Designing the DP8392 for Longer Cable Applications

National Semiconductor
Application Note 621
Mohammed Rajabzadeh
July 1989

The IEEE 802.3 standard is designed for 500 meters of Ethernet cable and 185 meters of Cheapernet (RG58A/U) cable. To extend such segments to 1000 meters of Ethernet cable and 300 meters of Cheapernet cable requires utilization of Transmit mode collision detection. This method is described below.

COLLISION DETECTION SCHEMES

The collision circuitry monitors the coaxial DC level. If the level is more negative than the collision threshold, the collision output is enabled.

There are two different collision detection schemes that can be implemented with the CTI; Receive mode, and Transmit mode. The IEEE 802.3 standard allows the use of receive and transmit modes for non-repeater node applications. Repeaters are required to have to receive mode implementation. These different modes are defined as follows:

Receive Mode: Detects a collision between any two stations on the network with certainty at all times.

Transmit Mode: Detects a collision with certainty only when the station is transmitting.

Table I summarizes the receive and transmit mode definitions:

TABLE I

Mode	Receive				Transmit			
No. of Stations	0	1	2	>2	0	1	2	>2
Transmitting	N	N	Y	Y	N	N	Y	Y
Non-Transmitting	N	N	Y	Y	N	N	M	Y

Y = Detects Collision
N = Does Not Detect Collision
M = Might Detect Collision

Receive Mode: The Receive mode scheme has a very simple truth table. However, the tight threshold limits make the design of it difficult. The threshold in this case has to be between the maximum DC level of one station (−1300 mV) and the minimum DC level of two far stations (−1581 mV). Several factors such as the termination resistor variation, signal skew, and input bias current of non-transmitting nodes contribute to this tight margin. On top of the −1300 mV minimum level, the impulse response of the internal low pass filter has to be added. The CTI incorporates a 4-pole Bessel filter in combination with a trimmed on board bandgap reference to provide this mode of collision detection.

Transmit Mode: In this case, collision has to be detected only when the station is transmitting. Thus, collision caused by two other nodes may or may not be detected. This feature relaxes the upper limit of the threshold. As a result of this, longer cable segments can be used. With the CTI, a resistor divider can be used at the Collision Detection Sense (CDS) pin to lower the threshold from receive to transmit mode.

COLLISION LEVELS—TRANSMIT MODE

Table II shows the parameter values that are used in calculating the collision levels in transmit mode.

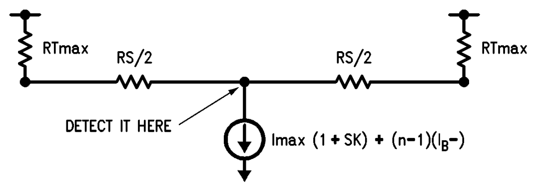
TABLE II. Assumptions and Definitions

R_T	= Termination Resistor at 20°C	= 50 ±1°%Ω		802.3
t_T	= Temp. Coef. of the Terminator	= 0.0001/Deg.		ASSUMPTION
L	= Maximum Segment Length	= 300m	Cheapernet	802.3
		= 1000m	Ethernet	802.3
R_{DC}	= Maximum Cable DC Res. at 20°C	= 0.0489Ω/m	Cheapernet	BELDEN
		= 0.0100Ω/m	Ethernet	BELDEN
tc	= Temp. Coef. of Copper	= 0.004/°C		PHYSICS
Tm	= Maximum Cable Temp.	= 50°C		ASSUMPTION
SR	= Step Response at Max Cable Length	= 0.97	Cheapernet	NATIONAL
		= 0.94	Ethernet	NATIONAL
R_C	= Max. Connector Res./Station	= 0.0034Ω	Cheapernet	MIL SPEC
		= 0.0001Ω	Ethernet	ASSUMPTION
I_{B+}	= Max. Positive Bias Current	= 2 μA		802.3
I_{B-}	= Max. Negative Bias Current	= 25 μA		802.3
I_{max}	= Max. DC Drive Current	= 45 mA		802.3
I_{min}	= Min. DC Drive Current	= 37 mA		802.3
Ro	= Non Transmitting Output Impedance	= 100 kΩ		802.3
N	= Max Nodes per Segment	= 100	Cheapernet	802.3
		= 100	Ethernet	802.3
SK	= Skew Factor, Effect of Encoder Skew on DC Level			802.3
	= (SKEW×4)/100	= 0.02 for 0.5 ns Skew		
R_S	= Max. DC Loop Res. of a Segment			DEFINITION
R_L	= Load Resistance Seen by a Driver			DEFINITION
SEO	= Sending End Overshoot	= 0.10	Cheapernet	ASSUMPTION
		= 0.14	Ethernet	ASSUMPTION

The calculations below explain how the values for the resistor divider in *Figure 1* are obtained. First, collision levels V_{max} and V_{min} must be calculated. The V_{max} or ‘‘no detect’’ level is the maximum DC voltage generated by one node. The worst case here occurs when the transmitting node is at the center of a maximum length cable, and the collision is being detected either by itself or by a station right next to it. On the other hand, the V_{min} or ‘‘must detect’’ level is the minimum DC voltage generated by one minimum transmitting station and another minimum transmitting station at the other end of a maximum length cable.

The filter impulse response is not included in these calculation since it is mutually exclusive with the Sending End Overshoot. If the impulse response is larger than the Sending End Overshoot, the exceeding portion should be added on to the limits.

Maximum Non Collision Level V_{Max} (NO DETECT)—Transmit Mode



TL/F/10445–1

$R_{Tmax} = R_T \times 1.01 \times [(Tm - 20) \times t_T + 1]$

$R_S = R_{DC} \times L \times [(Tm - 20) \times t_c + 1] + N \times RC$

$R_L = (R_{Tmax} + R_S/2)/2$

$V_{Max} = [I_{Max} \times (1 + SK) + (N - 1)(I_{B-})] \times R_L \times (1 + SEO)$

CHEAPERNET Cable, 300 Meters, 100 Stations:

$R_{Tmax} = 50 \times 1.01 \times [(50 - 20) \times 0.0001 + 1] = 50.652\Omega$

$R_S = 0.0489 \times 300 [(50 - 20) \times 0.004 + 1] + 100 \times 0.0034 = 16.770\Omega$

$R_L = (50.652 + 16.770/2)/2 = 29.519\Omega$

$V_{Max} = [45 \times 1.02 + 99 \times 0.025] \times 29.519 \times 1.10$ $=$ **1571 mV**

ETHERNET Cable, 1000 Meters, 100 Stations:

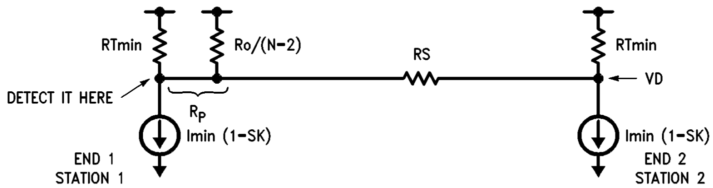
$R_{Tmax} = 50 \times 1.01 \times [(50 - 20) \times 0.0001 + 1) = 50.652\Omega$

$R_S = 0.01 \times 1000 [(50 - 20) \times 0.004 + 1] + 100 \times 0.0001 = 11.21\Omega$

$R_L = (50.652 + 11.21/2)/2 = 28.129\Omega$

$V_{Max} = [45 \times 1.02 + 99 \times 0.025] \times 28.129 \times 1.14$ $=$ **1551 mV**

Minimum Collision Level V_{Min} (MUST DETECT)—Transmit Mode



R_P = Near End Shunt Resistance
= $[Ro/(N - 2)]//R_{Tmin}$

$R_{T_{Min}} = R_T \times 0.99$

VS1(1) = Station 1's DC Voltage at End 1
= $I_{Min} \times (1 - SK) \times [R_P//(R_S + R_{Tmin})]$

VS2(2) = Station 2's DC Voltage at End 2
= $I_{Min} \times (1 - SK) \times [R_{Tmin}//(R_S + R_P)]$

VS2(1) = Station 2's DC Voltage at End 1
= $VS2(2) \times [R_P/(R_S + R_P)] \times SR$

V_{Min} = VS1(1) + VS2(1)

CHEAPERNET Cable, 300 Meters, 100 Stations:

R_P = [100k/98]//(50 × 0.99)
= 1020//49.5 = 47.209Ω

VS1(1) = 37 × 0.98 × [47.209//(16.770 + 49.5)]
= 1000 mV

VS2(2) = 37 × 0.98 × [49.5//(16.770 + 47.209)]
= 1012 mV

VS2(1) = 1012 × [47.209/(47.209 + 16.770)] × 0.97
= 724 mV

V_{Min} = 1000 + 724 = **1724 mV**

ETHERNET Cable, 1000 Meters, 100 Stations:

R_P = [100k/98]//(50 × 0.99) = 1020//49.5
= 47.209Ω

VS1(1) = 37 × 0.98 × [47.209//(11.21 + 49.5)]
= 963 mV

VS2(2) = 37 × 0.98 × [49.5//(11.21 + 47.209)]
= 972 mV

VS2(1) = 972 × [47.209/(47.209 + 11.21)] × 0.94
= 738 mV

V_{Min} = 963 + 738 = **1701 mV**

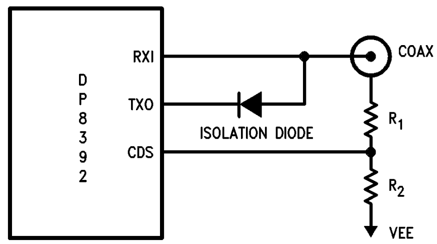
CIRCUIT IMPLEMENTATION

Table III summarizes the design parameters.

TABLE III

Parameter	ETHERNET	CHEAPERNET
L	1000 Meter	300 Meter
N	100	30
V_{Min}	1701 mV	1724 mV
V_{Max}	1551 mV	1571 mV
R_1	125Ω ±1%	150Ω ±1%
R_2	10 kΩ ±1%	10 kΩ ±1%

Circuit implementation is shown in *Figure 1*



TL/F/10445–3

FIGURE 1

To check the design, subtract the additional offset generated by the resistor divider from these levels (V_{Max} and V_{Min}) and make sure that the internal 8392 collision levels (1450 mV to 1580 mV) are within this window. The supply voltage is assumed to be 9V ± 5%.

Ethernet

$1551\ \text{mV} - 8.55\text{V}\ (125\Omega/(10\ \text{k}\Omega + 125\Omega)) = 1445\ \text{mV}$

$1701\ \text{mV} - 9.45\text{V}\ (125\Omega/10\ \text{k}\Omega + 125\Omega)) = 1584\ \text{mV}$

Cheapernet

$1571\ \text{mV} - 8.55\text{V}\ (150\Omega/(10\ \text{k}\Omega + 150\Omega) = 1445\ \text{mV}$

$1724\ \text{mV} - 9.45\text{V}\ (150\Omega/(10\ \text{k}\Omega + 150\Omega) = 1584\ \text{mV}$

These calculations show that the resistor values are properly selected.

National Semiconductor Corporation
1111 West Bardin Road
Arlington, TX 76017
Tel: 1(800) 272-9959
Fax: 1(800) 737-7018

National Semiconductor Europe
Fax: (+49) 0-180-530 85 86
Email: cnjwge@tevm2.nsc.com
Deutsch Tel: (+49) 0-180-530 85 85
English Tel: (+49) 0-180-532 78 32
Français Tel: (+49) 0-180-532 93 58
Italiano Tel: (+49) 0-180-534 16 80

National Semiconductor Hong Kong Ltd.
13th Floor, Straight Block,
Ocean Centre, 5 Canton Rd.
Tsimshatsui, Kowloon
Hong Kong
Tel: (852) 2737-1600
Fax: (852) 2736-9960

National Semiconductor Japan Ltd.
Tel: 81-043-299-2309
Fax: 81-043-299-2408