
    if ((c=='a') || (c=='A'))
   {
    AT_off_state = AT_off_a ;
    TestHarnessDCE_SendChar(c) ;
   }
   break;
   case AT_off_a:
    if ((c=='t') || (c=='T'))
   {
    AT_off_state = AT_off_at ;
    TestHarnessDCE_SendChar(c) ;
   }
   else if ((c=='a') || (c=='A'))
   {
    TestHarnessDCE_SendChar(c) ;
   }
   else AT_off_state = AT_off_idle ;
   break;
   case AT_off_at:
```

```
        TestHarnessDCE_SendChar(c) ;
        if (c== '\r')
        {
         AT_off_state = AT_off_idle ;
         if (!AT_q_flag) TestHarnessDCE_SendBlock((byte *)"\nOK\r\n", 5, &n);
        }
        else if ((c=='a') || (c=='A'))
        {
         AT_off_state = AT_off_ata ;
        }
        else if ((c=='d') || (c=='D'))
        {
         AT_off_state = AT_off_atd ;
         p_phone_number = phone_number ;
        }
        else if ((c=='i') || (c=='I'))
        {
         AT_off_state = AT_off_ati ;
        }
        else if ((c=='q') || (c=='Q'))
        {
         AT_off_state = AT_off_atq ;
         AT_q_flag = FALSE ;
        }
        else if ((c=='z') || (c=='Z'))
        {
         AT_off_state = AT_off_atz ;
        }
        else if (c=='+')
        {
         AT_off_state = AT_off_plus ;
         V21_Mode = TRUE ;
        }
        break;
        case AT_off_ata:
        TestHarnessDCE_SendChar(c) ;
        if (c == '\r')
        {
         call_phone_number = FALSE ;
         AT_off_state = AT_off_idle ;
         is_time_to_shake = TRUE;
        }
        break;
        case AT_off_atd:
        TestHarnessDCE_SendChar(c) ;
        if ((c >= '0' && c <= '9')||(c >= 'a' && c <= 'd')||(c >= 'A' && c <= 'D') || c == '*'
     || c == '#')
        {
         if (p_phone_number != &phone_number[39]) *p_phone_number++ = c;
        }
        if (c == '\r')
        {
         *p_phone_number = '\0';
         call_phone_number = TRUE ;
         AT_off_state = AT_off_idle ;
        }
        break;
```

```
   case AT_off_atq:
   TestHarnessDCE_SendChar(c) ;
    if (c == '0') AT_q_flag = FALSE ; else if (c == '1') AT_q_flag = TRUE ;
   if (c == '\r')
   {
   if (!AT_q_flag) TestHarnessDCE_SendBlock((byte *)"\n\rOK\r\n", 6, &n);
    AT_off_state = AT_off_idle ;
   }
   break;
   case AT_off_ati:
   TestHarnessDCE_SendChar(c) ;
   if (c == '\r')
   {
   if (!AT_q_flag) TestHarnessDCE_SendBlock((byte *)"\n\rFreescale Modem Model DSCAT8037
Serial 0001 Version at003gb16\r\nV.22bis\r\nOK\r\n", 78, &n);
#ifdef STCK1_stackcheckSizeAllocated
     if (   STCK1_stackcheckSizeUsed()
          > STCK1_stackcheckSizeAllocated() )
     asm(debughlt);
#endif
    AT_off_state = AT_off_idle ;
   }
   break;
   case AT_off_atz:
   TestHarnessDCE_SendChar(c) ;
   if (c == '\r')
   {
   if (!AT_q_flag) TestHarnessDCE_SendBlock((byte *)"\n\rOK\r\n", 6, &n);
    AT_off_state = AT_off_idle ;
    AT_z_flag = TRUE ;
   }
   break;
  case AT_off_plus:
    TestHarnessDCE_SendChar(c) ;
   if (c == '\r')
   {
   if (!AT_q_flag) TestHarnessDCE_SendBlock((byte *)"\n\rOK\r\n", 6, &n);
    AT_off_state = AT_off_idle ;
    AT_z_flag = TRUE ;
   }
   else if (c == '0')
   {
    V21_Mode = TRUE ;
   }
   else if (c == '2')
   {
    V21_Mode = FALSE ;
   } // else if
     // case
  } // switch
 } // if
} // function
```

3.1.4 AT_online()

When the modem is connected to another modem, there is no need to dial. All that can be done is to end the call. One way provided to end the call is simply to hang up the phone, while keeping the data pump running. This is the case for the ath command provided. The other way is the zap command, atz, which both hangs up the call and totally resets the call from the application.

```
/*****************************************************************************
*
* Module: AT_online
*
* Description: Converse with serial port to control hook relay with H command.
*              This routine is designed only for the "online" command mode.
*              Simply call this routine about 2400 times per second or perhaps
*              more often when the modem has been escaped to the online command mode.
*
* Returns: None
*
* Arguments: None
*
*****************************************************************************/

void AT_online (void)
{
 unsigned int n;
 byte c;
 if (TestHarnessDCE_GetCharsInRxBuf())
 {
  tty_in_status = TestHarnessDCE_RecvBlock(&c,1,&n) ;
  switch (AT_on_state)
  {
   case AT_on_idle:
  if ((c=='a') || (c=='A'))
     {
     AT_on_state = AT_on_a ;
     TestHarnessDCE_SendChar(c) ;
    }
   break;
   case AT_on_a:
   if ((c=='t') || (c=='T'))
   {
     AT_on_state = AT_on_at ;
    TestHarnessDCE_SendChar(c) ;
   }
   else if ((c=='a') || (c=='A'))
   {
    TestHarnessDCE_SendChar(c) ;
   }
   else AT_on_state = AT_on_idle ;
   break;
   case AT_on_at:
    TestHarnessDCE_SendChar(c) ;
   if (c== '\r')
   {
    AT_on_state = AT_on_idle ;
```

```
     if (!AT_q_flag) TestHarnessDCE_SendBlock((byte *)"\nOK\r\n", 5, &n);
    }
    else if ((c=='h') || (c=='H'))
    {
     AT_on_state = AT_on_ath ;
     h_parm = 0 ;
    }
    else if ((c=='o') || (c=='O'))
    {
     AT_on_state = AT_on_ato ;
    }
    else if ((c=='z') || (c=='Z'))
    {
     AT_on_state = AT_on_atz ;
    }
    break;
    case AT_on_ath:
     TestHarnessDCE_SendChar(c) ;
    if (c == '0')
    {
     h_parm = 0 ;
    }
     if (c == '1')
    {
     h_parm = 1 ;
    }
   if (c == '\r')
    {
     if (h_parm) OffHook_SetVal(); else OffHook_ClrVal();
      AT_on_state = AT_on_idle ;
     if (!AT_q_flag) TestHarnessDCE_SendBlock((byte *)"\n\rOK\r\n", 6, &n);
     }
     break ;
    case AT_on_ato:
     TestHarnessDCE_SendChar(c) ;
   if (c == '\r')
    {
     state_of_escape = Escape_idle_zero;
      AT_on_state = AT_on_idle ;
     if (!AT_q_flag) TestHarnessDCE_SendBlock((byte *)"\n\rCONNECT\r\n", 11, &n);
     }
     break ;
    case AT_on_atz:
     TestHarnessDCE_SendChar(c) ;
   if (c == '\r')
    {
     state_of_escape = Escape_idle_zero;
      AT_on_state = AT_on_idle ;
     if (!AT_q_flag) TestHarnessDCE_SendBlock((byte *)"\n\rOK\r\n", 6, &n);
     AT_z_flag = TRUE ;
     }
   }
  }
 }
```

3.1.5 CPTDetCallback()

This is the callback function used in conjunction with dial tone detection.

```
/*****************************************************************************
*
* Module: CPTDetCallback ()
*
* Description:
*
* Returns: None
*
* Arguments:
*  pCallbackArg -> pointer to the argument list passed to the CPTDetection
*  return_value - detected CPT digit
*
*****************************************************************************/

void CPTDetCallback (void *pCallbackArg, UWord16 return_value)
{
 Line_Tones = return_value ;
 if (pCallbackArg) return ;
}
```

3.1.6 TxCallbackV21()

This function is called when the V.21 data pump is being called from the main online data loop. It dumps the samples that it has formed by modulation of the bit it is sending. Note that __V21_H is not defined.

```
#ifdef __V21_H

/*********************************************************************
*
* Module: TxCallbackV21 ()
*
* Description: Once the samples are ready for transmission, the
*              V21 library calls this routine through callback
*              procedure. This function writes these samples into the
*              codec buffer for transmission.
*
* Returns: None
*
* Arguments: pCallbackArg - supplied by the user in the
*                           v21_sTXCallback structure; this value is
*                           passed back to the user during the call
*                           to the TxCallback procedure. pCallbackArg
*                           typically points to context information
*                           used by the user's callback procedure
*                           (user has to write his/her own callback
*                           function). But in the current test set-up
*                           it is NULL.
*            pSamples - pointer to samples buffer for transmission.
*            NumberSamples - Number of samples to be transmitted.
*********************************************************************/
void TxCallbackV21 (void *pCallbackArg, Word16 *pSamples, UWord16 NumberSamples)
{
 Word16  i;
```

```
 UWord16 num_words;
 if (pCallbackArg != NULL)
 {
  asm(debughlt);
  while(1){}
 }
 for  ( i = 0; i < NumberSamples; i++)
 {
  CodecTxBuffer[i] = pSamples[i];
 }
 num_words = 0;
 do
 {
  num_words += WriteAnalogTxData((CodecTxBuffer + num_words), NumberSamples - num_words);
 }
 while (num_words < NumberSamples);
}
#endif
```

3.2 TXCallbackRoutine()

In the case of V.22bis, samples are delivered as the modem modulates them. This interface also indicates the status of the modem connection in the case of a V.22bis or V.22 connection.

```
/*********************************************************************
*
* Module: TXCallbackRoutine ()
*
* Description: This is a V22 transmit callback routine. This module is
*              called by V22bis library as and when it has samples
*              to be sent across to the remote modem.
*
* Returns: None
*
* Arguments: pCallbackArg -> Supplied by the user in the
*                            v22bis_TXCallback structure; this value is
*                            passed back to the user during the call
*                            to the Callback procedure. pCallbackArg
*                            typically points to context information
*                            used by the user's callback procedure
*                            (user has to write his/her own callback
*                            function)
*            Status - This is an enum containing the following fields
*                     V22BIS_1200BPS_CONNECTION_ESTABLISHED,
*                     V22BIS_2400BPS_CONNECTION_ESTABLISHED,
*                     V22BIS_CONNECTION_LOST,
*                     V22BIS_DATA_AVAILABLE,
*                     V22BIS_RETRAINING
*
*            pSamples -> Pointer to the buffer containing 16-bit
*                        linear samples for transmission to the
*                        remote modem
*
*            NumberSamples - Number of samples in the sample
*                            buffer pointer by pSamples
*
* Range Issues: None
```

```
*
* Special Issues: None
*
* Test Method: interopans.mcp
*
*********************************************************************/

void TXCallbackRoutine (void * pCallbackArg, v22bis_eStatus Status,
                        Word16 * pSamples, UWord16 NumberSamples)
{
 Word16  i;
 UWord16 num_words;
 unsigned int n;
 /* Modem is in re-trainig mode, and hence, user should not call the transmitter to send
the data */
 if ( Status == V22BIS_RETRAINING)
 {
  v22bis_connection_established = FALSE;
  if (!AT_q_flag) TestHarnessDCE_SendBlock((byte *)"\n\rTRAINING\r\n", 12, &n);
 }
 /* Connection established. This could happen in 2 ways.
       During power-up, after the handshake this flag is set to
       indicate the user that, the data can be sent to the remote
       modem.
       During data transfer, modem can enter re-training mode due
       to high noise on the channel. Once the re-traning is over,
       this flag is set to indicate that user can now send the
       data. During re-training user should not call the transmitter
       for sending the data
 */
 else if ( Status == V22BIS_1200BPS_CONNECTION_ESTABLISHED)
 {
  v22bis_connection_established = TRUE;
  rate_negotiated = V22BIS_1200BPS_CONNECTION_ESTABLISHED;
  if (!AT_q_flag) TestHarnessDCE_SendBlock((byte *)"\n\rCONNECT 1200\r\n", 16, &n);
 }
 /* Above comment holds good here too */
 else if ( Status == V22BIS_2400BPS_CONNECTION_ESTABLISHED)
 {
  v22bis_connection_established = TRUE;
  rate_negotiated = V22BIS_2400BPS_CONNECTION_ESTABLISHED;
  if (!AT_q_flag) TestHarnessDCE_SendBlock((byte *)"\n\rCONNECT 2400\r\n", 16, &n);
 }
 else if ( Status == V22BIS_DATA_AVAILABLE)
 {
 for  ( i = 0; i < NumberSamples; i++)
 {
  CodecTxBuffer[i] = pSamples[i];
 }
 num_words = 0;
 do
 {
  num_words += WriteAnalogTxData((CodecTxBuffer + num_words), NumberSamples - num_words);
 }
 while (num_words < NumberSamples);
 }
}
```

3.2.1 RxCallbackV21()

Unlike V.22bis, the V.21 RxCallback function is called each time just one bit is received. This makes it possible to perform the search for the character's start bit in this function. After a zero bit is detected (start bit), then the next 8 bits are considered as data, and the following bit as a stop bit. However, this stop bit is optional in the implementation below. Notice that it is really looking for the next start bit as soon as the eight data bits are done. This makes operation at zero stop bits possible. Any number of stop bits may be used, as long as they are an integral number equal to or greater than zero.

```
#ifdef __V21_H


/**********************************************************************
*
* Module: RxCallbackV21 ()
*
* Description: The demodulated bits are given to the user through this
*              function once zero is detected
*              and once for each subsequent bit that is detected.
*(assume async start 8 data no parity one stop).. other formats may be supported
* by making modifications herein.
*
* Arguments: pCallbackArg - not used
*            pChars - pointer to demodulated byte.
*            NumberBytes - Number of bytes received/demodulated at Rx.
*
**********************************************************************/

#define V21_NUM_BITS 8  /* 8 bits per byte for 8N1 async format */
word StartBitRXd = FALSE ;
unsigned char MsgByteRx1 = 0;
int BitCounterRx1 = V21_NUM_BITS;
void RxCallbackV21 (void *pCallbackArg, char *pChars, UWord16 NumberBits)
{
  Word16 tempBit ;

   if (NumberBits !=1 )   {
   asm(debughlt);
   while(1){}
  }
 // assumption check
   if (pCallbackArg != NULL )   {
   asm(debughlt);
   while(1){}
  }
 // assumption check
   tempBit = *pChars & 0x01;        // The bit we are being delivered is here
  if (StartBitRXd)              // ignore stop bits .. as many as may be present.. if any.
   {
   MsgByteRx1 >>= 1;             // Make way for the next bit to enter .. LSB's received
first.
    tempBit <<= (V21_NUM_BITS - 1); // Seven
    MsgByteRx1 |= tempBit;          // collect the bit for the developing character
    BitCounterRx1--;                // Byte formed ?
    if (BitCounterRx1 == 0)         // If byte is formed ...
    {
```

```
     StartBitRXd = FALSE ;        // look for another start bit.. stop bits are OPTIONAL
here.
     BitCounterRx1 = V21_NUM_BITS; // Reinit. bit counter
     *pModemRxWrt++ = MsgByteRx1;
     if (pModemRxWrt>= &ModemRxBuffer[MODEM_RX_BUFF_SIZE])
     {
      pModemRxWrt = ModemRxBuffer;
     }
     MsgByteRx1 = 0;               // Reset, for collecting next data byte
    }
   }
   else
   {
    if (tempBit == 0) StartBitRXd = TRUE ;
   }
}
#endif
```

3.2.2 RXCallbackRoutine()

The V.22bis data pump puts the characters together for the application, so it is somewhat simple. This function is not called for each bit, but deals only in bytes. That is because this data pump performs the function of sync to async for the application.

```
/*********************************************************************
*
* Module: RXCallbackRoutine ()
*
* Description: This is a V22 recive callback routine. This module is
*              called by V22bis library as and when it receives
*              few bits .
*
* Returns: None
*
* Arguments: pCallbackArg -> Supplied by the user in the
*                            v22bis_TXCallback structure; this value is
*                            passed back to the user during the call
*                            to the Callback procedure. pCallbackArg
*                            typically points to context information
*                            used by the user's callback procedure
*                            (user has to write his/her own callback
*                            function)
*            Status - This is an enum containing the following fields
*                     V22BIS_1200BPS_CONNECTION_ESTABLISHED,
*                     V22BIS_2400BPS_CONNECTION_ESTABLISHED,
*                     V22BIS_CONNECTION_LOST,
*                     V22BIS_DATA_AVAILABLE,
*                     V22BIS_RETRAINING
*
*            pBits -> Pointer to the buffer containing the bits
*                     received / decoded
*
*            NumberSamples - Number of bits received pointed by pBits
*
* Range Issues: None
*
* Special Issues: Instant response to lost carrier to speed lab testing.
```

```
*
* Test Method: loopback_test.mcp
*
**************************** Change History *************************
*
*    DD/MM/YY     Code Ver    Description       Author
*    --------     --------    -----------       ------
*    12-04-2000   0.0.1       Created           Sanjay Karpoor
*    13-09-2000   1.0.0       Reviewed and      Sanjay Karpoor
*                             Baselined
*
*********************************************************************/
void RXCallbackRoutine (void * pCallbackArg, v22bis_eStatus Status, char * pBits, UWord16
NumberBits)
{
 UWord16  NumberRxBytes, i;
 unsigned char Key;
 NumberRxBytes = NumberBits >> 3;
 if (   (Status == V22BIS_CONNECTION_LOST)
     || (Status == V22BIS_CARRIER_LOST_IN_DATAMODE ))   // this term may be thresholded
per S register
 {
  connection_lost = TRUE;
 }
 if ( Status ==  V22BIS_DATA_AVAILABLE)
 {
  for (i = 0; i < NumberRxBytes; i++)
  {
   Key = (unsigned char) pBits[i];
   *pModemRxWrt++ = Key;
   if (pModemRxWrt>= &ModemRxBuffer[MODEM_RX_BUFF_SIZE])
   {
    pModemRxWrt = ModemRxBuffer;
   } // end if
  } // end for
 } // end if
 if (pCallbackArg) return ;
} // end function
```

3.2.3 InitAnalogRxChannel()

The sequence:

```
pAnalogRxWrite = NULL;
pAnalogRxRead = &AnalogRxBuffer[0];
```

may appear strange. However, the NULL value is used to keep the ISR from being active with the FIFO.

The FIFO (first in first out) is a special kind of buffer called a circular buffer. When writing is done, the first pointer is used and advanced. When reading is done, the second pointer is used and advanced until it once again equals the first pointer. The pointers wrap around the end of the FIFO, so there is no first location.

This circularity is achieved only with software in this case, although this processor does implement such things in hardware. You will find this software in the assembly language expansions of the beans related to digital filters.

Because location zero is not included in the RAM locations that programs can use, the NULL address can have a special meaning. We take full advantage of this possibility in the following application example.

```
/*********************************************************************
*
* Module: InitAnalogRxChannel ()
*
* Description: This function initializes the code required for the
*              analog receive portion of this demo.
*
* Returns: None
*
* Arguments: None
*
* Range Issues: None
*
* Special Issues: The NULL pointer is used to disable some ISR activities
*
*********************************************************************/
void InitAnalogRxChannel(void)
{int i;
 for (i=0 ; i < RX_BUFFER_SIZE; i++)
  AnalogRxBuffer[i] = 0;
 pAnalogRxWrite = NULL;  // TURN OFF FIFO.. no writes to FIFO if no pointers untill first
request comes in
 pAnalogRxRead  = &AnalogRxBuffer[0]; // but initialize the input buffer pointer to start.
 PESL(QTIMER_A1, QT_WRITE_LOAD_REG, 0);  // 802x set for 7200 SPS.
}
```

3.2.4 InitAnalogTxChannel()

This function is another case of a circular FIFO implemented in C. Again NULL is used to keep the ISR from operating with the FIFO. If it is not using the FIFO, it instead takes the center value of the DAC and uses that. Also, the FIFO is initialized to the center value, which represents zero, or no signal out. The DAC deals with unsigned left-justified 12-bit hexadecimal values. So, 0x8000 means 800 on a scale of 0 to FFF, hexadecimal.

```
/*********************************************************************
*
* Module: InitAnalogTxChannel ()
*
* Description: This function initializes the analog TX FIFO required for the
*              analog transmit (to DAC) portion of this demo.
*
* Returns: None
*
* Arguments: None
*
* Range Issues: None
*
* Special Issues: Use of the NULL pointer is to hold off some ISR activities.
*
*********************************************************************/
void InitAnalogTxChannel(void)
{
 int i;
```

```
 for (i=0 ; i < TX_BUFFER_SIZE; i++)
  AnalogTxBuffer[i] = 0x8000;  // mid voltage for DAC left just.
 pAnalogTxRead  = NULL;               // 1st this holds off the ISR reading till first
deposit complete
 pAnalogTxWrite = &AnalogTxBuffer[0]; // 2nd this allows first deposit to be in first
part of fifo.
}
```

3.2.5 InitPoorMansCodec()

These simply call both of the functions above, InitAnalogRxChannel() and InitAnalogTxChannel().

```
/*********************************************************************
*
* Module: InitPoorMansCodec()
*
* Description: This function initializes the TX and RX FIFO set.
*
* Returns: None
*
* Arguments: None
*
* Range Issues: None
*
* Special Issues: None
*
*********************************************************************/
void InitPoorMansCodec(void)
{
 InitAnalogRxChannel(); // init ADC channel FIFO
 InitAnalogTxChannel(); // init DAC channel FIFO
}
```

3.2.6 ReadAnalogRxData()

The ADC is the origin of this data. It is used to sample the data provided here.

```
/*********************************************************************
*
* Module: ReadAnalogRxData()
*
* Description: This function reads the samples from the AnalogRxBuffer
*              and returns them back to the calling function.  Will not block
*              but may return nothing at all.
*
* Returns: Number of Samples Read
*
* Arguments: pRxBuffer - Buffer to store the samples in
*
*            Size - Number of samples to read
*
* Range Issues: None
*
* Special Issues: None
*
*********************************************************************/
UWord16 ReadAnalogRxData(Word16 * pRxBuffer, UWord16 Size)
```

```
{
 UWord16 SamplesRead = 0;
 if ((Size !=0 ) && pAnalogRxWrite == NULL) pAnalogRxWrite = &AnalogRxBuffer[0]; // allow
ADC ISR to input to FIFO  check 0
 else
 {
  while ((pAnalogRxRead != pAnalogRxWrite) && (SamplesRead < Size)) // while not empty
and stuff
  {
   *pRxBuffer++ = *pAnalogRxRead++;
   SamplesRead++;
   if (pAnalogRxRead >= &AnalogRxBuffer[RX_BUFFER_SIZE])
   {
    pAnalogRxRead = &AnalogRxBuffer[0];
   }
  }
 }
 return(SamplesRead);
}
```

3.2.7 WriteAnalogTxData()

Analog data is written to the DAC. The DAC signal is then fed to a low-pass filter to achieve a baseband signal limited to 4000 hertz. Any glitches produced by the DAC have an energy low enough not to affect the baseband signal. There is no restriction on amplitude, and rounding is used to get maximum resolution. If the FIFO is inactive when this function is called, it will activate the FIFO for the ISR. It does this with the statement:

```
pAnalogTxRead = &AnalogTxBuffer[TX_BUFFER_SIZE-NUMSAMPLES];
```

The entire function follows:

```
/*********************************************************************
*
* Module: WriteAnalogTxData()
*
* Description: This function writes the samples to the AnalogTxBuffer.
*              For each sample, four samples are actually transmitted.
*              The extra three samples are calculated by the DAC
*              between the previous sample and the new sample.
*
*              This function also checks for and avoids transmitter overrun errors.
*
* Returns: Number of Samples Written
*
* Arguments: pTxBuffer - Buffer containing the samples to be written
*
*            Size - Number of samples to be written
*
* Range Issues: None
*
* Special Issues:
* To sync the actual output startup to the first write to the FIFO,
* to minimize handshake delays,
* pAnalogTxRead is initialized to zero when the transmitter is not in use.
```

```
* Use is initiated here by setting this pointer.
*
* Assumption:  write less in one call here than
* the size of the buffer.
*********************************************************************/
UWord16 WriteAnalogTxData(Word16 * pTxBuffer, UWord16 Size)
{
 UWord16 SamplesWritten = 0;
 while ((pAnalogTxWrite != pAnalogTxRead)  &&  // fifo not full
        (SamplesWritten < Size))               // samples left to send
 {
  // generate left justified unsigned rounded dac value
  *pAnalogTxWrite++ = ((unsigned int)(((*pTxBuffer++) >> Blue_DAC_Scale)
                                      +  BLUE_DAC_OFFSET)) << 1 ;
  SamplesWritten ++;
  if (pAnalogTxWrite >= &AnalogTxBuffer[TX_BUFFER_SIZE])
  {
   pAnalogTxWrite =     &AnalogTxBuffer[0]; // wraps the fifo
  }
 }
// Check to see if this FIFO is being inaugurated.. if this is the first write.
 if ((SamplesWritten !=0 ) && pAnalogTxRead == NULL)
 pAnalogTxRead = &AnalogTxBuffer[TX_BUFFER_SIZE-NUMSAMPLES];  // set back one frame.
  // If you do not set it back one frame, the code will stall when it tries to write
  // and the FIFO is full.  This does perhaps increase the response time of the modem
  // including during handshaking, but the tradeoff is that writes to the FIFO will not
  // ever have to wait during V22bis operation.  DTMF still relies on the full-check.
  // Turn on the reading of the FIFO by the ISR. ISR is hands off zeros.
  // No need to start if no samples are written yet.
  // Location zero in Ram is not allowed to be allocated.
  // This means a NULL valued pointer can have a special meaning:
  // Not defined yet.  This means the sink of this fifo is not yet
  // defined.  It will not define until the source is manifest.
  // the source is manifest when the data is writen and the condition above
  // is satisfied.
 return(SamplesWritten);
}
```

3.2.8 ADC_EOS_INT()

Both the DAC and the ADC are serviced in one ISR. This has several advantages:

- The timing is fixed, so that noise can be constant.
- Only one ISR overhead is needed for TX and RX functions.
- FIFOs will have a fixed relationship regarding fullness, with respect to the TX and RX FIFOs.

```
/*********************************************************************
*
* Module: ADC End Of Scan Interrupt (ADC_EOS_INT)
*
* Description:
* This code reads a sample from the ADC after 8 samples have been read.
* It writes the sample to the AnalogRxBuffer.
* The mid voltage offset is subtracted by the ADC. When we arrive here,
* the ADC has already placed the 8 samples, read within 8.5 + 7*6 us.
```

```
* or 50.5 uS window. So we are working with signed numbers here.
* Note the new syntax available with CW 8.2 to make it easy to work
* with an array of samples. During this code execution, the ADC
* is waiting for a new trigger from SYNC from timer 3 OFLAG positive
* transition. 1/7200 is 138.8888888 us.  1/8000 is 125 us.
* To save overhead, the DAC is also directed in this ISR.
* The DAC step clock is locked to the ADC sample clock.
**********************************************************************/
// ADC is at F080 on the mc56f8037.
// Result registers begin at C and go to 13 hex on the mc56F802x3x.
volatile int The_ADC_Result1 : 0xF08C ;
volatile int The_ADC_Result2 : 0xF08D ;
volatile int The_ADC_Result3 : 0xF08E ;
volatile int The_ADC_Result4 : 0xF08F ;
volatile int The_ADC_Result5 : 0xF090 ; // this sample is chosen
volatile int The_ADC_Result6 : 0xF091 ;
volatile int The_ADC_Result7 : 0xF092 ;
volatile int The_ADC_Result8 : 0xF093 ;
#pragma interrupt alignsp saveall
void ADC_EOS_INT (void)
//////////////////////////////////ADC/////////////////
{
 PESL(ADC, ADC_CLEAR_STATUS_EOSI, NULL);  // Must clear regardless of FIFO or will reenter
again.
 if ((pAnalogRxWrite != NULL) && (pAnalogRxRead != NULL)) // check if FIFO OFF
 {
  *pAnalogRxWrite++ = (Word16)  periphMemRead( (Word16 *) 0xF090);
  // uncomment the assert if debugging is required only.
  // assert (pAnalogRxWrite != pAnalogRxRead); // if so, overrun DSP!! empty after write
  // reduce application cycles.
  if (pAnalogRxWrite >= &AnalogRxBuffer[RX_BUFFER_SIZE]) pAnalogRxWrite =
&AnalogRxBuffer[0];
 }
```

Note the DAC code. It sets up the DAC to run for four adjusts of the output at a 24400 per second rate.

```
//////////////////////////////////DAC/////////////////
 if ( (pAnalogTxRead != 0) && (pAnalogTxWrite != 0))  // reading from the FIFO is inhibited
by setting pointer zero.
 {
  This_Dac_Value = *pAnalogTxRead++  ;
  if (This_Dac_Value > Last_Dac_Value)
  {
   This_Delta_Value = ((This_Dac_Value - Last_Dac_Value) >> 2) & 0xfff0 ;
   PESL(DAC0, DAC_DOWN_COUNTING, DAC_DISABLE)
   PESL(DAC0, DAC_UP_COUNTING, DAC_ENABLE);
   Last_Dac_Value = Last_Dac_Value + (This_Delta_Value << 2) ;
  }
  else
  {
   This_Delta_Value = ((Last_Dac_Value - This_Dac_Value) >> 2) & 0xfff0 ;
   PESL(DAC0, DAC_UP_COUNTING, DAC_DISABLE);
   PESL(DAC0, DAC_DOWN_COUNTING, DAC_ENABLE);
   Last_Dac_Value = Last_Dac_Value - (This_Delta_Value << 2) ;
  }
  DAC_Analog_TX_SetStep  ( &This_Delta_Value );
  if(pAnalogTxRead >= &AnalogTxBuffer[TX_BUFFER_SIZE])
```

```
    {
     pAnalogTxRead = &AnalogTxBuffer[0];
    }
   }
   else // DAC data flush.. do not use queue.. just hold center
   {
    This_Dac_Value = 0x8000  ;
    if (This_Dac_Value > Last_Dac_Value)
    {
     This_Delta_Value = ((This_Dac_Value - Last_Dac_Value) >> 2) & 0xfff0 ;
     PESL(DAC0, DAC_DOWN_COUNTING, DAC_DISABLE)
     PESL(DAC0, DAC_UP_COUNTING, DAC_ENABLE);
     Last_Dac_Value = Last_Dac_Value + (This_Delta_Value << 2) ;
    }
    else
    {
     This_Delta_Value = ((Last_Dac_Value - This_Dac_Value) >> 2) & 0xfff0 ;
     PESL(DAC0, DAC_UP_COUNTING, DAC_DISABLE);
     PESL(DAC0, DAC_DOWN_COUNTING, DAC_ENABLE);
     Last_Dac_Value = Last_Dac_Value - (This_Delta_Value << 2) ;
    }
    DAC_Analog_TX_SetStep  ( &This_Delta_Value );
   }
  }
  #pragma interrupt reset
```

3.3 modem.h

There are four little state machines defined here, RING_STATE, AT_OFF_STATES, AT_ON_STATES, and ESCAPEMENT_STATES. The AT_OFF_STATES machine is active when the main program does not have a call established. The various commands that it supports are spelled out in the state names. AT_ON_STATES machine supports a more limited set of commands for use after escaping to the online command mode from the data state of the modem. The process of escaping from the online data state to the online command mode is achieved with the ESCAPEMENT_STATES machine, which enforces an idle period both before and after the “+++” escape sequence, before entering the online command mode.

There are also the scaling, offsetting, and rounding of the DAC defined here, as well as a way to make the output of the DTMF dialing differ in magnitude from that of the modem code.

```
void AT_offline(void) ;
void AT_online(void) ;

#define ANS_ON ((int) ring_count_up + 20) // 20 is 2 seconds try to answer during middle
of quite no ring period
typedef enum  {ring_idle, ring_rang, ring_count_up, ring_set_ans_flag=ANS_ON}
  RING_STATE ;

typedef enum  { AT_off_idle, AT_off_a, AT_off_at, AT_off_ata, AT_off_atd, AT_off_ati,
AT_off_atq, AT_off_atz,AT_off_plus }
   AT_OFF_STATES ;

typedef enum  { AT_on_idle, AT_on_a, AT_on_at, AT_on_ath, AT_on_ato, AT_on_atq,
AT_on_atz}
   AT_ON_STATES ;
```

```
typedef enum { Escape_idle_zero, Escape_pre_idle_1, Escape_p1, Escape_p2, Escape_p3,
Escape_post_idle}
   ESCAPEMENT_STATES;

//#define CALIBRATE
#define BLUE_DAC_SCALE_V22bis 0 // was 1. goodboy13 testing full excursion dac
#define BLUE_DAC_SCALE_DTMF 2
                    // 2 assumes modem uses all available bits in its signed output.
                    // If it comes short in this by n bits, then 2-n may be used.
                   // To calibrate this scale, check the value comming out the DAC used
1/4 to 3/4 range.
                    // This would be Vcc*1/4 to Vcc*3/4, or 400 to bff hex input to dac.
                    // This should be the absolute maximum output, not the average, but
the peak over time.
                // Otherwise peaks will result in nonlinear hits, probably on the local RX.
#define BLUE_DAC_OFFSET 0x4004  // includes rounding .. becomes 8008.
                        // The offset is added to the signed output to convert it to an
unsigned output.
                        // The final shift is to replace what used to be the sign bit
with the MSB
                        // because the DAC will take left justified data.
                        //
```

3.4 Events.c

A bean in Processor Expert has Properties, Methods, and Events. The Events.c file is generated by Processor Expert. Code is added as needed by the application author, in locations flagged for such additions by comments provided by Processor Expert.

```
/** ###################################################################
**     Filename  : Events.C
**     Project   : modem
**     Processor : 56F8367
**     Beantype  : Events
**     Version   : Driver 01.02
**     Compiler  : Metrowerks DSP C Compiler
**     Date/Time : 4/5/2005, 2:52 PM
**     Abstract  :
**         This is user's event module.
**         Put your event handler code here.
**     Settings  :
**     Contents  :
**         TwentythSecInt_OnInterrupt - void TwentythSecInt_OnInterrupt(void);
**         TestHarnessDCE_OnError             - void TestHarnessDCE_OnError(void);
**         TestHarnessDCE_OnRxChar            - void TestHarnessDCE_OnRxChar(void);
**         TestHarnessDCE_OnTxChar            - void TestHarnessDCE_OnTxChar(void);
**         TestHarnessDCE_OnFullRxBuf         - void TestHarnessDCE_OnFullRxBuf(void);
**         TestHarnessDCE_OnFreeTxBuf         - void TestHarnessDCE_OnFreeTxBuf(void);
**         AD1_OnEnd               - void AD1_OnEnd(void);
**
**     (c) Copyright UNIS, spol. s r.o. 1997-2004
**     UNIS, spol. s r.o.
**     Jundrovska 33
**     624 00 Brno
**     Czech Republic
**     http      : www.processorexpert.com
**     mail      : info@processorexpert.com
```

```
** ###################################################################*/
/* MODULE Events */

#include "Cpu.h"
#include "Events.h"
//#include "MEM1.h"
//#include "AD1.h"
//#include "Mdm1.h"
//#include "OutputTimer.h"
//#include "IV1.h"

/*Include shared modules, which are used for whole project*/
//#include "PE_Types.h"
//#include "PE_Error.h"
//#include "PE_Const.h"
//#include "IO_Map.h"

#include "modem.h"
#define ring_pulse_min 6 // minimum ring (filtered) pulses in 100MS to initiate ring
logic.. anti tinkle measure.. varies with hardware implementations, filtering of daa ring
signal

//#define ANS_ON ((int) ring_count_up + 20) // 20 is 2 seconds try to answer during middle
of quite no ring period
//enum RING_STATE {ring_idle, ring_rang, ring_count_up, ring_set_ans_flag=ANS_ON}
RING_STATE ring_state = ring_idle;
extern int      AnalogRxBuffer[];
extern volatile int     *pAnalogRxWrite;
extern volatile int     *pAnalogRxRead;
 int CountTime ;
extern int      AnalogTxBuffer[];
extern volatile int     *pAnalogTxWrite;
extern volatile int     *pAnalogTxRead;
extern volatile UWord16  is_time_to_shake;
//#define MODEM_DEBUG_RING // ring working without mod multiple family
#ifdef MODEM_DEBUG_RING
word ring_history[100] ;
word ring_index = 1 ;
#endif
TestHarnessDCE_TError the_errors ;
word error_cnt = 0;  // debug?
word ring_pulse_count = 0;
byte xresetC ;
/*
```

3.5 TwentythSecInt_OnInterrupt()

This twentieth-second timer is used for mundane timing of events relating to ring detect and the AT command set. It could be supplanted by tapping into another timer that is being used. However, for the sake of clarity, it uses its own bean and its own hardware timer.

This function does two useful things. It operates the ring-detect state machine, designed to trigger an answer exactly between the first ring and the second ring, and it counts up time in the CountTime variable for the AT command set, to reference passing time.

```
/*
** ===================================================================
**     Event       :  TwentythSecInt_OnInterrupt (module Events)
**
**     From bean   :  TwentythSecInt [TimerInt]
**     Description :
**         When a timer interrupt occurs this event is called (only
**         when the bean is enabled - "Enable" and the events are
**         enabled - "EnableEvent").
**     Parameters  : None
**     Returns     : Nothing
** ===================================================================
*/
//#pragma interrupt called /* Comment this line if the appropriate 'Interrupt preserve
registers' property */
                       /* is set to 'yes' (#pragma interrupt saveall is generated before
the ISR)      */

//#pragma interrupt called

word TimeToggle ; // convert 50MS to 100MS time base

void TwentythSecInt_OnInterrupt(void)
{
 TimeToggle = (word) (1 - TimeToggle);
 if (TimeToggle)
{
 CountTime++ ;
 RingDetect_GetCounterValue(&ring_pulse_count);
#ifdef MODEM_DEBUG_RING
 ring_history[ring_index++] = ring_pulse_count ;
 if (ring_index == 100) ring_index = 1;
#endif
 if (ring_state == ring_idle)
 {
  if (ring_pulse_count >= ring_pulse_min)
  {
  ring_state = ring_rang;
  }
 }
 else if (ring_state == ring_rang)
 {
  if (ring_pulse_count == 0)
  {
  ring_state = ring_count_up;
  }
 }
 else if (ring_state >= ring_count_up && ring_state < ring_set_ans_flag)
 {
  ring_state++;
 }
 else
 {
   ring_state = ring_idle;
//#define  DEBUG_NOP_RING_DETECT // use to diable ring det.
#ifndef  DEBUG_NOP_RING_DETECT
   is_time_to_shake = TRUE;  /* to be cleared by main program or subroutine of it */
```

```
#endif
 }
 RingDetect_ResetCounter();
 }
}
```

3.5.1 TestHarnessDCE_OnError()

Although they are not expected, errors on the test fixture interface are counted.

```
/*
** ===================================================================
**     Event       :  TestHarnessDCE_OnError (module Events)
**
**     From bean   :  AS1 [AsynchroSerial]
**     Description :
**         This event is called when a channel error (not the error
**         returned by a given method) occurs. The errors can be
**         read using <GetError> method.
**     Parameters  : None
**     Returns     : Nothing
** ===================================================================
*/
//#pragma interrupt called /* Comment this line if the appropriate 'Interrupt preserve
registers' property */
                        /* is set to 'yes' (#pragma interrupt saveall is generated before
the ISR)      */
void TestHarnessDCE_OnError(void)
{
 byte rc ;
 TestHarnessDCETError * ptr ;
 ptr  = &the_errors ;
 rc = TestHarnessDCEGetError(ptr) ;
 //asm(debughlt);
 error_cnt++ ;
}
```

3.5.2 TestHarnessDCE_OnRxChar()

No action is needed by the application program for each character received. Check the bean; it is configured to use buffers and interrupts, so it does all of that work for you.

```
/*
** ===================================================================
**     Event       :  TestHarnessDCE_OnRxChar (module Events)
**
**     From bean   :  AS1 [AsynchroSerial]
**     Description :
**         This event is called after a correct character is
**         received.
**         DMA mode:
**         If DMA controller is available on the selected CPU and
**         the receiver is configured to use DMA controller then
**         this event is disabled. Only OnFullRxBuf method can be
**         used in DMA mode.
```

```
**     Parameters  : None
**     Returns     : Nothing
** ===================================================================
*/
//#pragma interrupt called /* Comment this line if the appropriate 'Interrupt preserve
registers' property */
                        /* is set to 'yes' (#pragma interrupt saveall is generated before
the ISR)      */
void TestHarnessDCE_OnRxChar(void)
{
  /* Write your code here ... */
}

/*
```

3.5.3 TestHarnessDCE_OnTxChar()

Again, we are using interrupts here. See the bean.

```
** ===================================================================
**     Event       :  TestHarnessDCE_OnTxChar (module Events)
**
**     From bean   :  AS1 [AsynchroSerial]
**     Description :
**         This event is called after a character is transmitted.
**     Parameters  : None
**     Returns     : Nothing
** ===================================================================
*/
//#pragma interrupt called /* Comment this line if the appropriate 'Interrupt preserve
registers' property */
                        /* is set to 'yes' (#pragma interrupt saveall is generated before
the ISR)      */
void TestHarnessDCE_OnTxChar(void)
{
  /* Write your code here ... */
}
```

3.5.4 TestHarnessDCE_OnFullRxBuf()

We have flow control for the PC to modem direction. We trust the PC is faster in the other direction.

```
/*
** ===================================================================
**     Event       :  TestHarnessDCE_OnFullRxBuf (module Events)
**
**     From bean   :  AS1 [AsynchroSerial]
**     Description :
**         This event is called when the input buffer is full.
**     Parameters  : None
**     Returns     : Nothing
** ===================================================================
*/
//#pragma interrupt called /* Comment this line if the appropriate 'Interrupt preserve
registers' property */
                        /* is set to 'yes' (#pragma interrupt saveall is generated before
the ISR)      */
```

```
void TestHarnessDCE_OnFullRxBuf(void)
{
  //asm(debughlt);
}
```

3.5.5 TestHarnessDCE_OnFreeTxBuf*()

As in the previous section, this is left as a stub because the test harness only needs flow control in one direction. Should the user need bidirectional flow control, these two stubs may be fleshed out.

```
/*
** ===================================================================
**     Event       :  TestHarnessDCE_OnFreeTxBuf (module Events)
**
**     From bean   :  AS1 [AsynchroSerial]
**     Description :
**         This event is called after the last character in output
**         buffer is transmitted.
**     Parameters  : None
**     Returns     : Nothing
** ===================================================================
*/
//#pragma interrupt called /* Comment this line if the appropriate 'Interrupt preserve
registers' property */
                       /* is set to 'yes' (#pragma interrupt saveall is generated before
the ISR)      */
void TestHarnessDCE_OnFreeTxBuf(void)
{
  /* Write your code here ... */
}
```

3.6 v21_processA.c

The V.21 bean was designed to support synchronous mode only. The bean generates a file called v21_process.c. This file was replicated/modified for support of asynchronous character structure and renamed with the suffix A as v21_processA.c.

This new file contains functions v21TxProcessA(), v21RxProcessA(), and getDemodByteA(). The corresponding functions in v21_process.c are not utilized for async in this application: v21TxProcess(), v21RxProcess(), and getDemodByte().

These functions are part of the default application program interface provided by the bean's methods. In order to support an alternative character structure, this file is duplicated under a related name specialized for the desired character structure: v21_processA.c. Some of the functions in this file were modified to support asynchronous character format over the line. The format includes one start bit, set first, followed by eight data bits, sent least-significant bit first, and then one stop bit, sent last, for a total of ten bits per character. While this is more than the eight bits per character used by sync mode, it does not require sync characters, 0x7e, to be sent. A space bit is just a zero, a stop bit is just a one. Another term for the zero is space; another term for stop bit is mark. Any number of marks, or stop bits, may follow a character, unlike synchronous mode where there is no space between the 8-bit characters. Sync is used for FAX and V.8bis. Most simple applications use async.

For security applications, the character structure may be quite unusual. It may even include reversing the start and stop bits, and the order of the data bits. Such changes can be made by simply changing the programming in this file.

The following sections outline the changes made to support 8n1 async (one start, eight data, one stop).

3.6.1 v21TxProcessA()

In this case, the routine v21TxProcessA() is modified to initialize BitCounterTx for the larger character structure of ten bits. It is then checked so that the start bits and stop bits are sent out, as well as the original data bits sent out in the async format.

```
#ifdef __V21_H

/*********************************************************************
*
* (c) Freescale Semiconductor
* 2004 All Rights Reserved
*
*
*********************************************************************
*
* File Name: v21_process.c
*
* Description: Includes function V.21 Transmitter and Receiver.
*
* Modules Included: v21TxProcessA ()
*                   v21RxProcessA ()
*                   v21TxSamplesAmplifyA ()
*                   getDemodByteA ()
*
* Author: Prasad N. R.
*
* Date: 09 Aug 2001
*
*********************************************************************/

#include "v21.h"
#include "v21_api.h"
#include "arch.h"

/* Function prototypes */
void v21Mod (UWord16 mod_bit, Word16 *pSamples, v21_sHandle *pV21);
void v21Rxctrl (v21_sHandle *pV21);
void getDemodByteA (v21_sHandle *pV21);
Result v21TxProcessA (v21_sHandle *pV21, unsigned char *pBytes,UWord16 NumBytes);
Result v21RxProcessA (v21_sHandle *pV21, Word16 *pSamples, UWord16 NumSamples);
asm void v21TxSamplesAmplifyA (Word16 *pSamples, Word16 Gain);
/*********************************************************************
*
* Module: v21TxProcessA ()
*
* Description: Transmits data bytes using CPFSK modulation. Every
*              baud will have 24 samples.  Outputs start, 8 data, stop.
*
* Returns: V21_TX_BUSY - Indicates that Tx. is still transmitting data.
```

```
*          V21_TX_FREE - Indicates that Tx. has transmitted data.
*
* Arguments: pV21 - a pointer to v21_sHandle structure.
*            pBytes - a pointer to data bytes to be transmitted.
*            NumBytes - Number of data bytes to be transmitted,
*                       pointed to by pBytes.
*
* Range Issues: None
*
* Special Issues: 1. pBytes should not be destroyed
*                 2. if NumBytes is zero, just send mark without status change.
*
*
*********************************************************************/
Result v21TxProcessA (v21_sHandle *pV21, unsigned char *pBytes,
                      UWord16 NumBytes)
{
    bool SatBit = false; /* Variable to remember old saturation bit */
    UWord16 mod_bit;

    mod_bit = 1 ;           // mark or stop bit
   /* Reset the saturation mode bit */
    SatBit = archGetSetSaturationMode (SatBit);
  if( NumBytes != 0 )
  {
    /* Initialize byte counter */
    if ((pV21->CountStatusTx & V21_BYTE_COUNT_INIT_TX) == V21_BYTE_COUNT_INIT_TX)
    {
        pV21->ByteCounterTx = 0;
        pV21->CountStatusTx = (pV21->CountStatusTx) & V21_BYTE_COUNT_RESET_TX;
    }

    /* Initialize bit counter */
    if ((pV21->CountStatusTx & V21_NEW_BYTE_BIT_TX) == V21_NEW_BYTE_BIT_TX)
    {
       pV21->BitCounterTx = V21_NUM_BITS + 2;  // add one for the start bit, one for the
stop bit
        pV21->CountStatusTx = (pV21->CountStatusTx) & V21_NEW_BYTE_BIT_RESET_TX;
    }

    /* Get the bit to be modulated */
   if      ( pV21->BitCounterTx == (V21_NUM_BITS + 2))
   {
    mod_bit = 0 ; // start bit.. then lsb..
   }
   else if ( pV21->BitCounterTx == 1)
   {
    mod_bit = 1 ; // finally, stop bit.
   }
   else
   {
    mod_bit = (unsigned int)(pBytes[pV21->ByteCounterTx]) >> (V21_NUM_BITS + 1 -
pV21->BitCounterTx);
    mod_bit = mod_bit & V21_GET_BIT_MASK; /* Get LSB */
   }
  }
    /* Get the samples for the bit to be modulated */
```

```
    v21Mod (mod_bit, pV21->CpFskSamples, pV21);

    /* Amplify the signal to be transmitted unless during quite part of handshake*/
    v21TxSamplesAmplifyA (pV21->CpFskSamples, pV21->Gain);

    /* Give the samples to the user through Tx callback */
    (*(pV21->pTxCallback->pCallback)) (pV21->pTxCallback->pCallbackArg,
                                       pV21->CpFskSamples,
                                       V21_SAMPLES_PER_BAUD);

  if( NumBytes != 0 )
  {
    /* Decrement the bit counter */
    (pV21->BitCounterTx)--;
    if (pV21->BitCounterTx == 0)
    {
        /* Restore status value */
        pV21->CountStatusTx |= V21_NEW_BYTE_BIT_TX;

        /* Increment the byte counter */
        (pV21->ByteCounterTx)++;
        if (pV21->ByteCounterTx == NumBytes)
        {
            /* Restore status value */
            pV21->CountStatusTx |= V21_BYTE_COUNT_INIT_TX;
            archGetSetSaturationMode (SatBit);
            return (V21_TX_FREE);
        }
    }
  }
  archGetSetSaturationMode (SatBit);
  if (NumBytes !=0)
  {
   return (V21_TX_BUSY);
  }
  else
  {
   return (V21_TX_FREE) ;
  }
 }
```

3.6.2 v21RxProcessA()

The function v21RxProcessA() is modified from the original v21RxProcess(). It calls getDemodByteA() instead of getDemodByte(). That is the only change made to this function. The change is required to support the asynchronous mode of the V.21 modem.

```
/*******************************************************************
*
* Module: v21RxProcessA ()
*
* Description: Receives samples and demodulates to get back the
*              transmitted characters. The receiver works on a
*              baud of samples (24).
*
```

```
* Returns: V21_RX_CARRIER_LOST - Indicates loss of carrier.
*          V21_RX_PASS - Indicates that Rx. has passed.
*
* Arguments: pV21 - pointer to v21_sHandle structure.
*            pSamples - pointer to samples of received signal.
*            NumSamples - Number of received samples.
*
* Range Issues: None
*
* Special Issues:
*
*******************************************************************/

Result v21RxProcessA (v21_sHandle *pV21, Word16 *pSamples,
                      UWord16 NumSamples)
{
    Int16 NumBauds;
    UInt16 Clen, tempLen;
    Int16 i, j, k;
    bool SatBit = false; /* Variable to remember old saturation bit */

    /* Reset the saturation mode bit */
    SatBit = archGetSetSaturationMode (SatBit);

    Clen = (unsigned int)pV21->ContextLen; /* Copied here for frequent use */

    if ((Clen + NumSamples) >= V21_SAMPLES_PER_BAUD)
    {
        /* First complete the context buffer frame */
        tempLen = V21_SAMPLES_PER_BAUD - Clen;
        for (i = 0; i < tempLen; i++)
        {
            pV21->ContextBufRx[Clen+i] = pSamples[i];
        }

        pV21->p_samples_buf_ptr = pV21->ContextBufRx; /* Set up the pointer */
        v21Rxctrl (pV21); /* Demodulate */

        /* Register first-carrier-detection and first-zero-cross
         * detection */
        if ((pV21->syncFlag == 1) && (pV21->v21_flags.cdbit == 1) &&
            (pV21->first_zero_cross == 1))
        {
            pV21->syncFlag = 0; /* Reset sync flag for ever */
            pV21->StatusFlagRx = V21_CD_FLAF_PREV_RX + V21_FIRST_ZERO_CROSS_RX;
        }

        /* We say carrier is lost only when we have detected
         * the carrier before losing it ... */
        if ((pV21->v21_flags.cdbit == 0) &&
            ((pV21->StatusFlagRx & V21_CD_FLAF_PREV_RX) == V21_CD_FLAF_PREV_RX))
        {
            archGetSetSaturationMode (SatBit);
            return (V21_RX_CARRIER_LOST);
        }

        /* Process the demodulated bits */
```

```
            getDemodByteA (pV21);

            /* Next, process the remaining frames */
            k = (int)tempLen;
            tempLen = NumSamples - tempLen;
            NumBauds = (int)tempLen / V21_SAMPLES_PER_BAUD;
            tempLen = tempLen - NumBauds * V21_SAMPLES_PER_BAUD;

            for (i = 0; i < NumBauds; i++)
            {
                /* Process the full-length frames first */
                pV21->p_samples_buf_ptr = &pSamples[k+i*V21_SAMPLES_PER_BAUD];
                v21Rxctrl (pV21); /* Demodulate */

                /* Register first-carrier-detection and first-zero-cross
                 * detection */
                if ((pV21->syncFlag == 1) && (pV21->v21_flags.cdbit == 1) &&
                    (pV21->first_zero_cross == 1))
                {
                    pV21->syncFlag = 0; /* Reset sync flag for ever */
                    pV21->StatusFlagRx = V21_CD_FLAF_PREV_RX + V21_FIRST_ZERO_CROSS_RX;
                }


                /* We say carrier is lost only when we have detected
                 * the carrier before losing it ... */
                if ((pV21->v21_flags.cdbit == 0) &&
                   ((pV21->StatusFlagRx & V21_CD_FLAF_PREV_RX) == V21_CD_FLAF_PREV_RX))
                {
                    archGetSetSaturationMode (SatBit);
                    return (V21_RX_CARRIER_LOST);
                }

                /* Process the demodulated bits */
                getDemodByteA (pV21);
            }

            /* Store the remaining samples in context buffer */
            pV21->ContextLen = (short)tempLen; /* Update context len */
            tempLen = (unsigned int)k + i * V21_SAMPLES_PER_BAUD;
            i = 0;
            for (j = (int)tempLen; j < NumSamples; j++)
            {
                pV21->ContextBufRx[i++] = pSamples[j];
            }
            archGetSetSaturationMode (SatBit);
            return (V21_RX_PASS);

        }
        else
        {
            /* If there are no enough samples to process, save all
             * the samples into context buffer */
            for (j = 0; j < NumSamples; j++)
            {
                pV21->ContextBufRx[Clen+j] = pSamples[j];
            }
```

```
            pV21->ContextLen = (short)Clen + (short)NumSamples; /* Update context len */
            archGetSetSaturationMode (SatBit);
            return (V21_RX_PASS);
        }
    }
```

3.6.3 v21TxSamplesAmplifyA()

This function was not modified, but a renamed function was included for possible future modifications. The user-specified gain is important in this case, because the range of the analog signal is limited. It should be adjusted as high as possible, so that the range of the analog signal is completely used. If this is not done, quantization error will increase. Adjustment of the final output level to the –10 dBm range is done in the hardware. This preserves the most information in the signal. This function is only needed for V.21.

```
/*********************************************************************
*
* Module: v21TxSamplesAmplifyA ()
*
* Description: Multiplies the samples to be transmitted with the user
*              specified gain.
*
* Returns: None
*
* Arguments: pSamples - pointer to samples to be transmitted.
*            Gain - Gain value supplied by the user.
*
* Range Issues: None
*
* Special Issues: None
*
* Test Method: test_v21.mcp for testing
*
**************************** Change History *************************
*
*    DD/MM/YY   Code Ver       Description         Author
*    --------   --------       -----------         ------
*    09/08/2001   0.1          Created             Prasad N R
*    06/09/2001   1.0          Baselined           Prasad N R
*
*********************************************************************/

asm void v21TxSamplesAmplifyA (Word16 *pSamples, Word16 Gain)
{
    do        #V21_SAMPLES_PER_BAUD,_gain_loop
                                        /* for i = 0:23 */
                                        /* r2 -> samples' buffer */
                                        /* y0 = Gain */
    move.w    x:(r2),x0                 /* x0 = samples[i] */
    mpyr      x0,y0,a                   /* a = sample x gain */
    move.w    a,x:(r2)+                 /* Store the result in the
                                           same buffer. */
_gain_loop:                             /* endfor */
    rts

}
```

3.6.4 getDemodByteA()

This function was modified to support the 10-bit async structure by simply not looking for the sync character used for the synchronous mode. That sync character was 0x7e. After this was done, the user's application is called on every received bit that follows an initial space condition. It is then up to the user's callback function to assemble the bits into characters according to the "start, eight data, stop asynchronous" format.

Applications using the sync mode would be FAX and V.8bis.

```
/*********************************************************************
*
* Module: getDemodByteA ()
*
* Description: After demodulation, packing of demodulated bits into
*              bytes is done here.
*
* Returns: None
*
* Arguments: pV21 - pointer to v21_sHandle structure.
*
* Range Issues: None
*
* Special Issues:
*
* Test Method: test_v21.mcp for testing
*
***************************** Change History *************************
*
*    DD/MM/YY   Code Ver       Description         Author
*    --------   --------       -----------         ------
*    09/08/2001   0.1          Created             Prasad N R
*    06/09/2001   1.0          Baselined           Prasad N R
*    11/09/2001   1.1          Converted to
*                              multichannel        Prasad N R
*
*********************************************************************/

void getDemodByteA (v21_sHandle *pV21)
{
    Word16 tempBit = 0;

    if (pV21->v21_rx_decision_length == 2)
    {
        /* Get the first demodulated bit out of 2 bits */
        tempBit = (pV21->v21_rxdemod_bits & 0x0003) >> 1;

        /* Give the demodulated bit to the user through Rx callback */
        (*(pV21->pRxCallback->pCallback)) (pV21->pRxCallback->pCallbackArg,
                                           (char *) &(tempBit), 1);

        /* Recover the second bit. */
        /* First get the 2nd demodulated bit out of 2-bits */
        tempBit = pV21->v21_rxdemod_bits & 0x0001;

        /* Give the second demodulated bit to the user through Rx callback */
        (*(pV21->pRxCallback->pCallback)) (pV21->pRxCallback->pCallbackArg,
```

```
                                                (char *) &(tempBit), 1);
        }

        else if (pV21->v21_rx_decision_length == 1)
        {
            /* Extract the demodulated bit */
            tempBit = pV21->v21_rxdemod_bits & 0x0001;

            /* Give the demodulated bit to the user through Rx callback */
            (*(pV21->pRxCallback->pCallback)) (pV21->pRxCallback->pCallbackArg,
                                                (char *) &(tempBit), 1);
        }

        return;
    }
```

4 Conclusion - System Performance

The modem is fully capable of error-free operation over average telephone lines in the USA.

Modem testing indicates that the modem meets the performance standards required for V.22bis operation. File transfers were easily accomplished without incident.

4.1 Test Setup

4.1.1 Routine File Transfer Testing

For routine file transfer setup, the TAS series 2 was configured with the script as below. This depicts the average USA line:

```
/ad,s03=1,s07=1,c3/
/exch,bal=1/
/file:cseq=usa1/
/io,i-100,l-230,r-100,t-230/
/ad,i3/
/gd,w17,x00,y16,z00/
/rn,l320,s1/
/nl,q520,c500,m0,x1,y1/
/fs,f+1250,m0,s1/
/pj,l0364,f1200,w0,s1/
```

The Hayes modem was simply configured with factory defaults:

```
ATZ
For a faster connect, on the Hayes modem, you may use:
ATS37=6
AT\n1
```

```
AT%C0
```

```
This will limit line rate to 2400 Characters per second, turn off the compression and use buffer
mode.
```

4.1.2 Bit Error Rate Testing

The bit error rate test (BERT) run was at 2400 bits per second, V.22bis mode.

White noise was used for the impairment. The contribution of the line to the tests are their phase magnitude responses.

The Hayes equipment was on the A equipment side, the UUT on the B equipment side.

Because the V.22bis contains a built-in scrambler, modem BERT performance was measured as a function of the number of error characters that were received when no characters were being transmitted. A test frame of seven minutes or about one million bits was used for each test. One synchronous bit error results in two asynchronous character errors, because it is seen as a start bit. The idle line condition is marking, or one.

The AGC feature of the TAS series 2 was used to align signal levels in the digital portion of the TAS series 2.

The units used were a Hayes Accura V.92 modem and the UUT (unit under test), which was the MC56F8037EVM with the LCMDC.

The test was done as follows:

```
/ad,s03=1,s07=1,c3/
/file:cseq=usa1/
/io,i-100,l-230,r-100,t-230/
/ad,i3/
/gd,w17,x17,y16,z16/
```

Connect. The “gd” command calls for EIA B Standard Gain Characteristics and EIA 2 Standard Group Delay Characteristics on lines to both modems. Further details of these commands are available in the TAS Series 2 Telephone Network Emulator Operations Manual.

Do agc:

```
/io,a1/
/io,g1/
```

Hang up.

Connect again.

Count errors.

Add white noise.

Repeat with more and more noise until one bit error in seven minutes. This represents the SNR that the modem can be used with only one bit error in a million, on average.

4.2 Bit Error Rate Test Results

The line impairment was present in both lines, from the central office simulation and to the central office simulation. This resulted in twice the dynamic range requirement imposed by just using one line impairment for one of the legs of the call. The modem operated down to a 16dB SNR with error rate of one bit in a million using the above test configuration on the TAS Series 2.

With no noise, the soft modem operated well down to -51dBm.

The performance of this V.22bis modem in the presence of noise is indicated by the bit error rate test result; the result indicates it will function on the public switched telephone network, as expected.

4.3 Memory Utilization on the MC56F8037

4.3.1 Summary Memory Utilization

```
# Memory map:
  v_addr   p_addr   size     name
  0000F000 0000F000 00000000 .x_Peripherals
  00000000 00000000 00000004 .p_Interruptsboot
  00000000 00000000 00000080 .p_Interrupts
  00000080 00000080 00003246 .p_Code
  00000001 00000001 00000B1F .x_Data
  00000D00 00000D00 00000300 .x_DynMem
  000032C6 00000001 000007AF .p_flash_ROM_data
  00008000 00008000 00001000 .p_internal_RAM
```

4.3.2 Complete Load Map

```
# Link map of F_EntryPoint




# .interrupt_vectorsboot
#>00000000          F_vector_addr (linker command file)
  00000000 00000004 interrupt_vectorsboot.text F_vectboot(Vectors.c)

# .interrupt_vectors
  00000000 00000080 interrupt_vectors.text F_vect(Vectors.c)

# .ApplicationCode
```

```
#>00000080          F_Pcode_start_addr (linker command file)
  00000080 00000057 .text   F_EntryPoint(Cpu.c)
  000000D7 00000007 .text   FCpu_Interrupt(Cpu.c)
  000000DE 0000010B .text   FPE_low_level_init(Cpu.c)
  000001E9 00000473 .text   Fmain(modemblue.c)
  0000065C 000001A6 .text   FAT_offline(modemblue.c)
  00000802 00000108 .text   FAT_online(modemblue.c)
  0000090A 0000000B .text   FCPTDetCallback(modemblue.c)
  00000915 00000066 .text   FTXCallbackRoutine(modemblue.c)
  0000097B 0000003C .text   FRXCallbackRoutine(modemblue.c)
  000009B7 0000001D .text   FInitAnalogRxChannel(modemblue.c)
  000009D4 00000019 .text   FInitAnalogTxChannel(modemblue.c)
  000009ED 00000005 .text   FInitPoorMansCodec(modemblue.c)
  000009F2 00000035 .text   FReadAnalogRxData(modemblue.c)
  00000A27 0000003B .text   FWriteAnalogTxData(modemblue.c)
  00000A62 000000BF .text   FADC_EOS_INT(modemblue.c)
  00000B21 00000003 .text   FMisalignedLongWordISR(modemblue.c)
  00000B24 0000000F .text   FRingDetect_Enable(RingDetect.c)
  00000B33 0000000D .text   FRingDetect_Disable(RingDetect.c)
  00000B40 00000006 .text   FRingDetect_ResetCounter(RingDetect.c)
  00000B46 0000000A .text   FRingDetect_GetCounterValue(RingDetect.c)
  00000B50 0000001A .text   FRingDetect_Init(RingDetect.c)
  00000B6A 00000044 .text   FBitIO__PutVal(OffHook.c)
  00000BAE 0000005F .text   FTEL1_CPTDetCreate(TEL1.c)
  00000C0D 00000014 .text   FTEL1_CPTDetInit(TEL1.c)
  00000C21 0000000F .text   FTEL1_CPTDetection(TEL1.c)
  00000C30 0000002E .text   FTEL1_CPTDetDestroy(TEL1.c)
  00000C5E 00000020 .text   FMEM1_Init(MEM1.c)
  00000C7E 00000014 .text   FmemMallocEM(mem.c)
  00000C92 0000001C .text   FmemMallocAlignedEM(mem.c)
  00000CAE 00000014 .text   FmemFreeEM(mem.c)
  00000CC2 0000001B .text   FmemIsAligned(mem.c)
  00000CDD 0000000B .text   FmemProtect(mem.c)
  00000CE8 0000005E .text   FMergeFree(mem.c)
  00000D46 00000064 .text   FSplitBlock(mem.c)
  00000DAA 00000055 .text   FSplitBlockRev(mem.c)
  00000DFF 0000005E .text   FmemInitializePool(mem.c)
  00000E5D 000000D3 .text   FmemExtendPool(mem.c)
  00000F30 00000038 .text   FmemFree(mem.c)
  00000F68 000000AF .text   FmemMalloc(mem.c)
```

```
00001017 000000DE .text   FmemMallocAligned(mem.c)
000010F5 0000009A .text   FInitialize(mem.c)
0000118F 0000000C .text   FmemInitialize(mem.c)
0000119B 00000002 .text   FmemIsIM(memtarget.c)
0000119D 00000002 .text   FmemIsEM(memtarget.c)
0000119F 0000003E .text   FTwentythSecInt_OnInterrupt(Events.c)
000011DD 0000000F .text   FTestHarnessDCE_OnError(Events.c)
000011EC 00000001 .text   FTestHarnessDCE_OnRxChar(Events.c)
000011ED 00000001 .text   FTestHarnessDCE_OnTxChar(Events.c)
000011EE 00000001 .text   FTestHarnessDCE_OnFullRxBuf(Events.c)
000011EF 00000001 .text   FTestHarnessDCE_OnFreeTxBuf(Events.c)
000011F0 0000002C .text   FSetCV(TwentythSecInt.c)
0000121C 00000018 .text   FSetPV(TwentythSecInt.c)
00001234 00000032 .text   FHWEnDi(TwentythSecInt.c)
00001266 00000030 .text   FTwentythSecInt_Init(TwentythSecInt.c)
00001296 00000011 .text   FTwentythSecInt_Interrupt(TwentythSecInt.c)
000012A7 00000015 .text   Fv22bisCreate(v22bisapi.c)
000012BC 0000002C .text   Fv22bisInit(v22bisapi.c)
000012E8 00000012 .text   Fv22bisTXDataInit(v22bisapi.c)
000012FA 000000A0 .text   Fv22bisTX(v22bisapi.c)
0000139A 00000014 .text   Fv22bisTransmit(v22bisapi.c)
000013AE 0000008C .text   Fv22bisRX(v22bisapi.c)
0000143A 0000000D .text   Fv22bisDestroy(v22bisapi.c)
00001447 0000007F .text   FTransmitV14(v22bisapi.c)
000014C6 000000B8 .text   FReceiveV14(v22bisapi.c)
0000157E 00000009 .text   FWDog1_Disable(WDog1.c)
00001587 0000000E .text   FWDog1_Init(WDog1.c)
00001595 0000001F .text   FDAC_Analog_TX_Init(DAC_Analog_TX.c)
000015B4 0000000B .text   FDAC_Analog_TX_SetStep(DAC_Analog_TX.c)
000015BF 000000A1 .text   FADC_Analog_RX_Init(ADC_Analog_RX.c)
00001660 00000038 .text   FDAC_Step_Clock_Init(DAC_Step_Clock.c)
00001698 00000038 .text   FSampleRateTimer_Init(SampleRateTimer.c)
000016D0 0000000A .text   FHWEnDi(TestHarnessDCE.c)
000016DA 0000004D .text   FTestHarnessDCE_RecvChar(TestHarnessDCE.c)
00001727 00000046 .text   FTestHarnessDCE_SendChar(TestHarnessDCE.c)
0000176D 00000022 .text   FTestHarnessDCE_RecvBlock(TestHarnessDCE.c)
0000178F 00000024 .text   FTestHarnessDCE_SendBlock(TestHarnessDCE.c)
000017B3 00000003 .text   FTestHarnessDCE_GetCharsInRxBuf(TestHarnessDCE.c)
000017B6 00000086 .text   FTestHarnessDCE_GetError(TestHarnessDCE.c)
0000183C 00000057 .text   FTestHarnessDCE_InterruptRx(TestHarnessDCE.c)
```

```
00001893 00000053 .text   FTestHarnessDCE_InterruptTx(TestHarnessDCE.c)
000018E6 00000039 .text   FTestHarnessDCE_InterruptError(TestHarnessDCE.c)
0000191F 0000001F .text   FTestHarnessDCE_Init(TestHarnessDCE.c)
0000193E 00000049 rtlib.text F@DummyFn1(process_cpt.asm)
0000193E 00000000 rtlib.text FPROCESS_CPT(process_cpt.asm)
0000193E 00000049 rtlib.text rtlib.text(process_cpt.asm)
00001987 0000018C rtlib.text F@DummyFn1(cpsi_api.asm)
00001987 00000000 rtlib.text SILENCE_DETECT_CPT(cpsi_api.asm)
00001987 0000018C rtlib.text rtlib.text(cpsi_api.asm)
0000198A 00000000 rtlib.text SILENCE_DEBOUNCE(cpsi_api.asm)
000019BE 00000000 rtlib.text FCALLPROGRESS_DETECT_INIT(cpsi_api.asm)
000019EE 00000000 rtlib.text CALLPROGRESS_DETECT(cpsi_api.asm)
000019FA 00000000 rtlib.text CALLPROGRESS_DEBOUNCE(cpsi_api.asm)
00001A03 00000000 rtlib.text no_cpt(cpsi_api.asm)
00001A0F 00000000 rtlib.text cpt_on(cpsi_api.asm)
00001A1D 00000000 rtlib.text noisy_cpt(cpsi_api.asm)
00001A28 00000000 rtlib.text end_cpt(cpsi_api.asm)
00001A36 00000000 rtlib.text cpt_silence(cpsi_api.asm)
00001A43 00000000 rtlib.text noisy_sil(cpsi_api.asm)
00001A4F 00000000 rtlib.text new_cpt(cpsi_api.asm)
00001A58 00000000 rtlib.text check_previous_cpt(cpsi_api.asm)
00001A64 00000000 rtlib.text check_cpt_off(cpsi_api.asm)
00001A71 00000000 rtlib.text reset_cpsi(cpsi_api.asm)
00001A78 00000000 rtlib.text exit_cpt_debounce(cpsi_api.asm)
00001A81 00000000 rtlib.text CALLPROGRESS_DECODE(cpsi_api.asm)
00001AA0 00000000 rtlib.text clear_bursts(cpsi_api.asm)
00001AA5 00000000 rtlib.text check_group2(cpsi_api.asm)
00001AD2 00000000 rtlib.text check_group3(cpsi_api.asm)
00001AE6 00000000 rtlib.text last_on(cpsi_api.asm)
00001AFE 00000000 rtlib.text end_cpt_on(cpsi_api.asm)
00001B06 00000000 rtlib.text not_cpt(cpsi_api.asm)
00001B0D 00000000 rtlib.text exit_decode(cpsi_api.asm)
00001B13 00000044 rtlib.text F@DummyFn1(cpsi_low.asm)
00001B13 00000044 rtlib.text rtlib.text(cpsi_low.asm)
00001B13 00000000 rtlib.text SIL_DEC_CPT(cpsi_low.asm)
00001B28 00000000 rtlib.text assign1_cpt(cpsi_low.asm)
00001B57 0000003D rtlib.text F@DummyFn1(cpt_api.asm)
00001B57 00000000 rtlib.text PAPI_TONE_DETECT(cpt_api.asm)
00001B57 0000003D rtlib.text rtlib.text(cpt_api.asm)
00001B94 00000042 rtlib.text rtlib.text(cpt_buf.asm)
```

```
00001B94 00000000 rtlib.text GENERATE_ANALYSIS_ARRAY_CPT(cpt_buf.asm)
00001B94 00000042 rtlib.text F@DummyFn1(cpt_buf.asm)
00001BC3 00000000 rtlib.text CALC_SIG_EN_CPT(cpt_buf.asm)
00001BD6 0000018A rtlib.text rtlib.text(cpt_low.asm)
00001BD6 0000018A rtlib.text F@DummyFn1(cpt_low.asm)
00001BD6 00000000 rtlib.text MG_EN(cpt_low.asm)
00001BE7 00000000 rtlib.text end_mg_cpt(cpt_low.asm)
00001BE9 00000000 rtlib.text NEWNUM_CPT(cpt_low.asm)
00001C01 00000000 rtlib.text TST_CPT(cpt_low.asm)
00001C1D 00000000 rtlib.text UPDCPT(cpt_low.asm)
00001C1F 00000000 rtlib.text l1(cpt_low.asm)
00001C35 00000000 rtlib.text FIND_PK_CPT(cpt_low.asm)
00001C35 00000000 rtlib.text End_upd_subroutine(cpt_low.asm)
00001C51 00000000 rtlib.text LOAD_THRESH_CPT(cpt_low.asm)
00001CBF 00000000 rtlib.text MAG_CPT(cpt_low.asm)
00001CD4 00000000 rtlib.text GROUP_TST_CPT(cpt_low.asm)
00001CF2 00000000 rtlib.text TWIST_CPT(cpt_low.asm)
00001CF2 00000000 rtlib.text REL_EN_CPT(cpt_low.asm)
00001D0B 00000000 rtlib.text REL_MAG_CPT(cpt_low.asm)
00001D53 00000000 rtlib.text FIND_REL_MAG(cpt_low.asm)
00001D60 0000000A rtlib.text F@DummyFn1(memcpy.asm)
00001D60 00000000 rtlib.text FmemMemcpy(memcpy.asm)
00001D60 0000000A rtlib.text rtlib.text(memcpy.asm)
00001D6A 00000020 rtlib.text F@DummyFn1(memset.asm)
00001D6A 00000000 rtlib.text FmemMemset(memset.asm)
00001D6A 00000020 rtlib.text rtlib.text(memset.asm)
00001D8A 00000011 rtlib.text F@DummyFn1(archgetsetsaturationmode.asm)
00001D8A 00000000 rtlib.text FarchGetSetSaturationMode(archgetsetsaturationmode.asm)
00001D8A 00000011 rtlib.text rtlib.text(archgetsetsaturationmode.asm)
00001D9B 00000000 rtlib.text FstackcheckInitialize(stackchck.asm)
00001D9B 0000002D rtlib.text rtlib.text(stackchck.asm)
00001D9B 0000002D rtlib.text F@DummyFn1(stackchck.asm)
00001DAE 00000000 rtlib.text FstackcheckSizeUsed(stackchck.asm)
00001DC0 00000000 rtlib.text FstackcheckSizeAllocated(stackchck.asm)
00001DC8 0000000F rtlib.text F@DummyFn1(v22bis_tx_b_end.asm)
00001DC8 00000000 rtlib.text end_tx(v22bis_tx_b_end.asm)
00001DC8 0000000F rtlib.text rtlib.text(v22bis_tx_b_end.asm)
00001DD7 000000A5 rtlib.text rtlib.text(v22bis_tx_ctrl.asm)
00001DD7 000000A5 rtlib.text F@DummyFn1(v22bis_tx_ctrl.asm)
00001DD7 00000000 rtlib.text TXBAUD(v22bis_tx_ctrl.asm)
```

```
00001DDE 00000000 rtlib.text Chk_St_Chg(v22bis_tx_ctrl.asm)
00001E07 00000000 rtlib.text next_task(v22bis_tx_ctrl.asm)
00001E0D 00000000 rtlib.text RETRAIN(v22bis_tx_ctrl.asm)
00001E76 00000000 rtlib.text perf_sti_tx(v22bis_tx_ctrl.asm)
00001E7C 00000038 rtlib.text F@DummyFn1(v22bis_tx_enc.asm)
00001E7C 00000038 rtlib.text rtlib.text(v22bis_tx_enc.asm)
00001E7C 00000000 rtlib.text tx_sbit(v22bis_tx_enc.asm)
00001E82 00000000 rtlib.text tx_enc_1(v22bis_tx_enc.asm)
00001E8B 00000000 rtlib.text tx_enc_2(v22bis_tx_enc.asm)
00001E91 00000000 rtlib.text tx_enc_4(v22bis_tx_enc.asm)
00001EB4 00000000 rtlib.text tx_sil(v22bis_tx_feed.asm)
00001EB4 00000078 rtlib.text F@DummyFn1(v22bis_tx_feed.asm)
00001EB4 00000078 rtlib.text rtlib.text(v22bis_tx_feed.asm)
00001EBB 00000000 rtlib.text tx_a_ton(v22bis_tx_feed.asm)
00001ED4 00000000 rtlib.text tx_wr4(v22bis_tx_feed.asm)
00001EE1 00000000 rtlib.text tx_one_2(v22bis_tx_feed.asm)
00001EE6 00000000 rtlib.text tx_s1(v22bis_tx_feed.asm)
00001EF0 00000000 rtlib.text tx_decide(v22bis_tx_feed.asm)
00001EFE 00000000 rtlib.text tx_109(v22bis_tx_feed.asm)
00001F0A 00000000 rtlib.text tx_112(v22bis_tx_feed.asm)
00001F1D 00000000 rtlib.text tx_one_4(v22bis_tx_feed.asm)
00001F22 00000000 rtlib.text dummy(v22bis_tx_feed.asm)
00001F24 00000000 rtlib.text tx_in_2(v22bis_tx_feed.asm)
00001F26 00000000 rtlib.text tx_in_4(v22bis_tx_feed.asm)
00001F28 00000000 rtlib.text ERROR(v22bis_tx_feed.asm)
00001F2C 00000033 rtlib.text F@DummyFn1(v22bis_tx_fm.asm)
00001F2C 00000000 rtlib.text tx_fm(v22bis_tx_fm.asm)
00001F2C 00000033 rtlib.text rtlib.text(v22bis_tx_fm.asm)
00001F5F 00000039 rtlib.text F@DummyFn1(v22bis_tx_scr.asm)
00001F5F 00000039 rtlib.text rtlib.text(v22bis_tx_scr.asm)
00001F5F 00000000 rtlib.text tx_scr_1(v22bis_tx_scr.asm)
00001F63 00000000 rtlib.text tx_scr_2(v22bis_tx_scr.asm)
00001F67 00000000 rtlib.text tx_scr_4(v22bis_tx_scr.asm)
00001F6A 00000000 rtlib.text tx_scr(v22bis_tx_scr.asm)
00001F98 000000DF rtlib.text rtlib.text(v22bis_tx_state.asm)
00001F98 000000DF rtlib.text F@DummyFn1(v22bis_tx_state.asm)
00001F98 00000000 rtlib.text tx_I1(v22bis_tx_state.asm)
00001FA0 00000000 rtlib.text tx_I2(v22bis_tx_state.asm)
00001FB6 00000000 rtlib.text tx_I3(v22bis_tx_state.asm)
00001FC3 00000000 rtlib.text tx_I4(v22bis_tx_state.asm)
```

```
00001FE1 00000000 rtlib.text tx_I5(v22bis_tx_state.asm)
00002010 00000000 rtlib.text tx_I6_1(v22bis_tx_state.asm)
00002032 00000000 rtlib.text tx_I6_2(v22bis_tx_state.asm)
00002045 00000000 rtlib.text tx_I7_2(v22bis_tx_state.asm)
0000205B 00000000 rtlib.text tx_I8_2(v22bis_tx_state.asm)
00002077 000000E6 rtlib.text F@DummyFn1(v22bis_txmdmini.asm)
00002077 00000000 rtlib.text TX_MDM_INIT(v22bis_txmdmini.asm)
00002077 000000E6 rtlib.text rtlib.text(v22bis_txmdmini.asm)
0000215D 00000068 rtlib.text rtlib.text(v22bis.asm)
0000215D 00000000 rtlib.text V22BIS_INIT(v22bis.asm)
0000215D 00000068 rtlib.text F@DummyFn1(v22bis.asm)
000021BF 00000000 rtlib.text V22BIS_TX(v22bis.asm)
000021BF 00000000 rtlib.text V22BIS_TX_DLB(v22bis.asm)
000021BF 00000000 rtlib.text V22BIS_TX_ALB(v22bis.asm)
000021C2 00000000 rtlib.text V22BIS_RX_DLB(v22bis.asm)
000021C2 00000000 rtlib.text V22BIS_RX_ALB(v22bis.asm)
000021C2 00000000 rtlib.text V22BIS_RX(v22bis.asm)
000021C5 000001E9 rtlib.text rtlib.text(v22bis_initsr.asm)
000021C5 00000000 rtlib.text INIT_SP_COMMON(v22bis_initsr.asm)
000021C5 000001E9 rtlib.text F@DummyFn1(v22bis_initsr.asm)
00002243 00000000 rtlib.text CLR_RAM2(v22bis_initsr.asm)
00002266 00000000 rtlib.text INIT_BEG_AGC(v22bis_initsr.asm)
0000227C 00000000 rtlib.text INIT_BEG(v22bis_initsr.asm)
000022ED 00000000 rtlib.text CLEQ_INIT(v22bis_initsr.asm)
0000237D 00000000 rtlib.text AGC_JAM(v22bis_initsr.asm)
000023AE 000000B7 rtlib.text F@DummyFn1(v22bis_rx_baud.asm)
000023AE 00000000 rtlib.text RXBAUD(v22bis_rx_baud.asm)
000023AE 000000B7 rtlib.text rtlib.text(v22bis_rx_baud.asm)
00002465 000002DA rtlib.text rtlib.text(v22bis_rx_bchk.asm)
00002465 00000000 rtlib.text RX_wait(v22bis_rx_bchk.asm)
00002465 000002DA rtlib.text F@DummyFn1(v22bis_rx_bchk.asm)
00002471 00000000 rtlib.text RX_cd(v22bis_rx_bchk.asm)
00002481 00000000 rtlib.text RX_atusb1(v22bis_rx_bchk.asm)
0000248A 00000000 rtlib.text RX_usb1(v22bis_rx_bchk.asm)
000024B1 00000000 rtlib.text RX_endusb1(v22bis_rx_bchk.asm)
000024BE 00000000 rtlib.text RX_s1call(v22bis_rx_bchk.asm)
000024F2 00000000 rtlib.text RX_cdrop(v22bis_rx_bchk.asm)
0000250F 00000000 rtlib.text RX_signal(v22bis_rx_bchk.asm)
0000252B 00000000 rtlib.text RX_carrierup(v22bis_rx_bchk.asm)
0000253E 00000000 rtlib.text RX_s1ans(v22bis_rx_bchk.asm)
```

```
00002577 00000000 rtlib.text RX_scr12(v22bis_rx_bchk.asm)
000025CD 00000000 rtlib.text RX_v22dm(v22bis_rx_bchk.asm)
000025F1 00000000 rtlib.text RX_s1end(v22bis_rx_bchk.asm)
000025FD 00000000 rtlib.text RX_wait32bit(v22bis_rx_bchk.asm)
00002619 00000000 rtlib.text RX_waitdm(v22bis_rx_bchk.asm)
00002622 00000000 rtlib.text RX_wait1sec(v22bis_rx_bchk.asm)
00002632 00000000 rtlib.text RX_v22bisdm(v22bis_rx_bchk.asm)
0000266F 00000000 rtlib.text RX_retrain(v22bis_rx_bchk.asm)
00002693 00000000 rtlib.text RX_RETR_REP(v22bis_rx_bchk.asm)
0000269E 00000000 rtlib.text RX_RETR_A(v22bis_rx_bchk.asm)
000026B8 00000000 rtlib.text RX_NEXT(v22bis_rx_bchk.asm)
000026BA 00000000 rtlib.text ENDRX(v22bis_rx_bchk.asm)
000026BB 00000000 rtlib.text error(v22bis_rx_bchk.asm)
000026DC 00000000 rtlib.text RXDM_CD(v22bis_rx_bchk.asm)
000026EA 00000000 rtlib.text RXDMCDON(v22bis_rx_bchk.asm)
0000271A 00000000 rtlib.text RXDMCDOFF(v22bis_rx_bchk.asm)
00002721 00000000 rtlib.text RXDM_OFF(v22bis_rx_bchk.asm)
00002733 00000000 rtlib.text CDONOF(v22bis_rx_bchk.asm)
0000273F 0000004A rtlib.text F@DummyFn1(v22bis_rx_bpf.asm)
0000273F 00000000 rtlib.text RXBPF(v22bis_rx_bpf.asm)
0000273F 0000004A rtlib.text rtlib.text(v22bis_rx_bpf.asm)
00002789 00000021 rtlib.text F@DummyFn1(v22bis_rx_car.asm)
00002789 00000000 rtlib.text RXCAR(v22bis_rx_car.asm)
00002789 00000021 rtlib.text rtlib.text(v22bis_rx_car.asm)
000027AA 000000B9 rtlib.text F@DummyFn1(v22bis_rx_cdagc.asm)
000027AA 00000000 rtlib.text RXCDAGC(v22bis_rx_cdagc.asm)
000027AA 000000B9 rtlib.text rtlib.text(v22bis_rx_cdagc.asm)
00002863 00000019 rtlib.text rtlib.text(v22bis_rx_ctrl.asm)
00002863 00000000 rtlib.text RXBAUDPROC(v22bis_rx_ctrl.asm)
00002863 00000019 rtlib.text F@DummyFn1(v22bis_rx_ctrl.asm)
0000286B 00000000 rtlib.text rx_no_sti(v22bis_rx_ctrl.asm)
00002870 00000000 rtlib.text rx_next_task(v22bis_rx_ctrl.asm)
0000287C 0000002F rtlib.text F@DummyFn1(v22bis_rx_decim.asm)
0000287C 00000000 rtlib.text RXDECIM(v22bis_rx_decim.asm)
0000287C 0000002F rtlib.text rtlib.text(v22bis_rx_decim.asm)
000028AB 00000049 rtlib.text F@DummyFn1(v22bis_rx_demod.asm)
000028AB 00000000 rtlib.text RXDEMOD(v22bis_rx_demod.asm)
000028AB 00000049 rtlib.text rtlib.text(v22bis_rx_demod.asm)
000028F4 0000007E rtlib.text rtlib.text(v22bis_rx_difdc.asm)
000028F4 00000000 rtlib.text RXDEC4(v22bis_rx_difdc.asm)
```

```
000028F4 0000007E rtlib.text F@DummyFn1(v22bis_rx_difdc.asm)
00002905 00000000 rtlib.text DECA(v22bis_rx_difdc.asm)
0000290F 00000000 rtlib.text DECB(v22bis_rx_difdc.asm)
00002924 00000000 rtlib.text RXDEC16(v22bis_rx_difdc.asm)
0000294D 00000000 rtlib.text RXDIFDEC(v22bis_rx_difdc.asm)
00002972 00000000 rtlib.text RXDESCR2(v22bis_rx_dscr.asm)
00002972 0000004B rtlib.text rtlib.text(v22bis_rx_dscr.asm)
00002972 0000004B rtlib.text F@DummyFn1(v22bis_rx_dscr.asm)
00002976 00000000 rtlib.text RXDESCR4(v22bis_rx_dscr.asm)
0000297A 00000000 rtlib.text RXDESCR16(v22bis_rx_dscr.asm)
0000297D 00000000 rtlib.text rx_dscr(v22bis_rx_dscr.asm)
000029B7 00000000 rtlib.text dscr_upd(v22bis_rx_dscr.asm)
000029BD 0000007E rtlib.text F@DummyFn1(v22bis_rx_eqerr.asm)
000029BD 00000000 rtlib.text RXEQERR(v22bis_rx_eqerr.asm)
000029BD 0000007E rtlib.text rtlib.text(v22bis_rx_eqerr.asm)
00002A3B 00000058 rtlib.text F@DummyFn1(v22bis_rx_eqfil.asm)
00002A3B 00000000 rtlib.text RXEQFIL(v22bis_rx_eqfil.asm)
00002A3B 00000058 rtlib.text rtlib.text(v22bis_rx_eqfil.asm)
00002A93 0000002B rtlib.text F@DummyFn1(v22bis_rx_equpd.asm)
00002A93 00000000 rtlib.text RXEQUD(v22bis_rx_equpd.asm)
00002A93 0000002B rtlib.text rtlib.text(v22bis_rx_equpd.asm)
00002ABE 0000001A rtlib.text F@DummyFn1(v22bis_rx_int.asm)
00002ABE 00000000 rtlib.text RXINTP(v22bis_rx_int.asm)
00002ABE 0000001A rtlib.text rtlib.text(v22bis_rx_int.asm)
00002AD8 000002F2 rtlib.text rtlib.text(v22bis_rx_stat.asm)
00002AD8 00000000 rtlib.text rx_CA(v22bis_rx_stat.asm)
00002AD8 000002F2 rtlib.text F@DummyFn1(v22bis_rx_stat.asm)
00002AE9 00000000 rtlib.text rx_CB(v22bis_rx_stat.asm)
00002AF4 00000000 rtlib.text rx_CC(v22bis_rx_stat.asm)
00002B14 00000000 rtlib.text rx_CD(v22bis_rx_stat.asm)
00002B1C 00000000 rtlib.text rx_CE(v22bis_rx_stat.asm)
00002B3A 00000000 rtlib.text rx_CF(v22bis_rx_stat.asm)
00002B4F 00000000 rtlib.text rx_AA(v22bis_rx_stat.asm)
00002B5A 00000000 rtlib.text rx_AB(v22bis_rx_stat.asm)
00002B65 00000000 rtlib.text rx_AC(v22bis_rx_stat.asm)
00002B7C 00000000 rtlib.text rx_AC1(v22bis_rx_stat.asm)
00002B92 00000000 rtlib.text rx_AD(v22bis_rx_stat.asm)
00002BB0 00000000 rtlib.text rx_G22A(v22bis_rx_stat.asm)
00002BCA 00000000 rtlib.text rx_G22B(v22bis_rx_stat.asm)
00002BEC 00000000 rtlib.text rx_G22C(v22bis_rx_stat.asm)
```

```
00002C27 00000000 rtlib.text rx_G22D(v22bis_rx_stat.asm)
00002C76 00000000 rtlib.text rx_GBisA(v22bis_rx_stat.asm)
00002C96 00000000 rtlib.text rx_GBisB(v22bis_rx_stat.asm)
00002CA1 00000000 rtlib.text rx_GBisC(v22bis_rx_stat.asm)
00002CE8 00000000 rtlib.text rx_GBisD(v22bis_rx_stat.asm)
00002D17 00000000 rtlib.text rx_GBisE(v22bis_rx_stat.asm)
00002D33 00000000 rtlib.text rx_GBisF(v22bis_rx_stat.asm)
00002D7D 00000000 rtlib.text rx_GBisG(v22bis_rx_stat.asm)
00002D9B 00000000 rtlib.text rx_GRetA(v22bis_rx_stat.asm)
00002DCA 000000F8 rtlib.text F@DummyFn1(v22bis_rx_ton.asm)
00002DCA 00000000 rtlib.text RXUSB1(v22bis_rx_ton.asm)
00002DCA 000000F8 rtlib.text rtlib.text(v22bis_rx_ton.asm)
00002E07 00000000 rtlib.text RXS1(v22bis_rx_ton.asm)
00002EA1 00000000 rtlib.text RXTON(v22bis_rx_ton.asm)
00002EC2 00000091 rtlib.text F@DummyFn1(v22bis_rxmdmini.asm)
00002EC2 00000000 rtlib.text RX_MDM_INIT(v22bis_rxmdmini.asm)
00002EC2 00000091 rtlib.text rtlib.text(v22bis_rxmdmini.asm)
00002F53 0000001E rtlib.text F@DummyFn1(v22bis_tondet.asm)
00002F53 00000000 rtlib.text TONEDETECT(v22bis_tondet.asm)
00002F53 0000001E rtlib.text rtlib.text(v22bis_tondet.asm)
00002F71 0000000F rtlib.text F@DummyFn1(v22bis_rxstub.asm)
00002F71 00000000 rtlib.text rx_stub(v22bis_rxstub.asm)
00002F71 0000000F rtlib.text rtlib.text(v22bis_rxstub.asm)
00002F80 00000026 rtlib.text F@DummyFn1(v22bis_txstub.asm)
00002F80 00000000 rtlib.text tx_stub(v22bis_txstub.asm)
00002F80 00000026 rtlib.text rtlib.text(v22bis_txstub.asm)
00002FA6 000000CD rtlib.text F@DummyFn1(v22bisapi.asm)
00002FA6 00000000 rtlib.text FINITIALIZE_V22BIS(v22bisapi.asm)
00002FA6 000000CD rtlib.text rtlib.text(v22bisapi.asm)
00002FDB 00000000 rtlib.text FV22BIS_TRANSMIT(v22bisapi.asm)
00002FFC 00000000 rtlib.text FV22BIS_RECEIVE_SAMPLE(v22bisapi.asm)
00003073 00000094 rtlib.text F@DummyFn1(v22_v42d.asm)
00003073 00000000 rtlib.text V42DRV_INIT(v22_v42d.asm)
00003073 00000094 rtlib.text rtlib.text(v22_v42d.asm)
00003086 00000000 rtlib.text FV42_V22DRV_INIT(v22_v42d.asm)
0000308C 00000000 rtlib.text V22_V42DRV(v22_v42d.asm)
000030BB 00000000 rtlib.text V42_V22DRV(v22_v42d.asm)
000030BE 00000000 rtlib.text LAPM_MDM_INIT(v22_v42d.asm)
000030BF 00000000 rtlib.text WRITE_NIBBLE(v22_v42d.asm)
000030C1 00000000 rtlib.text READ_NIBBLE(v22_v42d.asm)
```

```
  00003102 00000000 rtlib.text End_ReadNibble(v22_v42d.asm)
  00003107 00000042 rtlib.text rtlib.text(Runtime 56800E.Lib save_reg.o     )
  00003107 00000000 rtlib.text INTERRUPT_SAVEALL(Runtime 56800E.Lib save_reg.o     )
  0000312A 00000000 rtlib.text INTERRUPT_RESTOREALL(Runtime 56800E.Lib save_reg.o     )
  00003149 00000037 rtlib.text F@DummyFn1(Runtime 56800E.Lib artdivrec_s32_0)
  00003149 00000000 rtlib.text FARTDIVREC_S16(Runtime 56800E.Lib artdivrec_s32_0)
  00003149 00000000 rtlib.text ARTDIVREC_S16(Runtime 56800E.Lib artdivrec_s32_0)
  00003149 00000037 rtlib.text rtlib.text(Runtime 56800E.Lib artdivrec_s32_0)
  00003150 00000000 rtlib.text ARTDIVREC_U16(Runtime 56800E.Lib artdivrec_s32_0)
  00003150 00000000 rtlib.text FARTDIVREC_U16(Runtime 56800E.Lib artdivrec_s32_0)
  00003157 00000000 rtlib.text ARTDIVREC_S32(Runtime 56800E.Lib artdivrec_s32_0)
  00003157 00000000 rtlib.text FARTDIVREC_S32(Runtime 56800E.Lib artdivrec_s32_0)
  00003169 00000000 rtlib.text ARTDIVREC_U32(Runtime 56800E.Lib artdivrec_s32_0)
  00003169 00000000 rtlib.text FARTDIVREC_U32(Runtime 56800E.Lib artdivrec_s32_0)
  00003180 00000100 rtlib.text rtlib.text(dtmfgen_3x.lib dtmf_gen.o     )
  00003180 00000000 rtlib.text FdtmfGenerate(dtmfgen_3x.lib dtmf_gen.o     )
  000031C7 00000000 rtlib.text FdtmfInit(dtmfgen_3x.lib dtmf_gen.o     )
  0000320F 00000000 rtlib.text FdtmfSetKey(dtmfgen_3x.lib dtmf_gen.o     )
  00003280 00000045 startup.text Finit_56800_(56F80xx_init.asm)
  00003280 00000045 startup.text startup.text(56F80xx_init.asm)
#>000032C5          F_Pbss_start_addr (linker command file)
#>000032C5          _P_BSS_ADDR (linker command file)
#>00000000          F_Pbss_length (linker command file)
#>000032C5          F_Pcode_end_addr (linker command file)
#>000032C6          __pROM_data_start (linker command file)

# .data_in_p_flash_ROM
#>00000001          __xRAM_data_start (linker command file)
  00000001 00000008 .const.data F@848(modemblue.c)
  00000009 00000007 .const.data F@849(modemblue.c)
  00000010 00000004 .const.data F@850(modemblue.c)
  00000013 00000008 .const.data F@851(modemblue.c)
  0000001B 00000003 .const.data F@986(modemblue.c)
  0000001E 00000004 .const.data F@987(modemblue.c)
  00000021 00000028 .const.data F@988(modemblue.c)
  00000049 00000006 .const.data F@1055(modemblue.c)
  0000004F 00000007 .const.data F@1103(modemblue.c)
  00000055 00000009 .const.data F@1104(modemblue.c)
  0000005E 00000009 .const.data F@1105(modemblue.c)
  00000066 00000000 rtlib.data cpt_cosval(cpt_dc.asm)
```

```
00000066 00000006 rtlib.data rtlib.data(cpt_dc.asm)
0000006C 00000002 .data   FBitIO_portDsc(Cpu.c)
0000006E 00000001 .data   FpModemRxWrt(modemblue.c)
0000006F 00000001 .data   FpModemRxRead(modemblue.c)
00000070 00000000 TX_MEM.data MDMCONFIG(v22bis_gmdmmem.asm)
00000070 00000000 TX_MEM.data FMDMCONFIG(v22bis_gmdmmem.asm)
00000070 0000000E TX_MEM.data TX_MEM.data(v22bis_gmdmmem.asm)
00000072 00000000 TX_MEM.data TX_GAIN(v22bis_gmdmmem.asm)
00000073 00000000 TX_MEM.data MDMSTATUS(v22bis_gmdmmem.asm)
00000073 00000000 TX_MEM.data FMDMSTATUS(v22bis_gmdmmem.asm)
00000074 00000000 TX_MEM.data mode_flg(v22bis_gmdmmem.asm)
00000075 00000000 TX_MEM.data rx_st_id(v22bis_gmdmmem.asm)
00000076 00000000 TX_MEM.data tx_st_id(v22bis_gmdmmem.asm)
00000077 00000000 TX_MEM.data flg_107(v22bis_gmdmmem.asm)
00000078 00000000 TX_MEM.data flg_112(v22bis_gmdmmem.asm)
00000079 00000000 TX_MEM.data flg_109(v22bis_gmdmmem.asm)
0000007A 00000000 TX_MEM.data flg_104(v22bis_gmdmmem.asm)
0000007B 00000000 TX_MEM.data flg_106(v22bis_gmdmmem.asm)
0000007C 00000000 TX_MEM.data loopback(v22bis_gmdmmem.asm)
0000007D 00000000 TX_MEM.data Fretrain_flag(v22bis_gmdmmem.asm)
0000007D 00000000 TX_MEM.data retrain_flag(v22bis_gmdmmem.asm)
0000007E 00000000 TX_MEM.data txI1ctr(v22bis_txmdmmem.asm)
0000007E 00000000 TX_MEM.data TXMEMB(v22bis_txmdmmem.asm)
0000007E 00000047 TX_MEM.data TX_MEM.data(v22bis_txmdmmem.asm)
0000007F 00000000 TX_MEM.data txI2ctr(v22bis_txmdmmem.asm)
00000080 00000000 TX_MEM.data txI3ctr(v22bis_txmdmmem.asm)
00000081 00000000 TX_MEM.data txI4ctr(v22bis_txmdmmem.asm)
00000082 00000000 TX_MEM.data txI51ctr(v22bis_txmdmmem.asm)
00000083 00000000 TX_MEM.data txI52ctr(v22bis_txmdmmem.asm)
00000084 00000000 TX_MEM.data txI61ctr(v22bis_txmdmmem.asm)
00000085 00000000 TX_MEM.data txI62ctr(v22bis_txmdmmem.asm)
00000086 00000000 TX_MEM.data txI72ctr(v22bis_txmdmmem.asm)
00000087 00000000 TX_MEM.data txI82ctr(v22bis_txmdmmem.asm)
00000088 00000000 TX_MEM.data mdm_flg(v22bis_txmdmmem.asm)
00000089 00000000 TX_MEM.data gt_flg(v22bis_txmdmmem.asm)
0000008A 00000000 TX_MEM.data ccitt_flg(v22bis_txmdmmem.asm)
0000008B 00000000 TX_MEM.data tx_ans_flg(v22bis_txmdmmem.asm)
0000008C 00000000 TX_MEM.data tx_rx16(v22bis_txmdmmem.asm)
0000008D 00000000 TX_MEM.data atone_ptr(v22bis_txmdmmem.asm)
0000008E 00000000 TX_MEM.data tx_data(v22bis_txmdmmem.asm)
```

```
0000008F 00000000 TX_MEM.data tx_out(v22bis_txmdmmem.asm)
0000008F 00000000 TX_MEM.data Ftx_out(v22bis_txmdmmem.asm)
0000009B 00000000 TX_MEM.data tx_quad(v22bis_txmdmmem.asm)
0000009C 00000000 TX_MEM.data Ival(v22bis_txmdmmem.asm)
0000009D 00000000 TX_MEM.data Qval(v22bis_txmdmmem.asm)
0000009E 00000000 TX_MEM.data tx_scr_buf(v22bis_txmdmmem.asm)
0000009F 00000000 TX_MEM.data tx_scr_buf_1(v22bis_txmdmmem.asm)
000000A0 00000000 TX_MEM.data tx_scr_ctr(v22bis_txmdmmem.asm)
000000A1 00000000 TX_MEM.data gtamp(v22bis_txmdmmem.asm)
000000A2 00000000 TX_MEM.data gtone_ptr(v22bis_txmdmmem.asm)
000000A3 00000000 TX_MEM.data tx_fm_buf(v22bis_txmdmmem.asm)
000000A9 00000000 TX_MEM.data tx_fm_coef(v22bis_txmdmmem.asm)
000000AA 00000000 TX_MEM.data tx_fm_gt_offset(v22bis_txmdmmem.asm)
000000AB 00000000 TX_MEM.data tx_ctr(v22bis_txmdmmem.asm)
000000AC 00000000 TX_MEM.data tx_tmp(v22bis_txmdmmem.asm)
000000AD 00000000 TX_MEM.data tmp_flg(v22bis_txmdmmem.asm)
000000AE 00000000 TX_MEM.data tx_st_chg(v22bis_txmdmmem.asm)
000000AF 00000000 TX_MEM.data TxQ(v22bis_txmdmmem.asm)
000000B0 00000000 TX_MEM.data TxQ_1(v22bis_txmdmmem.asm)
000000B1 00000000 TX_MEM.data TxQ_2(v22bis_txmdmmem.asm)
000000B2 00000000 TX_MEM.data TxQ_3(v22bis_txmdmmem.asm)
000000B3 00000000 TX_MEM.data TxQ_4(v22bis_txmdmmem.asm)
000000B4 00000000 TX_MEM.data TxQ_5(v22bis_txmdmmem.asm)
000000B5 00000000 TX_MEM.data StQ1(v22bis_txmdmmem.asm)
000000B6 00000000 TX_MEM.data StQ1_1(v22bis_txmdmmem.asm)
000000B7 00000000 TX_MEM.data StQ1_2(v22bis_txmdmmem.asm)
000000B8 00000000 TX_MEM.data StQ1_3(v22bis_txmdmmem.asm)
000000B9 00000000 TX_MEM.data StQ1_4(v22bis_txmdmmem.asm)
000000BA 00000000 TX_MEM.data StQ1_5(v22bis_txmdmmem.asm)
000000BB 00000000 TX_MEM.data StQ2(v22bis_txmdmmem.asm)
000000BE 00000000 TX_MEM.data StQ_ptr(v22bis_txmdmmem.asm)
000000BF 00000000 TX_MEM.data TxQ_ptr(v22bis_txmdmmem.asm)
000000C0 00000000 TX_MEM.data TXMEMSIZE(v22bis_txmdmmem.asm)
000000C1 00000000 TX_MEM.data DC_Alpha(v22bis_txmdmmem.asm)
000000C2 00000000 TX_MEM.data DC_Tap(v22bis_txmdmmem.asm)
000000C3 00000000 TX_MEM.data DC_Tap_Scaled(v22bis_txmdmmem.asm)
000000C4 00000000 TX_MEM.data DC_Error(v22bis_txmdmmem.asm)
000000C5 00000000 API.data cnt7(v22bis_rxstub.asm)
000000C5 00000002 API.data API.data(v22bis_rxstub.asm)
00000100 00000000 V22B_PROM.data SIN_TBL(v22bis_mdm_prom.asm)
```

```
00000100 000002EC V22B_PROM.data V22B_PROM.data(v22bis_mdm_prom.asm)
00000200 00000000 V22B_PROM.data cos2100(v22bis_mdm_prom.asm)
00000220 00000000 V22B_PROM.data MOD_TBL(v22bis_mdm_prom.asm)
0000022C 00000000 V22B_PROM.data absdat(v22bis_mdm_prom.asm)
0000023C 00000000 V22B_PROM.data tx_quadtab(v22bis_mdm_prom.asm)
0000024C 00000000 V22B_PROM.data tx_IQmap(v22bis_mdm_prom.asm)
0000026C 00000000 V22B_PROM.data IFCOE(v22bis_mdm_prom.asm)
000003EC 00000000 ROM_XMEM.data PAR_2100(v22bis_mdm_xrom.asm)
000003EC 00000153 ROM_XMEM.data ROM_XMEM.data(v22bis_mdm_xrom.asm)
000003EF 00000000 ROM_XMEM.data RXBPF22H(v22bis_mdm_xrom.asm)
0000044F 00000000 ROM_XMEM.data RXBPF22L(v22bis_mdm_xrom.asm)
000004AF 00000000 ROM_XMEM.data tx_fm_coef_low(v22bis_mdm_xrom.asm)
000004F7 00000000 ROM_XMEM.data tx_fm_coef_high(v22bis_mdm_xrom.asm)
00000540 00000000 RX_MEM.data rx_st_chg(v22bis_rxmdmmem.asm)
00000540 00000000 RX_MEM.data RXMEMB(v22bis_rxmdmmem.asm)
00000540 00000268 RX_MEM.data RX_MEM.data(v22bis_rxmdmmem.asm)
00000541 00000000 RX_MEM.data rx_ans_flg(v22bis_rxmdmmem.asm)
00000542 00000000 RX_MEM.data RX_LAPM_EN(v22bis_rxmdmmem.asm)
00000543 00000000 RX_MEM.data TX_LAPM_EN(v22bis_rxmdmmem.asm)
00000544 00000000 RX_MEM.data retctr(v22bis_rxmdmmem.asm)
00000545 00000000 RX_MEM.data rx_ctr(v22bis_rxmdmmem.asm)
00000546 00000000 RX_MEM.data err_ctr(v22bis_rxmdmmem.asm)
00000547 00000000 RX_MEM.data rx_toutctr(v22bis_rxmdmmem.asm)
00000548 00000000 RX_MEM.data RXTH(v22bis_rxmdmmem.asm)
00000549 00000000 RX_MEM.data DEL_2100(v22bis_rxmdmmem.asm)
0000054E 00000000 RX_MEM.data TON2100(v22bis_rxmdmmem.asm)
0000054F 00000000 RX_MEM.data TON150(v22bis_rxmdmmem.asm)
00000550 00000000 RX_MEM.data TONS1(v22bis_rxmdmmem.asm)
00000551 00000000 RX_MEM.data SPEED(v22bis_rxmdmmem.asm)
00000552 00000000 RX_MEM.data USB1PAT(v22bis_rxmdmmem.asm)
00000553 00000000 RX_MEM.data RETRCNT(v22bis_rxmdmmem.asm)
00000554 00000000 RX_MEM.data TRN_LNG(v22bis_rxmdmmem.asm)
00000580 00000000 RX_MEM.data IB(v22bis_rxmdmmem.asm)
000005A2 00000000 RX_MEM.data IBPTR(v22bis_rxmdmmem.asm)
000005A3 00000000 RX_MEM.data RXSB(v22bis_rxmdmmem.asm)
000005C0 00000000 RX_MEM.data RXRB(v22bis_rxmdmmem.asm)
000005F0 00000000 RX_MEM.data RXFPTR(v22bis_rxmdmmem.asm)
000005F1 00000000 RX_MEM.data DPHASE(v22bis_rxmdmmem.asm)
000005F2 00000000 RX_MEM.data CDP(v22bis_rxmdmmem.asm)
000005F3 00000000 RX_MEM.data DP(v22bis_rxmdmmem.asm)
```

```
000005F4 00000000 RX_MEM.data DPHADJ(v22bis_rxmdmmem.asm)
000005F5 00000000 RX_MEM.data BPF_OUT(v22bis_rxmdmmem.asm)
0000060D 00000000 RX_MEM.data BPFOUT_PTR(v22bis_rxmdmmem.asm)
0000060E 00000000 RX_MEM.data RXMPTR(v22bis_rxmdmmem.asm)
0000060F 00000000 RX_MEM.data RXCB2A(v22bis_rxmdmmem.asm)
00000610 00000000 RX_MEM.data RXCB2A_1(v22bis_rxmdmmem.asm)
00000611 00000000 RX_MEM.data RXCB2A_2(v22bis_rxmdmmem.asm)
00000612 00000000 RX_MEM.data RXCB2A_3(v22bis_rxmdmmem.asm)
00000613 00000000 RX_MEM.data RXCB2A_4(v22bis_rxmdmmem.asm)
00000614 00000000 RX_MEM.data RXCB2A_5(v22bis_rxmdmmem.asm)
00000615 00000000 RX_MEM.data RXCB2A_6(v22bis_rxmdmmem.asm)
00000627 00000000 RX_MEM.data RXCBPTR(v22bis_rxmdmmem.asm)
00000628 00000000 RX_MEM.data PREV_ENERGY(v22bis_rxmdmmem.asm)
00000634 00000000 RX_MEM.data PRV_ENPTR(v22bis_rxmdmmem.asm)
00000635 00000000 RX_MEM.data ENBUF_PTR(v22bis_rxmdmmem.asm)
00000636 00000000 RX_MEM.data AGCG(v22bis_rxmdmmem.asm)
00000637 00000000 RX_MEM.data AGCC1(v22bis_rxmdmmem.asm)
00000638 00000000 RX_MEM.data AGCC2(v22bis_rxmdmmem.asm)
00000639 00000000 RX_MEM.data AGCC3(v22bis_rxmdmmem.asm)
0000063A 00000000 RX_MEM.data AGCC4(v22bis_rxmdmmem.asm)
0000063B 00000000 RX_MEM.data AGCLP1(v22bis_rxmdmmem.asm)
0000063C 00000000 RX_MEM.data AGCLP2(v22bis_rxmdmmem.asm)
0000063D 00000000 RX_MEM.data AGCLG(v22bis_rxmdmmem.asm)
0000063E 00000000 RX_MEM.data RXSBAG(v22bis_rxmdmmem.asm)
0000063F 00000000 RX_MEM.data CD1(v22bis_rxmdmmem.asm)
00000640 00000000 RX_MEM.data ENERBUF(v22bis_rxmdmmem.asm)
00000680 00000000 RX_MEM.data RXCB(v22bis_rxmdmmem.asm)
00000681 00000000 RX_MEM.data RXCB_1(v22bis_rxmdmmem.asm)
00000682 00000000 RX_MEM.data RXCB_2(v22bis_rxmdmmem.asm)
00000683 00000000 RX_MEM.data RXCB_3(v22bis_rxmdmmem.asm)
00000684 00000000 RX_MEM.data RXCB_4(v22bis_rxmdmmem.asm)
00000685 00000000 RX_MEM.data RXCB_5(v22bis_rxmdmmem.asm)
00000686 00000000 RX_MEM.data RXCB_6(v22bis_rxmdmmem.asm)
0000069E 00000000 RX_MEM.data RXCBIN_PTR(v22bis_rxmdmmem.asm)
0000069F 00000000 RX_MEM.data RXCBOUT_PTR(v22bis_rxmdmmem.asm)
000006A0 00000000 RX_MEM.data CD_CNT(v22bis_rxmdmmem.asm)
000006A1 00000000 RX_MEM.data LPBAGC(v22bis_rxmdmmem.asm)
000006A2 00000000 RX_MEM.data LPBAGC2(v22bis_rxmdmmem.asm)
000006A3 00000000 RX_MEM.data HPG1(v22bis_rxmdmmem.asm)
000006A4 00000000 RX_MEM.data HPG2(v22bis_rxmdmmem.asm)
```

```
000006A5 00000000 RX_MEM.data BLPG1(v22bis_rxmdmmem.asm)
000006A6 00000000 RX_MEM.data BLPG2(v22bis_rxmdmmem.asm)
000006A7 00000000 RX_MEM.data BOFF(v22bis_rxmdmmem.asm)
000006A8 00000000 RX_MEM.data BHPX1(v22bis_rxmdmmem.asm)
000006A9 00000000 RX_MEM.data BHPY1(v22bis_rxmdmmem.asm)
000006AA 00000000 RX_MEM.data BHPX3(v22bis_rxmdmmem.asm)
000006AB 00000000 RX_MEM.data BHPY3(v22bis_rxmdmmem.asm)
000006AC 00000000 RX_MEM.data BHPE1(v22bis_rxmdmmem.asm)
000006AD 00000000 RX_MEM.data BHPE3(v22bis_rxmdmmem.asm)
000006AE 00000000 RX_MEM.data BACC1(v22bis_rxmdmmem.asm)
000006AF 00000000 RX_MEM.data BACC2(v22bis_rxmdmmem.asm)
000006B0 00000000 RX_MEM.data BLP(v22bis_rxmdmmem.asm)
000006B1 00000000 RX_MEM.data BINTG(v22bis_rxmdmmem.asm)
000006B2 00000000 RX_MEM.data BINTGA(v22bis_rxmdmmem.asm)
000006B3 00000000 RX_MEM.data status(v22bis_rxmdmmem.asm)
000006B4 00000000 RX_MEM.data CARG1(v22bis_rxmdmmem.asm)
000006B5 00000000 RX_MEM.data CARG2(v22bis_rxmdmmem.asm)
000006B6 00000000 RX_MEM.data CARG3(v22bis_rxmdmmem.asm)
000006B7 00000000 RX_MEM.data CARG4(v22bis_rxmdmmem.asm)
000006B8 00000000 RX_MEM.data COFF(v22bis_rxmdmmem.asm)
000006B9 00000000 RX_MEM.data CLP(v22bis_rxmdmmem.asm)
000006BA 00000000 RX_MEM.data RCBUF(v22bis_rxmdmmem.asm)
000006BB 00000000 RX_MEM.data RCBUF_1(v22bis_rxmdmmem.asm)
000006BC 00000000 RX_MEM.data RCBUF_2(v22bis_rxmdmmem.asm)
000006BD 00000000 RX_MEM.data RCBUF_3(v22bis_rxmdmmem.asm)
000006BE 00000000 RX_MEM.data RCBUF_4(v22bis_rxmdmmem.asm)
000006BF 00000000 RX_MEM.data RCBUF_5(v22bis_rxmdmmem.asm)
000006C0 00000000 RX_MEM.data THBUF(v22bis_rxmdmmem.asm)
000006D0 00000000 RX_MEM.data BBUF(v22bis_rxmdmmem.asm)
000006DD 00000000 RX_MEM.data JITTER(v22bis_rxmdmmem.asm)
000006DE 00000000 RX_MEM.data JITG1(v22bis_rxmdmmem.asm)
000006DF 00000000 RX_MEM.data JITG2(v22bis_rxmdmmem.asm)
000006E0 00000000 RX_MEM.data WRPFLG(v22bis_rxmdmmem.asm)
000006E1 00000000 RX_MEM.data ACODE(v22bis_rxmdmmem.asm)
000006E2 00000000 RX_MEM.data EQRT(v22bis_rxmdmmem.asm)
000006E3 00000000 RX_MEM.data EQRT_1(v22bis_rxmdmmem.asm)
000006E4 00000000 RX_MEM.data EQRT_2(v22bis_rxmdmmem.asm)
000006E5 00000000 RX_MEM.data EQRT_3(v22bis_rxmdmmem.asm)
000006E6 00000000 RX_MEM.data EQRT_4(v22bis_rxmdmmem.asm)
000006E7 00000000 RX_MEM.data EQRT_5(v22bis_rxmdmmem.asm)
```

```
000006E8 00000000 RX_MEM.data EQRT_6(v22bis_rxmdmmem.asm)
000006E9 00000000 RX_MEM.data EQRT_7(v22bis_rxmdmmem.asm)
000006EA 00000000 RX_MEM.data EQRT_8(v22bis_rxmdmmem.asm)
000006EB 00000000 RX_MEM.data EQRT_9(v22bis_rxmdmmem.asm)
000006EC 00000000 RX_MEM.data EQRT_10(v22bis_rxmdmmem.asm)
000006F1 00000000 RX_MEM.data EQIT(v22bis_rxmdmmem.asm)
00000700 00000000 RX_MEM.data EQRSB(v22bis_rxmdmmem.asm)
0000071E 00000000 RX_MEM.data EQRBIN(v22bis_rxmdmmem.asm)
0000071F 00000000 RX_MEM.data EQIBIN(v22bis_rxmdmmem.asm)
00000720 00000000 RX_MEM.data EQISB(v22bis_rxmdmmem.asm)
0000073E 00000000 RX_MEM.data EQUDSIZ(v22bis_rxmdmmem.asm)
0000073F 00000000 RX_MEM.data LUPALP(v22bis_rxmdmmem.asm)
00000740 00000000 RX_MEM.data RXSCRD(v22bis_rxmdmmem.asm)
00000741 00000000 RX_MEM.data RXODAT(v22bis_rxmdmmem.asm)
00000742 00000000 RX_MEM.data RXQ(v22bis_rxmdmmem.asm)
00000743 00000000 RX_MEM.data RXQ_1(v22bis_rxmdmmem.asm)
00000744 00000000 RX_MEM.data RXQ_2(v22bis_rxmdmmem.asm)
00000745 00000000 RX_MEM.data RXQ_3(v22bis_rxmdmmem.asm)
00000746 00000000 RX_MEM.data RXQ_4(v22bis_rxmdmmem.asm)
00000747 00000000 RX_MEM.data RXQ_5(v22bis_rxmdmmem.asm)
00000748 00000000 RX_MEM.data RXQ_6(v22bis_rxmdmmem.asm)
00000749 00000000 RX_MEM.data RXQ_7(v22bis_rxmdmmem.asm)
0000074A 00000000 RX_MEM.data RXQ_8(v22bis_rxmdmmem.asm)
0000074B 00000000 RX_MEM.data RXQ_9(v22bis_rxmdmmem.asm)
0000074C 00000000 RX_MEM.data RXQ_10(v22bis_rxmdmmem.asm)
0000074D 00000000 RX_MEM.data RXQ_11(v22bis_rxmdmmem.asm)
0000074E 00000000 RX_MEM.data RXQ_12(v22bis_rxmdmmem.asm)
0000074F 00000000 RX_MEM.data RXQ_13(v22bis_rxmdmmem.asm)
00000750 00000000 RX_MEM.data RXQ_14(v22bis_rxmdmmem.asm)
00000751 00000000 RX_MEM.data RXQ_15(v22bis_rxmdmmem.asm)
0000075B 00000000 RX_MEM.data RxQ_ptr(v22bis_rxmdmmem.asm)
0000075C 00000000 RX_MEM.data Rx_StQC(v22bis_rxmdmmem.asm)
00000762 00000000 RX_MEM.data Rx_StQA(v22bis_rxmdmmem.asm)
00000767 00000000 RX_MEM.data Rx_StQG22(v22bis_rxmdmmem.asm)
0000076C 00000000 RX_MEM.data Rx_StQGBis(v22bis_rxmdmmem.asm)
00000774 00000000 RX_MEM.data Rx_StQ_ptr(v22bis_rxmdmmem.asm)
00000775 00000000 RX_MEM.data RXMASK_MC(v22bis_rxmdmmem.asm)
00000776 00000000 RX_MEM.data RXMASK(v22bis_rxmdmmem.asm)
00000777 00000000 RX_MEM.data TXMASK_MC(v22bis_rxmdmmem.asm)
00000778 00000000 RX_MEM.data TXMASK(v22bis_rxmdmmem.asm)
```

```
  00000779 00000000 RX_MEM.data RN_BITS_BAUD(v22bis_rxmdmmem.asm)
  0000077A 00000000 RX_MEM.data TN_BITS_BAUD(v22bis_rxmdmmem.asm)
  0000077B 00000000 RX_MEM.data T401_VALUE(v22bis_rxmdmmem.asm)
  0000077C 00000000 RX_MEM.data T401B_VALUE(v22bis_rxmdmmem.asm)
  0000077D 00000000 RX_MEM.data T403_VALUE(v22bis_rxmdmmem.asm)
  0000077E 00000000 RX_MEM.data LASTDP(v22bis_rxmdmmem.asm)
  0000077F 00000000 RX_MEM.data WRAP(v22bis_rxmdmmem.asm)
  00000780 00000000 RX_MEM.data BBUFPTR(v22bis_rxmdmmem.asm)
  00000781 00000000 RX_MEM.data rx_data(v22bis_rxmdmmem.asm)
  00000781 00000000 RX_MEM.data Frx_data(v22bis_rxmdmmem.asm)
  00000782 00000000 RX_MEM.data NOISE(v22bis_rxmdmmem.asm)
  00000783 00000000 RX_MEM.data RETCNT_RM(v22bis_rxmdmmem.asm)
  00000784 00000000 RX_MEM.data speed(v22bis_rxmdmmem.asm)
  00000785 00000000 RX_MEM.data ICOEFF(v22bis_rxmdmmem.asm)
  00000791 00000000 RX_MEM.data BPF_PTR(v22bis_rxmdmmem.asm)
  00000792 00000000 RX_MEM.data temp1(v22bis_rxmdmmem.asm)
  00000793 00000000 RX_MEM.data temp2(v22bis_rxmdmmem.asm)
  00000794 00000000 RX_MEM.data mod_tbl_offset(v22bis_rxmdmmem.asm)
  00000795 00000000 RX_MEM.data TRAINING(v22bis_rxmdmmem.asm)
  00000796 00000000 RX_MEM.data IFBANK(v22bis_rxmdmmem.asm)
  00000797 00000000 RX_MEM.data IBCNT(v22bis_rxmdmmem.asm)
  00000798 00000000 RX_MEM.data TXBD_CNT(v22bis_rxmdmmem.asm)
  00000799 00000000 RX_MEM.data TNSUM(v22bis_rxmdmmem.asm)
  0000079A 00000000 RX_MEM.data TNASUM(v22bis_rxmdmmem.asm)
  0000079B 00000000 RX_MEM.data EQX(v22bis_rxmdmmem.asm)
  0000079C 00000000 RX_MEM.data EQY(v22bis_rxmdmmem.asm)
  0000079D 00000000 RX_MEM.data RXDATA(v22bis_rxmdmmem.asm)
  0000079E 00000000 RX_MEM.data DECX(v22bis_rxmdmmem.asm)
  0000079F 00000000 RX_MEM.data DECY(v22bis_rxmdmmem.asm)
  000007A0 00000000 RX_MEM.data DX(v22bis_rxmdmmem.asm)
  000007A1 00000000 RX_MEM.data DY(v22bis_rxmdmmem.asm)
  000007A2 00000000 RX_MEM.data dscr_mask(v22bis_rxmdmmem.asm)
  000007A3 00000000 RX_MEM.data rx_dscr_buff(v22bis_rxmdmmem.asm)
  000007A4 00000000 RX_MEM.data rx_dscr_buff_1(v22bis_rxmdmmem.asm)
  000007A5 00000000 RX_MEM.data dscr_cntr(v22bis_rxmdmmem.asm)
  000007A6 00000000 RX_MEM.data RXMEMSIZE(v22bis_rxmdmmem.asm)
  000007A7 00000000 RX_MEM.data IBPTR_IN(v22bis_rxmdmmem.asm)
#>00000000          _EX_BIT (linker command file)
#>00000001          _NUM_IM_PARTITIONS (linker command file)
#>00000000          _NUM_EM_PARTITIONS (linker command file)
```

```
#>000007A8          FmemEXbit (linker command file)
#>000007A9          FmemNumIMpartitions (linker command file)
#>000007AA          FmemNumEMpartitions (linker command file)
#>000007AC          FmemIMpartitionAddr (linker command file)
#>000007AD          FmemIMpartitionSize (linker command file)
#>00000000          FmemEMpartitionAddr (linker command file)
#>000007AE          FmemEMpartitionSize (linker command file)
#>000007B0          __xRAM_data_end (linker command file)
#>000007AF          __data_size (linker command file)

# .ApplicationData
#>000007B0          F_Xbss_start_addr (linker command file)
#>000007B0          _START_BSS (linker command file)
  000007B0 00000001 .bss    FSR_lock(Cpu.c)
  000007B1 00000001 .bss    FSR_reg(Cpu.c)
  000007B2 00000001 .bss    Fis_time_to_shake(modemblue.c)
  000007B3 00000001 .bss    FpAnalogRxWrite(modemblue.c)
  000007B4 00000001 .bss    FpAnalogRxRead(modemblue.c)
  000007B5 00000001 .bss    FpAnalogTxWrite(modemblue.c)
  000007B6 00000001 .bss    FpAnalogTxRead(modemblue.c)
  000007B7 00000001 .bss    FPreviousSample(modemblue.c)
  000007B8 00000001 .bss    FCumCnt(modemblue.c)
  000007B9 00000001 .bss    FLast_Dac_Value(modemblue.c)
  000007BA 00000001 .bss    FThis_Delta_Value(modemblue.c)
  000007BB 00000001 .bss    FThis_Dac_Value(modemblue.c)
  000007BC 00000001 .bss    FBlue_DAC_Scale(modemblue.c)
  000007BD 00000001 .bss    Fstate_of_escape(modemblue.c)
  000007BD 00000001 .bss    FAT_on_state(modemblue.c)
  000007BE 00000001 .bss    FAT_off_state(modemblue.c)
  000007BE 00000029 .bss    Fphone_number(modemblue.c)
  000007D3 00000001 .bss    Fp_phone_number(modemblue.c)
  000007D4 00000001 .bss    Fh_parm(modemblue.c)
  000007D6 00000002 .bss    FAC24(modemblue.c)
  000007D8 00000002 .bss    FAC12(modemblue.c)
  000007DA 00000002 .bss    FAC0(modemblue.c)
  000007DC 00000002 .bss    FACa(modemblue.c)
  000007DE 00000001 .bss    FLine_Tones(modemblue.c)
  000007DF 00000019 .bss    FAnalogTxBuffer(modemblue.c)
  000007F8 00000020 .bss    FAnalogRxBuffer(modemblue.c)
  00000818 00000010 .bss    FModemRxBuffer(modemblue.c)
```

```
00000820 00000001 .bss    Ftty_in_status(modemblue.c)
00000820 00000064 .bss    Fmodem_in(modemblue.c)
00000852 00000064 .bss    Ftty_in(modemblue.c)
00000885 00000064 .bss    FCodecRxBuffer(modemblue.c)
000008E9 0000000C .bss    FCodecTxBuffer(modemblue.c)
000008F5 00000001 .bss    FAns_Tone_Detect(modemblue.c)
000008F6 00000001 .bss    FAns_Tone_Start(modemblue.c)
000008F7 00000001 .bss    FV21_Mode(modemblue.c)
000008F8 00000001 .bss    FAT_q_flag(modemblue.c)
000008F9 00000001 .bss    FAT_z_flag(modemblue.c)
000008FA 00000001 .bss    Fcall_phone_number(modemblue.c)
000008FB 00000001 .bss    FCaller_Modem(modemblue.c)
000008FC 00000004 .bss    Fv22bis_RXCallback(modemblue.c)
00000900 00000004 .bss    Fv22bis_TXCallback(modemblue.c)
00000904 00000001 .bss    Frate_negotiated(modemblue.c)
00000905 00000001 .bss    Fconnection_lost(modemblue.c)
00000906 00000001 .bss    Fv22bis_connection_established(modemblue.c)
00000907 00000001 .bss    FbMemInitialized(mem.c)
00000908 00000004 .bss    FEmptyExternalMemoryPool(mem.c)
0000090C 00000004 .bss    FEmptyInternalMemoryPool(mem.c)
00000910 00000005 .bss    FInitialState(mem.c)
00000916 00000028 .bss    FExternalMemoryPool(mem.c)
0000093E 00000028 .bss    FInternalMemoryPool(mem.c)
00000966 00000001 .bss    Fring_state(Events.c)
00000967 00000001 .bss    Ferror_cnt(Events.c)
00000968 00000001 .bss    Fring_pulse_count(Events.c)
00000969 00000001 .bss    FTimeToggle(Events.c)
0000096A 00000001 .bss    Fthe_errors(Events.c)
0000096B 00000001 .bss    FCountTime(Events.c)
0000096C 00000001 .bss    FEnUser(TwentythSecInt.c)
0000096D 00000001 .bss    Fv22dibittxcount(v22bisapi.c)
0000096E 00000001 .bss    Frxbitcounter(v22bisapi.c)
0000096F 00000001 .bss    Fstartbit(v22bisapi.c)
00000970 00000001 .bss    FPartialRxByte(v22bisapi.c)
00000971 00000003 .bss    FNibbles(v22bisapi.c)
00000974 00000001 .bss    FNibbleCount(v22bisapi.c)
00000975 00000001 .bss    FNumberBytes(v22bisapi.c)
00000976 00000001 .bss    FBytePtr(v22bisapi.c)
00000977 00000001 .bss    FByteCount(v22bisapi.c)
00000978 00000001 .bss    Fmessageover(v22bisapi.c)
```

```
  0000097A 00000004 .bss    FRXCallback(v22bisapi.c)
  0000097E 00000004 .bss    FTXCallback(v22bisapi.c)
  00000982 00000001 .bss    FEnUser(WDog1.c)
  00000983 00000032 .bss    FOutBuffer(TestHarnessDCE.c)
  000009B5 00000001 .bss    FOutPtrW(TestHarnessDCE.c)
  000009B6 00000001 .bss    FOutPtrR(TestHarnessDCE.c)
  000009B7 00000001 .bss    FOutLen(TestHarnessDCE.c)
  000009B8 00000032 .bss    FInpBuffer(TestHarnessDCE.c)
  000009EA 00000001 .bss    FInpPtrW(TestHarnessDCE.c)
  000009EB 00000001 .bss    FInpPtrR(TestHarnessDCE.c)
  000009EC 00000001 .bss    FInpLen(TestHarnessDCE.c)
  000009ED 00000001 .bss    FErrFlag(TestHarnessDCE.c)
  000009EE 00000001 .bss    FSerFlag(TestHarnessDCE.c)
  000009EF 0000000E API.bss API.bss(v22bis_apimem.asm)
  000009EF 00000000 API.bss s_ctr(v22bis_apimem.asm)
  000009F0 00000000 API.bss Tx_Baud_Count(v22bis_apimem.asm)
  000009F1 00000000 API.bss Rx_Baud_Flg(v22bis_apimem.asm)
  000009F2 00000000 API.bss TIME_CNT(v22bis_apimem.asm)
  000009F3 00000000 API.bss TIME_CNTL(v22bis_apimem.asm)
  000009F4 00000000 API.bss TIME_CNTH(v22bis_apimem.asm)
  000009F5 00000000 API.bss in_data_ptr(v22bis_apimem.asm)
  000009F6 00000000 API.bss txrx_status(v22bis_apimem.asm)
  000009F7 00000000 API.bss WordWrFlg(v22bis_apimem.asm)
  000009F8 00000000 API.bss WordRdFlg(v22bis_apimem.asm)
  000009F9 00000000 API.bss StartCompare(v22bis_apimem.asm)
  000009FA 00000000 API.bss SyncWord_mem(v22bis_apimem.asm)
  000009FB 00000000 API.bss Sync_sent_status(v22bis_apimem.asm)
  000009FC 00000000 API.bss SyncWord_rx(v22bis_apimem.asm)
#>000009FD          _END_BSS (linker command file)
#>0000024D          F_Xbss_length (linker command file)
#>00000A00          _HEAP_ADDR (linker command file)
#>00000020          _HEAP_SIZE (linker command file)
#>00000A20          _HEAP_END (linker command file)
#>00000100          _min_stack_size (linker command file)
#>00000A20          _stack_addr (linker command file)
#>00000B20          _stack_end (linker command file)
#>00000A00          F_heap_addr (linker command file)
#>00000A20          F_heap_end (linker command file)
#>00000A20          F_Lstack_addr (linker command file)
#>00000A20          F_StackAddr (linker command file)
```

```
#>00000B1F          F_StackEndAddr (linker command file)
#>000007AF          F_Ldata_size (linker command file)
#>00000001          F_Ldata_RAM_addr (linker command file)
#>000032C6          F_Ldata_ROM_addr (linker command file)
#>00000000          F_xROM_to_xRAM (linker command file)
#>00000001          F_pROM_to_xRAM (linker command file)
#>000007B0          F_start_bss (linker command file)
#>000009FD          F_end_bss (linker command file)
#>00000B20          __DATA_END (linker command file)
#>0000F000          FArchIO (linker command file)
```

4.4 Core Processor Loading and RTOS

Because the modem uses very little of the resources of the core processor, an RTOS may be used to run several tasks along with the modem task.

4.4.1 Core Processor Load

When the modem is idle, waiting for a call, it consumes almost no MIPS because the hardware is used to count ring pulses without the help of the core. Only when a significant ring is detected is the core interrupted.

The V.22bis (line rate of 2400 characters per second) bean methods are called to receive data for a consumption rate of 6.21 MIPS. The V.22bis bean methods for transmission of data consume 0.94 MIPS. So, the total MIPS for V.22bis is only 7.15. This is just a small fraction of the MIPS available on the 32 MIPS digital signal controller, a little over 20 percent.

The fraction is much less when V.21 is used (line rate of 300 characters per second). It amounts to very little use of the processor.

4.4.2 Use of RTOS to Run Modem Concurrently with Other Tasks

To blend other tasks with the modem, it is advisable to use an RTOS, or real time operating system. A multi-tasking, context-switching RTOS could be used to share the remaining resources with other tasks, such as alarm monitoring or process control. The modem code itself would be one task, because it is written as one thread.

With the RTOS, the modem code would be made into a task which would sleep while waiting for IO to complete. This is what frees up and unlocks the CPU for other tasks.

The key to success here is to make sure that the TX does not have to wait to place data in the FIFO, so that it can be waiting only for RX characters from the ADC. This is the manner in which this project was tuned.

4.5 Peripheral Footprint

The small percentage of peripherals used by the modem is depicted in Figure 52. This also shows how the beans are graphically associated with pins on the device. Pins without such associations are free to use for other tasks. Each bean has a unique graphic icon that is easily associated with the pins in Figure 53.

The total resource usage is summarized in Figure 52. This resource load meter is a convenient feature of CodeWarrior with Processor Expert. As the project is developed, resource usage is easily tracked when beans are added.

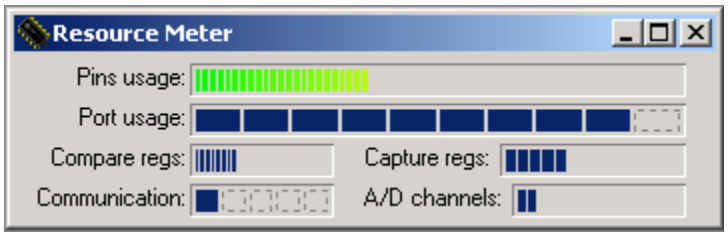


Figure 52. Resource Meter

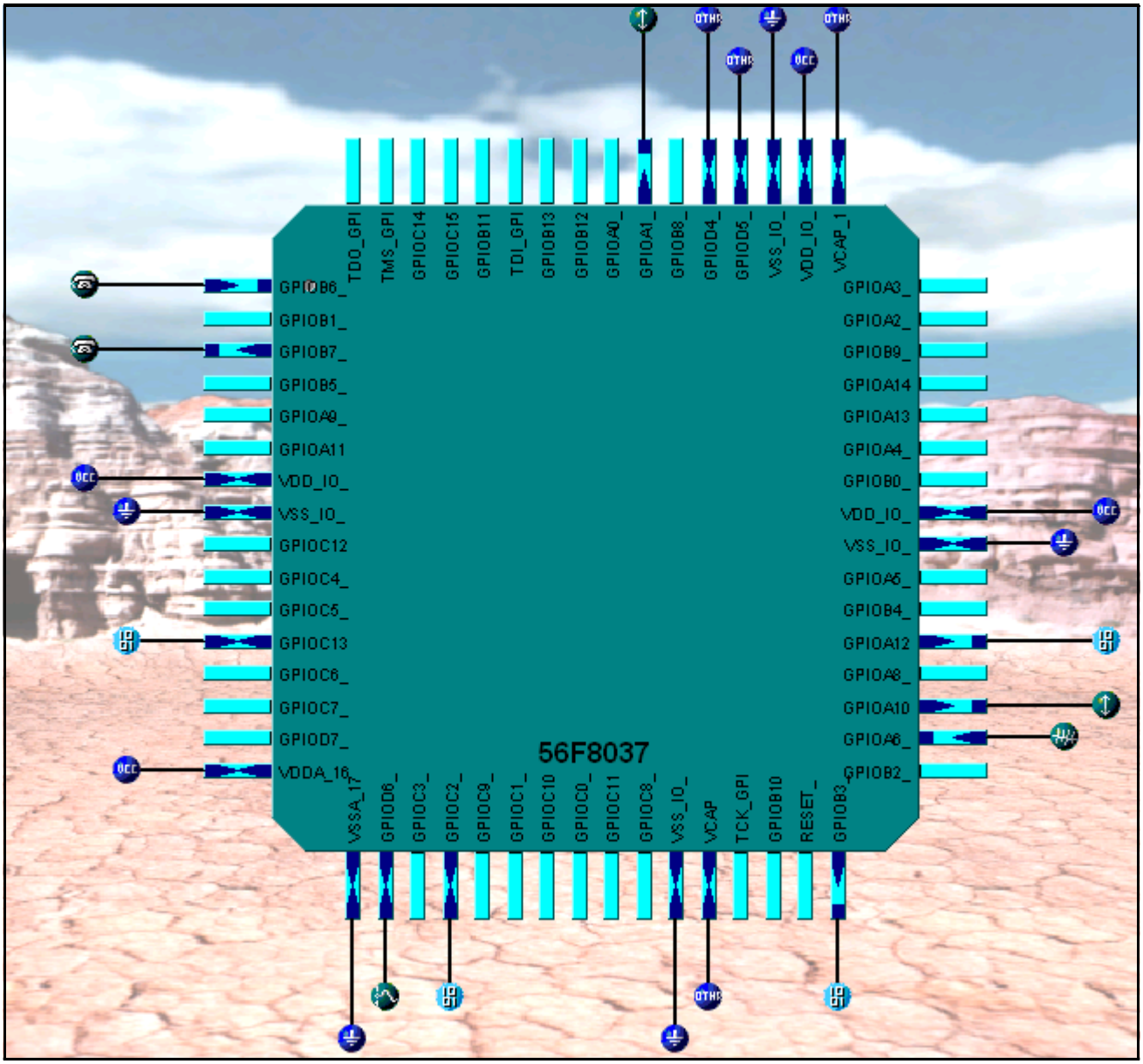


Figure 53. Pin Usage

4.6 Conclusions

The soft modem developed here is suitable for incorporation into commercial products requiring communication over the PSTN at speeds up to 2400 bits per second. A traditional telephone codec is not required in the design, resulting in a one chip/one core system capable of a complete mission, including communications functions.

Both V.21 and V.22bis/V.22 are supported. The V.22bis falls back to V.22 when noise dictates.

The modem is easily added to projects developed for the Freescale 56F802x/3x family.

5 Layout and Governmental Certifications

5.1 Design for Performance

The ADC and DAC use analog signals. They should not parallel at close range signals that contain clocks or signals that change often. Strip-mine-type shielding could be considered. We recommend that you refer to Freescale FAQs and application notes relating to optimal use of the ADC. The layout of the EVM may be used as an example, even though it is possible to reduce even further the noise floor. Given the dynamic range available, this is not required to obtain the performance documented herein.

5.2 Design for Agency Approvals

The final step in bringing a product containing a soft modem to market involves obtaining the approval of, and certification by, the various governmental agencies regulating the sale of products that are to be connected to the PSTN. In some countries the same agency that regulates the post office also regulates the modem product industry. In the United States, FCC part 15 and part 68 should be met. Also, UL approval of any electrical appliance is advised.

The government is concerned with several factors:

- **The ability of the equipment to operate in the presence of radio frequency interference.** Governments do not like to receive a lot of complaints about radio frequency interference. The more RFI that your product can be exposed to without faltering, the better the government will like it.
- **The amount of radio frequency interference produced by the product.** Certain frequencies are used by government agencies; these frequencies are especially monitored for compliance. For example, 75 megahertz is allocated to aeronautical radio navigation. If a product broadcasts on that frequency, planes could be in danger.
- **The effect of high voltages from tip and ring (including lightning strikes) on the product's viability and safety.** In the interest of consumer safety and product merchantability, the product should not be destroyed, and any damage should be limited, when lightning or other high voltage sources come down the tip and ring from the phone pole. The idea is to limit the damage to the parts of the product called the DAA, or data access arrangement, when lightning strikes or power lines become tangled with phone lines. The ring voltage itself is considered high voltage and dangerous.
- **The possibility that the product might become a nuisance by repeatedly calling wrong numbers in the middle of the night to private homes.** With the advent of the FAX machine and computer bulletin board, a disturbing trend began. People were called repeatedly by modems or FAX machines. Some countries require "blacklisting" certain numbers and limiting the number of times other numbers may be called per unit time. To comply with this, firmware must be tested by government agencies or their designated agents.

This last point simply requires software that cannot automatically and repeatedly dial phone numbers. As for the radio frequency issues, they are dealt with by shielding (u metal) and or current loop size minimization. Current-loop minimization is a layout technique in which the open area of a current loop is minimized.

The other points can be dealt with by selecting a DAA, such as the one selected for this design, that meets the standards of multiple governments. Besides that, special layout attention is required for the area of the product's PC board where this DAA device is mounted.

The layout should minimize the area of current loops, or enclose them in shielding, and isolate the high voltage section of the DAA on a one or two layer section of the board, well fused from the tip and ring, and located at the extreme boundary of the product.

Current loop area is minimized by running the return wire from any circuit next to, above, or below the source wire for the circuit. It is also good to surround these "wires" or traces with ground plane on as many sides as possible.

NOTE: This *project* design had not been examined by government authorities for compliance, but is only used on equipment that simulates the PSTN. Any products developed to be sold to the public will require the respective government agency approvals prior to use on the PSTN of the respective country and before sale.

6 References

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TAS Series II Telephone Network Emulator UCO Option Operations Manual, 2700-2734, Version 1.20.

TAS 240 Voiceband Subscriber Loop Emulator Operations Manual, 2700-2397, Version 1.20.

SAMS, Understanding Telephone Electronics, Seventh printing 1987.

ITU-T Recommendation V.22bis, 2400 Bits Per Second Duplex Modem Using The Frequency Division Technique Standardized For Use On The General Switched Telephone Network And On Point-to-Point.

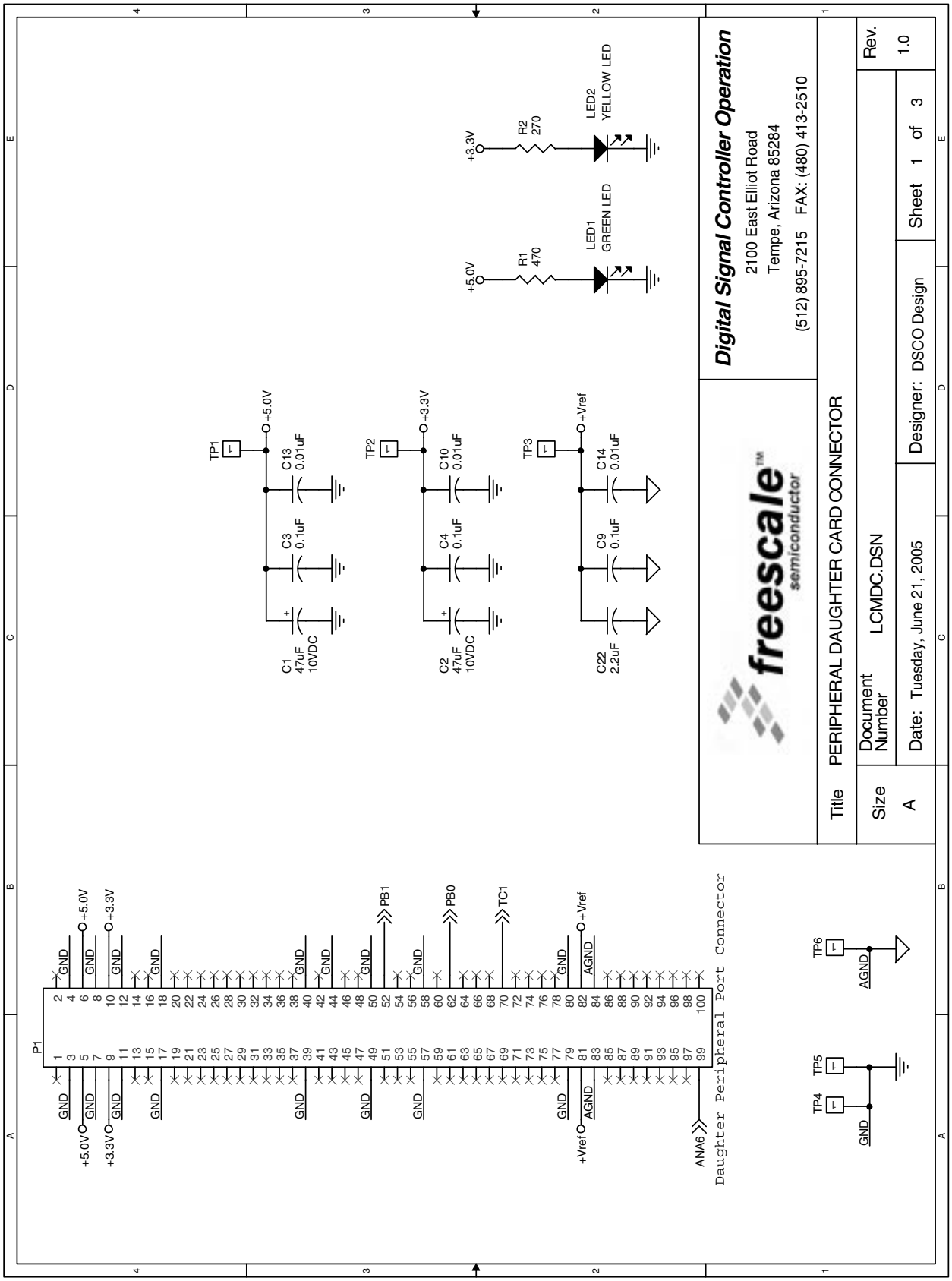
ITU-T Recommendation V.21, 300 Bits Per Second Duplex Modem Standardized For Use On The General Switched Telephone Network.

ITU-T Recommendation V.25, Automatic Answering Equipment and General Procedures for Automatic Calling Equipment on the General Switched Telephone Network Including Procedures for Disabling of Echo Control Devices for Both Manually and Automatically Established Calls.

Boonton Electronics, Application Note AN-50 1 Apr. '93, Measuring The Peak-to-Average Power Of Digitally Modulated Signals, Charles J. Meyer, Senior Applications Engineer.

Cermetek Microelectronics, CH1837A/7F/8A Data Access Arrangement Module Data Sheet, V.34bis High Speed DAA Module.

Appendix A Low-Cost Modem Daughter Card Schematics


Digital Signal Controller Operation
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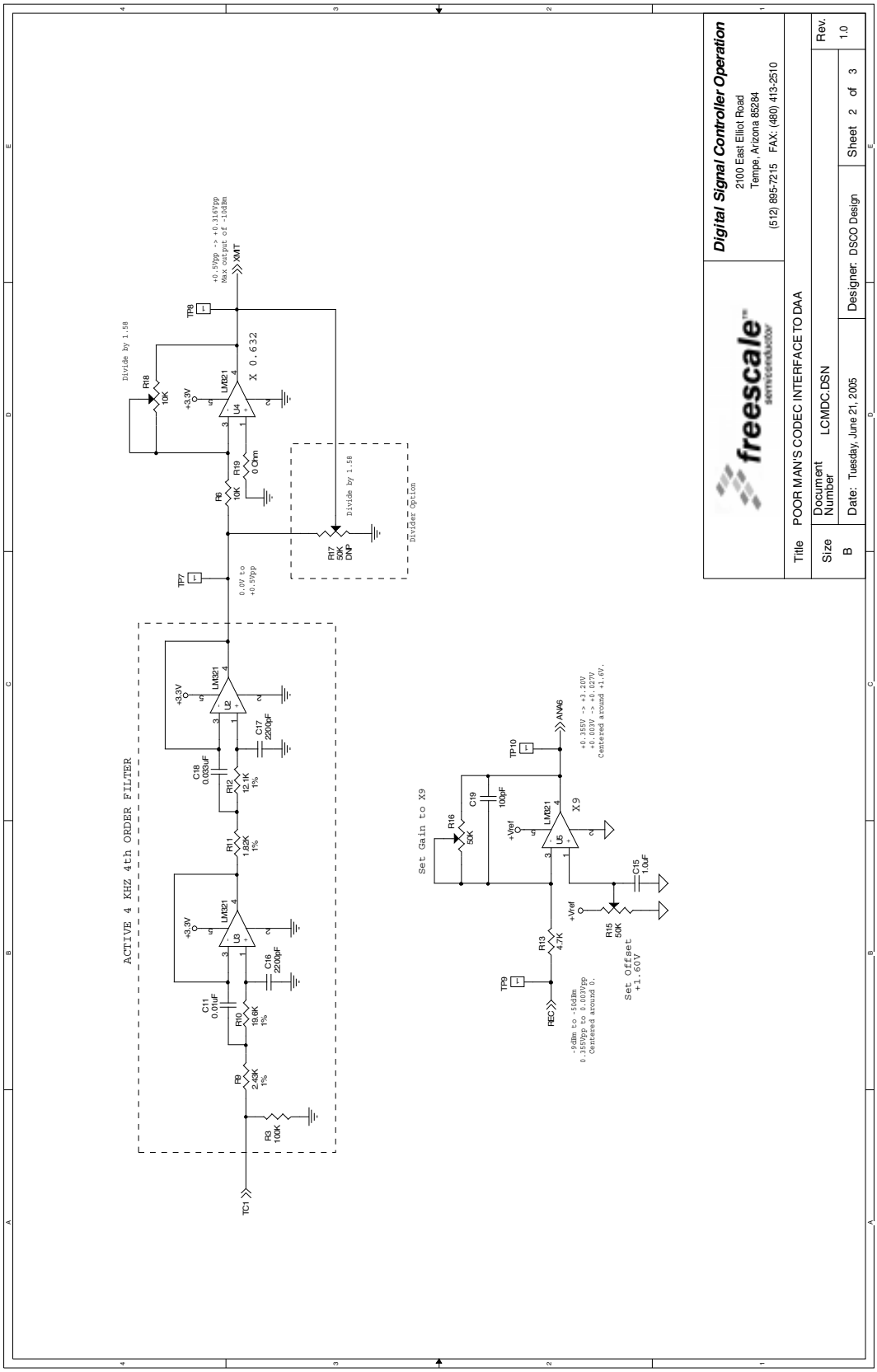
freescale semiconductor
Title PERIPHERAL DAUGHTER CARD CONNECTOR
Size A
Document Number LCMDC.DSN
Rev. 1.0
Date: Tuesday, June 21, 2005
Designer: DSCO Design
Sheet 1 of 3
P1
Daughter Peripheral Port Connector
LED1 GREEN LED
LED2 YELLOW LED
R1 470
R2 270
+5.0V
+3.3V
+Vref
TP1
TP2
TP3
TP4
TP5
TP6
C1 47uF 10VDC
C2 47uF 10VDC
C3 0.1uF
C4 0.1uF
C9 0.1uF
C10 0.01uF
C13 0.01uF
C14 0.01uF
C22 2.2uF
GND
AGND
PB1
PB0
TC1
ANA6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Tempe, Arizona 85284
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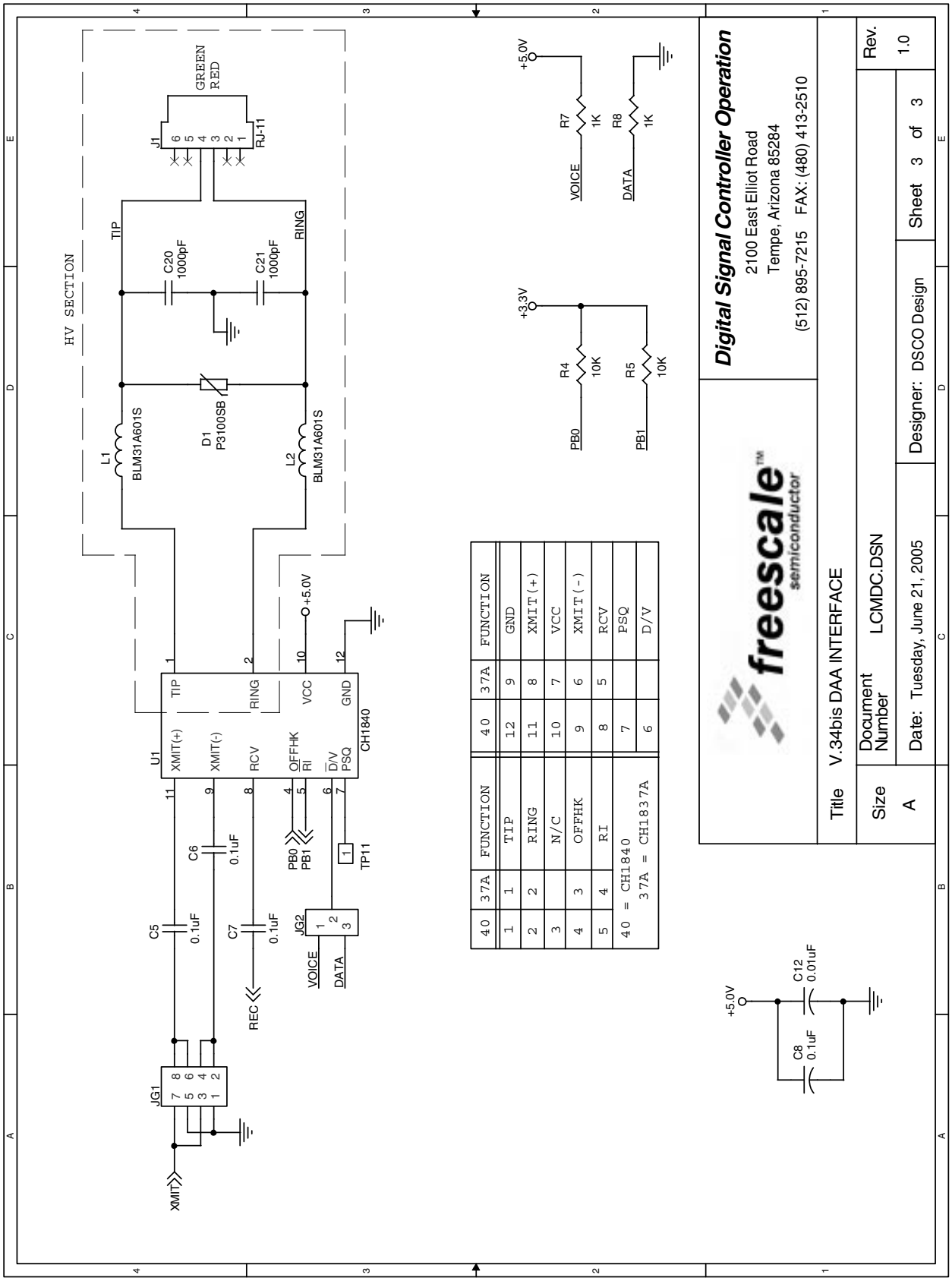
freescale semiconductor
Title POOR MAN'S CODEC INTERFACE TO DAA
Size B
Document Number LCMDC.DSN
Rev. 1.0
Date: Tuesday, June 21, 2005
Designer: DSCO Design
Sheet 2 of 3
ACTIVE 4 KHZ 4th ORDER FILTER
Divide by 1.58
Divide Option
Set Gain to X9
Set Offset +1.60V
X 0.632
X9
XMIT
ANA6
REC
TC1
TP7
TP8
TP9
TP10
+3.3V
+Vref
LM321
U3
U4
U5
U6
R3 100K
R9 2.43K 1%
R10 19.6K 1%
C11 0.01uF
C16 2200pF
R11 1.82K 1%
R12 12.1K 1%
C18 0.039uF
C17 2200pF
R8 10K
R19 0 Ohm
R18 10K
R17 50K DNP
R13 4.7K
R15 50K
C15 1.0uF
R16 50K
C19 100pF
0.0V to +0.5Vpp
+0.5Vpp -> +0.316Vpp Max output of -10dBm
-9dBm to -50dBm 0.355Vpp to 0.003Vpp Centered around 0.
+0.355V -> +3.20V +0.003V -> +0.027V Centered around +1.6V.


HV SECTION
J1
RJ-11
GREEN
RED
TIP
RING
C20
1000pF
C21
1000pF
L1
BLM31A601S
D1
P3100SB
L2
BLM31A601S
U1
CH1840
XMIT(+)
XMIT(-)
RCV
OFFHK
RI
D/V
PSQ
VCC
GND
+5.0V
C5
0.1uF
C6
0.1uF
C7
0.1uF
PB0
PB1
TP11
JG2
VOICE
DATA
REC
JG1
XMIT
+3.3V
R4
10K
R5
10K
R7
1K
R8
1K
C8
0.1uF
C12
0.01uF
40 37A FUNCTION
1 1 TIP
2 2 RING
3 N/C
4 3 OFFHK
5 4 RI
40 = CH1840
37A = CH1837A
40 37A FUNCTION
12 9 GND
11 8 XMIT(+)
10 7 VCC
9 6 XMIT(-)
8 5 RCV
7 PSQ
6 D/V
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Size A
Document Number LCMDC.DSN
Date: Tuesday, June 21, 2005
Designer: DSCO Design
Sheet 3 of 3
Rev. 1.0

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