MT8972 DNIC Questions and Answers

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These are some of the questions that have been frequently asked regarding the DNIC and associated technological implications.

1. What is the line code and transmit signal level?

The line code used is biphase with differential encoding. The amplitude of the signal on the line is 1.2 V_{p-p} 3%. Assuming a line termination of 120 ohms, this corresponds to a transmit power level of +1.0 dBm.

2. What does the Power Spectral Density graph of the transmitted line look like?

The spectral density graph shows a peak response of -24dBV at 0.75fb. This would be at 120 kHz when transmitting at 160 kHz, and 60 kHz when using 80 KHz. There are zeros at 0, and 2fb. The secondary lobes have at least 36dB additional attenuation relative to the spectral peak.

3. What is the maximum line length the DNIC can operate over?

The maximum line length of the DNIC is a function of the type of cable that is used. Gauge as well as composition affects the loop length achievable. A more reliable means of specifying range is by using allowable dB of attenuation. In this way one value can be specified, and from this value the achievable range over the various loop configurations can be derived. The DNIC is capable of handling typically 40 dB of total attenuation. This corresponds to 34 dB of cable attenuation, and 6 dB loss in the termination impedance. From transmission theory for line attenuation, this works out to a limit in excess of 4 km on 24 AWG for 160 kHz operation.

4. What is the limiting factor in the loop range specification?

The maximum loop length of the DNIC is limited by the signal attenuation and noise on the line. The calculation is done by dividing the total tolerable line attenuation (in dB), by the attenuation factor for each gauge of wire and frequency. Intersymbol interference (ISI) can also be the limiting factor in certain loop configurations. Near end crosstalk (NEXT) is thought of as being the limiting factor for echo-cancelling schemes as a whole. The loop range is further limited by the characteristics of the line. Bridged taps, noise, and severe impedance mismatches can result in a shorter range.

5. What are the associated SNR ratios and error rate figures for the listed specs?

The SNR is a measure of the receiver tolerance. This value is also a function of the data transmission rate and loop length. At 160 kbit/s transmission on 24 AWG, the DNIC has a SNR of better than 10 dB for any loop length between 500 metres and 2 km. This is for a BER of 10^{-6}.

6. What does "Channel Quality" in the transmit C-channel indicate?

The channel quality gives an indication of the relative signal to noise ratio. The two bits in the transmitted C-channel allow for four possible values of channel quality. The further the value is away from 0, the higher is the SNR (i.e., the better the performance). The actual value cannot be directly translated into an equivalent SNR, but rather it only provides a qualitative measurement of transmission quality.

7. What does the ”ATTACK“ feature do?

The ATTACK feature allows for faster convergence of the echo canceller RAM when powering up. Instead of incrementing / decrementing the LSB of a particular RAM value, ATTACK disables several least significant bits, making the effective step size of the echo canceller larger.

8. What is the convergence time of the echo canceller without "ATTACK"? ..with "ATTACK"?

Under normal operating conditions, the ATTACK feature is disabled except for power up. At power up ATTACK is turned on for a certain specified period of time, then it is deactivated, letting the RAM converge normally.

Convergence Times

	Characteristics	Sym	Min	Typ	Max	Units	Test Conditions
1	Attack Off at 80 kbit/s	T_{c80}		8.5	17.50	s	
2	Attack Off at 160 kbit/s	T_{c160}		4.0	8.80	s	
3	Attack On at 80 kbit/s	T_{ac80}		0.8	1.75	s	Atk. for 60ms.
4	Attack On at 160 kbit/s	T_{ac160}		0.4	.85	s	Atk. for 30ms.

9. Why is a 10.24 MHz crystal used as opposed to some other frequency?

The 10.24 MHz is used because it is the lowest common multiple of the data rate clocks (80 and 160 kbit/s) and the ST-BUS clocks (2.048 and 4.096 Mbit/s).

10. Can the DNIC operate with a 1.544 Mhz. data stream?

No. The internal operation of the DNIC is set up to work with a 2.048 MHz data stream such as the ST-BUS data stream. Operation with a 1.544 MHz network would only be possible if an interface was available to reformat the 1.544 MHz data into 2.048 MHz format, and a 10.24 MHz clock source was provided.

11. What types of packages does the DNIC come in?

The DNIC is available in 22 Pin CERDIP and PDIP and also in 28 Pin Plastic Leaded Chip Carrier (PLCC).

12. Is the DNIC an analog or digital device?

The DNIC is both an analog and digital device. It provides the interface between a digital system (ST-BUS) and an analog system (2 wire telephone loop plant), thus it has components internally which provide the necessary interface capabilities.

13. What does the PLL operate on?

A phase-locked loop is essentially a frequency comparator with feedback. In the DNIC, the PLL uses the incoming data stream as one input frequency, and a generated 160 kHz or 80 kHz as the other. The output clock from the PLL is a 10.24 MHz. phase-locked clock. This clock is divided down to get RCK which is then compared with the incoming data stream. The 10.24 MHz output clock is then adjusted accordingly.

14. How can you determine whether the DNIC or system is not operating properly?

The DNIC has special loopback testing capabilities which allows it to diagnose itself either via end-to-end testing, or via internal testing. This mode is accessed by using the received C-channel and the diagnostics register.

15. What are the leading causes of echoes in a digital network?

The leading causes of echoes are bridged taps, cable gauge changes, and impedance mismatches.

16. What effect do bridged taps have on system performance?

The effect of the bridged taps depends largely on where in the network these bridge taps are located. If they are at the transmitter / receiver, then the effect is quite severe. The length of the bridged taps is also of concern. The most severe bridged tap is of the quarter wave length (around 250 meters). Other factors are whether the bridged tap is terminated or not, and what impedance is at the termination. Signal degradation up to 6dB per tap may be encountered.

17. Are the ST-BUS transmit and receive frames aligned wrt each other, or are they skewed?

The ST-BUS transmit and receive frames are aligned wrt each other. This is achieved by double buffering the transmit data, and triple buffering the receive data**.** This allows transmission and reception to be activated by the same pulse.

18. What happens with the unused ST-BUS channels?

Once the DNIC has finished its active channels (4 at 160 kbit/s), then the F0o pin is set. The rest of the ST-BUS channels are set to high impedance. This allows for other DNICs to access the unused channels on the ST-BUS. By using the F0o pin connected to the F0i of the next DNIC, you could multiplex several DNIC streams onto a single ST-BUS link.

19. How is the DNIC powered?

The DNIC can be powered from the telephone line. Since it is a low power CMOS device with a typical power draw of only 50 mW, it can be continuously powered from the central office battery.

20. Is there a power down mode on the DNIC?

No. Once the DNIC loses power, the contents of the RAM are lost. On power up, the RAM must first settle before meaningful data can be transmitted.

21. With reference to the ISDN model, where does the DNIC fit it?

The DNIC transfers basic rate data (2B+D) over a single twisted pair by employing full duplex echo-cancellation techniques, thus corresponding to the U-interface reference point of the ISDN model. The DNIC uses a differential bi-phase line code rather than the ANSI defined 2B1Q line code. DNIC provides a simpler and cheaper basic rate transmission scheme for proprietary applications. For a fully compatible U-interface device refer to the MT8910 Digital Subscriber Line Interface Circuit.

22. What are the advantages of Echo Cancellation over TCM (ping-pong)?

Echo cancellation is a full duplex solution in that it transmits data continuously in both directions at the same time. TCM only transmits in one direction at a time. Therefore in order to get the same effective data rate, the TCM system must transmit at over twice the required data rate. This has the effect of increasing the frequency content of the signal, making it prone to increased crosstalk, attenuation and other interference. The increased spectrum also results in a larger amount of radiated energy, which can be quite disruptive to any other transmission schemes operating in the same binder group. It seems that TCM is limited ultimately by loop delay, which is a physical limitation and is difficult to overcome. Efforts to overcome this may result in substantial degradation of customer service.

23. What are the advantages of Biphase over other line codes?

There are several advantages inherent with the Biphase line code. Since it is a two level code, it has an extra 6dB of SNR over a three level code (e.g. AMI). Differential encoding makes the transmission insensitive to wiring crossover. Furthermore, the nature of the PSD graph enables the signal to be effectively bandlimited without losing the major portion of the signal content. The guaranteed zero-crossing in each baud makes data and clock extraction much more reliable and robust. Equalization for Biphase is much less complex than for other codes such as AMI and 4B3T, as these require very complex adaptive equalizers to operate properly. The adaptive equalizer adds to the cost geometry and complexity of the interface solution.

24. How long does the DNIC take to achieve synchronization after power up?

The time before valid data transmission begins is a function of the data rate, the line condition, and the initial value of the RAM. The majority of the activation time is taken up by the settling of the RAM to the appropriate line value. Synchronization is achieved concurrently with the settling of the RAM. Therefore, by the time the RAM has settled, the DNIC will have achieved synchronization.

25. Why is the data scrambled before being transmitted?

The data stream is scrambled in order to ensure orthogonality of transmission, i.e. the transmitted and received data should not be correlated in any way. Another reason for scrambling is to ensure that every RAM location is accessed and iterated down to the correct value in the initialization sequence.

26. What is the training sequence for the DNIC on power up?

The DNIC does not require a specific training sequence to achieve synchronization on power up. The scramblers in the DNIC ensure that random data is put on the line, thus guaranteeing convergence. Synchronization is achieved from the received data stream, and is independent of the actual transmitted data.

27. What kind of echo cancelling scheme does the DNIC use?

The echo cancelling scheme is referred to as “RAM based echo cancelling, using the sign bit algorithm”. The process of echo cancelling is as follows. An estimate of the echo resulting from a particular transmit data sequence is stored in RAM. The value in RAM is a digital representation of the echo estimated to be reflected from the line. The RAM value is passed through a D/A converter into a summer. The summer subtracts the echo estimate from the composite signal made up of the far-end signal and actual reflected echo. An error signal, either positive or negative (i.e., sign bit), is generated which serves to either increment or decrement the value of the echo estimate stored in RAM. The next time the same data sequence is transmitted, the new value of echo estimate is used, and the process repeats itself. The RAM is active continuously and adapts to any changes in the line, characteristics, hence it is referred to as an adaptive echo canceler.

28. What is the recommended value to use as a termination impedance?

The termination impedance (Z_t) designated by R2 C2 and C2' in Figure 18 and 19 of the datasheet, is used to match the characteristic impedance of the telephone line (Z_o). Z_t should be approximately equal to four times Z_o. This is due to the four times impedance multiplication through the 2:1 transformer. C2‘ has been placed in parallel to R2 to correct the phase of the signal being returned to L_{in}. Tailoring of R2, C2, and C2‘ can be done for specific situations such as bit rate, cable gauge, and cable characteristics. Recommended values for 160 kbit/s are: R2= 390 ohms, C2=22 nF, C2‘=1.5 nF. For 80 kbit/s R2=390 ohms, C2=22 nF, C2‘=3.3 nF.

29. How does the DNIC transmit information in the Modem Mode?

The DNIC can be used as a high speed, limited distance, modem. It is capable of transmitting up to 160 kHz of NRZ data either synchronously or asynchronously. The DNIC samples the signal presented to its Di pin at the selected baud rate. This signal is converted to a biphase signal and sent onto the line. At the far end, the DNIC decodes the biphase signal, and recreates the equivalent NRZ data pattern.

30. What loopback functions does the DNIC provide?

The DNIC has three loopback options which are activated via the C-channel and the diagnostics register. The first loopback loops DSTi to DSTo at the local end for system diagnostics. The second loopback loops back L_{out} to L_{in} at the local end for system and DNIC diagnostics. The third loopback loops back DSTo to DSTi at the remote end to provide full end to end diagnostics. In the DSTi to DSTo and DSTo to DSTi cases, it's only the B channels which are looped back. With the L_{out} to L_{in} loopback, the entire Biphase output stream is looped back.

31. What are the major applications of the DNIC?

The DNIC is essentially a digital transmission device. It can easily be used in voice and data transmission systems. The DNIC is an excellent PBX device, allowing flexible digital line card and terminal design using 2 wire transmission. ISDN type services can be carried by the DNIC over the U-Interface. The DNIC can provide a high speed data stream for multiplexed lower rate data, such as RS-232C. The DNIC can also be used as a SLC-96, or D4 channel bank interface, allowing easy multiplexing into a T1 stream.

32. What further information is available on the DNIC?

The DNIC is supported by a team of highly skilled applications engineers providing practical information to potential users in order to facilitate the design-in of the DNIC. There is a DNIC Application Note (MSAN-124) available which highlights some of the many potential applications of the DNIC. Reprints of several DNIC related published papers are also available.

33. What is in the future for the DNIC?

An application circuit is available which can be used to increase the performance of the DNIC. MSAS-46 describes the extender circuit configuration as well as specifying values for 80 and 160 kbit/s operation. With the extender circuit, performance in the range of 42 dB of cable attenuation can be achieved. This corresponds to over 6 km on standard 24 AWG telephone cable for 80 kbit/s and 5 km for 160 kbit/s.

34. What other devices does Mitel have for ISDN?

Mitel makes a complete family of devices for ISDN. Devices used in CPE applications include the MT896X series of PCM filter codecs and the MT8950 data codec, which converts lower speed data (up to 19.2 kbps async) into 64 kbit/s channels. An S-Interface transceiver (MT8930) is available. T1 (MT8976) and CEPT (MT8979) interface families are currently available for the Primary Access Rates (S1 and S2). The MT8952 HDLC Protocol Controller is designed to provide D-channel layer two X.25 formatted information. Further to these ISDN devices, Mitel has other ST-BUS devices which facilitate circuit design. These include the MT8980 Digital Crosspoint Switch, and the MT8940 Dual Digital Phase-Locked Loop. For the pre-ISDN environment, Mitel has a family of analog line interfaces (C.O., ONS, OPS) which provide transformerless conversion between analog and digital lines.