

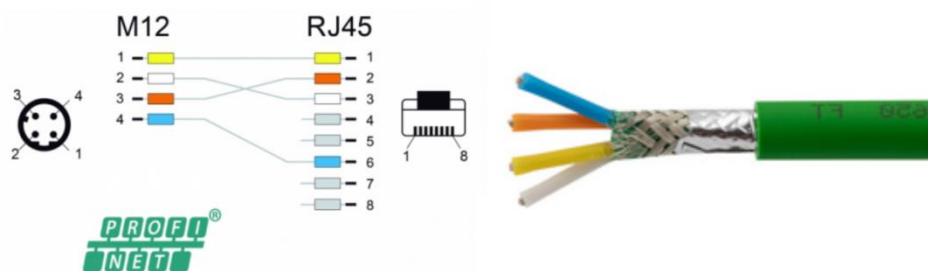
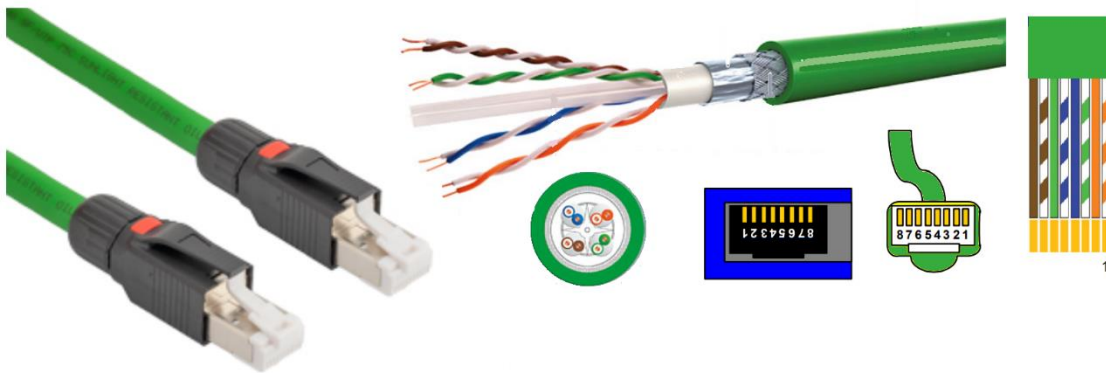
Ethernet Coupling Capacitive and Magnetic

Introduction

Copley recommends using industrial Ethernet cables and magnetic coupling between Ethernet devices. It is acceptable to consider capacitive—or even direct coupling—between Copley modules mounted on a common mounting board. We will consider a multi axis mounting board with a common ethernet “backplane” after a review of magnetics.

Ethernet Cable

Four-Pair CAT5 S/UTP (Shielded with Unshielded Twisted Pair) Ethernet devices are recommended to account for the possibility of redundancy and signal integrity in an industrial environment. It is acceptable for 100BASE-T to use Two-Pair CAT5 S/UTP for normal operation without redundancy.

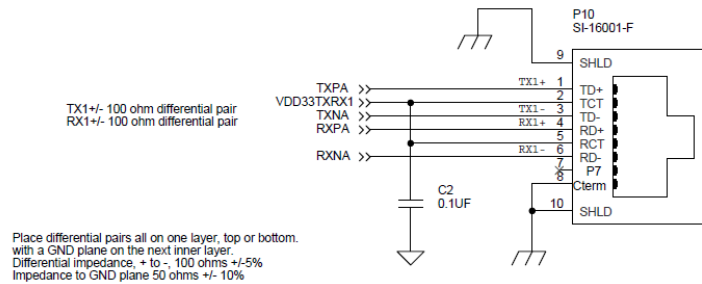


Magnetic Coupling

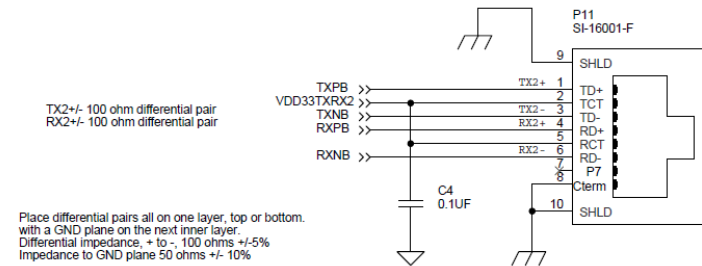
It is recommended by Copley to use magnetics when there are more than a few inches between drives. Magnetics provide good DC isolation and common mode filtering. The Nano NES DEV KIT REF (see drawings at www.copleycontrols.com) is showing RJ45 bel Magnetics Solutions 10/100 BASE-TX SI-16001-F with integrated magnetics interface to the NES module signal connector P1 (see NES datasheet at www.copleycontrols.com). The NES EZ KIT REF is showing 1X4 1.25MM PITCH pins using Halo 10/100BASE-TX magnetics TG111-S12NYNLF

NES DEV KIT REF DSGN:

EtherCAT EXTERNAL CONNECTORS (Locate on Primary Side of PCB)



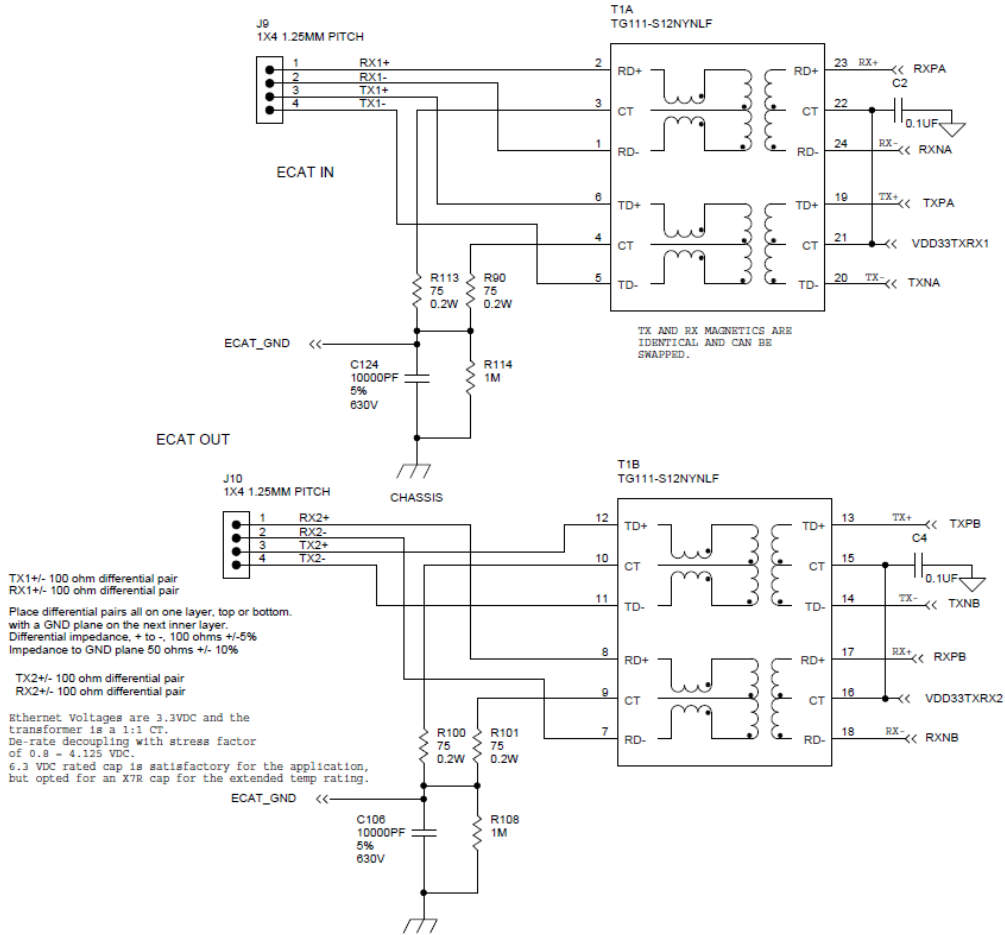
Ethernet Voltages are 3.3VDC and the transformer is a 1:1 CT.
De-rate decoupling with stress factor of 0.8 = 4.125 VDC.
6.3 VDC rated cap is satisfactory for the application, but opted for an X7R cap for the extended temp rating.



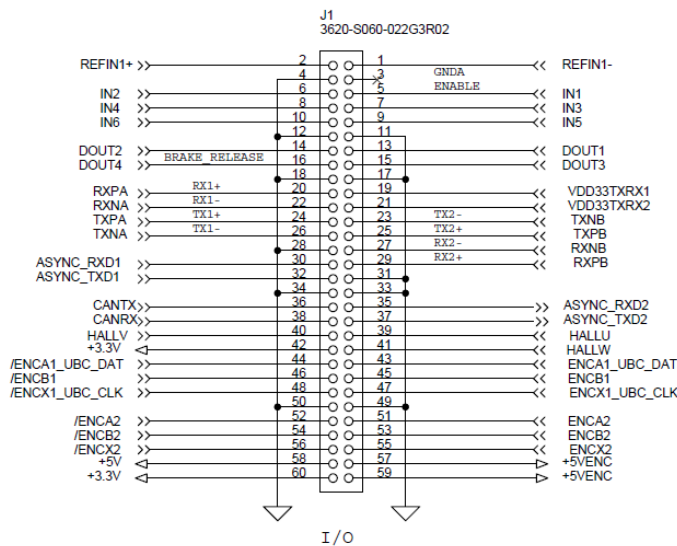
ELECTRICAL CHARACTERISTICS @ 25°C		PINS		SCHEMATIC		RJ45	
1.0 TURNS RATIO: (P6-P5-P4) : (J6-J3)	: 1CT : 1CT ± 3%	TD+ P1	J1 TX+		J2 TX-		
(P3-P2-P1) : (J2-J1)	: 1CT : 1CT ± 3%	TCT P2	J3 RX+		J4		J5
2.0 INDUCTANCE: (P6-P4)	: 350uH MIN. @ 0.1V, 100KHz, 8mA DC Bias	TD- P3	J6 RX-	J6	J7		
(P3-P1)	: 350uH MIN. @ 0.1V, 100KHz, 8mA DC Bias	RD+ P4	J7	J7	J8		
3.0 LEAKAGE INDUCTANCE: P6-P4 (WITH J6 AND J3 SHORT)	: 0.3uH MAX. @ 1MHz	RCT P5	J8	4X 75 OHMS 1000pF 2kV			
P3-P1 (WITH J2 AND J1 SHORT)	: 0.3uH MAX. @ 1MHz	RD- P6	CHASSIS GROUND P8				
4.0 INTERWINDING CAPACITANCE: (P6,P5,P4) TO (J6,J3)	: 30pF MAX. @ 1MHz	NOTES: 1.0 PINS WITHOUT ELECTRICAL CONNECTION ARE OMITTED.					
(P3,P2,P1) TO (J2,J1)	: 30pF MAX. @ 1MHz	1.1 dB TYP 18dB MIN. 60MHz TO 80MHz : 12dB MIN.					
5.0 DC RESISTANCE: (J6-J3)=(J2-J1)	: 1.2 ohms Max.	3.0 nS MAX PULSE WIDTH= 112nS : 3.0 nS MAX					
6.0 RETURN LOSS: (P6-P4)=100 OHMS AND (P1-P3)=100 OHM REF.		40 dB TYP 35dB TYP					
1MHz TO 30MHz : 18dB MIN.							
60MHz TO 80MHz : 12dB MIN.							
NOTE: 100 OHMS CONNECTED TO (J2-J1) OR (J6-J3).							
7.0 VOLTAGE WITHSTAND: (J1, J2) TO (P1, P3)	: 1500 Vrms						
(J3, J6) TO (P4,P6)	: 1500 Vrms						
8.0 INSERTION LOSS: RS=RL=100 ohms							
100kHz TO 100MHz	: 1.1 dB TYP						
9.0 RISE TIME: RS=100 OHMS AND RL = 100 OHMS							
OUTPUT VOLTAGE = 1 V peak	: 3.0 nS MAX						
PULSE WIDTH= 112nS	: 3.0 nS MAX						
10.0 CROSS TALK: 1MHz TO 100MHz	: 40 dB TYP						
11.0 COMMON TO COMMON MODE ATTENUATION:							
30MHz TO 100MHz	: 35dB TYP						

NES EZ KIT REF DSGN:

EtherCAT EXTERNAL CONNECTORS



NES DEV KIT REF DSGN J1 to NES Model P1:



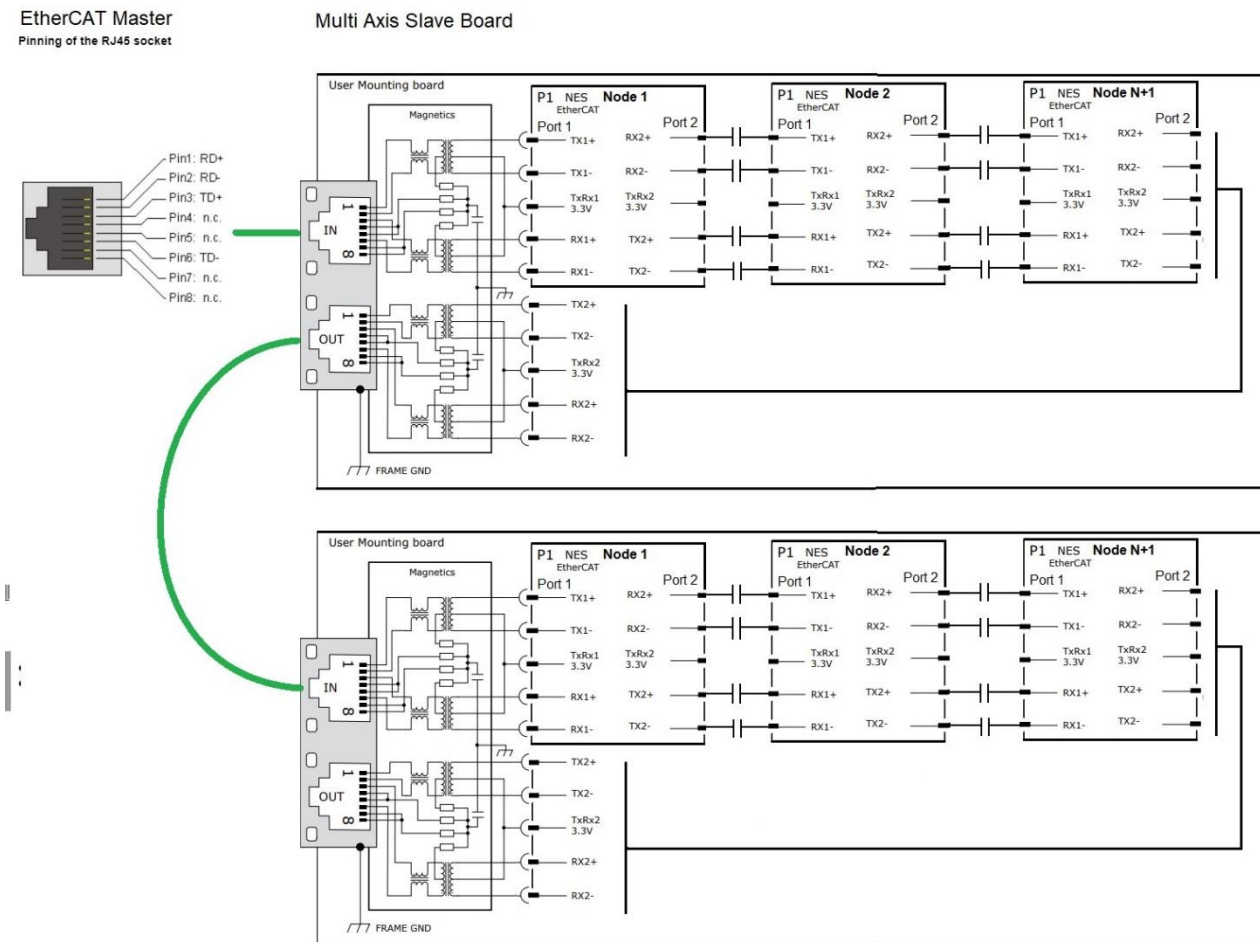
Capacitive Coupling

It is not recommended by Copley to use capacitive or direct coupling over distances greater than a few inches. However, it is acceptable to use capacitive coupling on mounting boards or backplane if good design practices are followed. As an example, two multi axis robot controllers are shown below. There are magnetics between the robot controllers and capacitive coupling between nodes on a mounting board or backplane.

NES ROBOT CONTROLER REF DSGN:

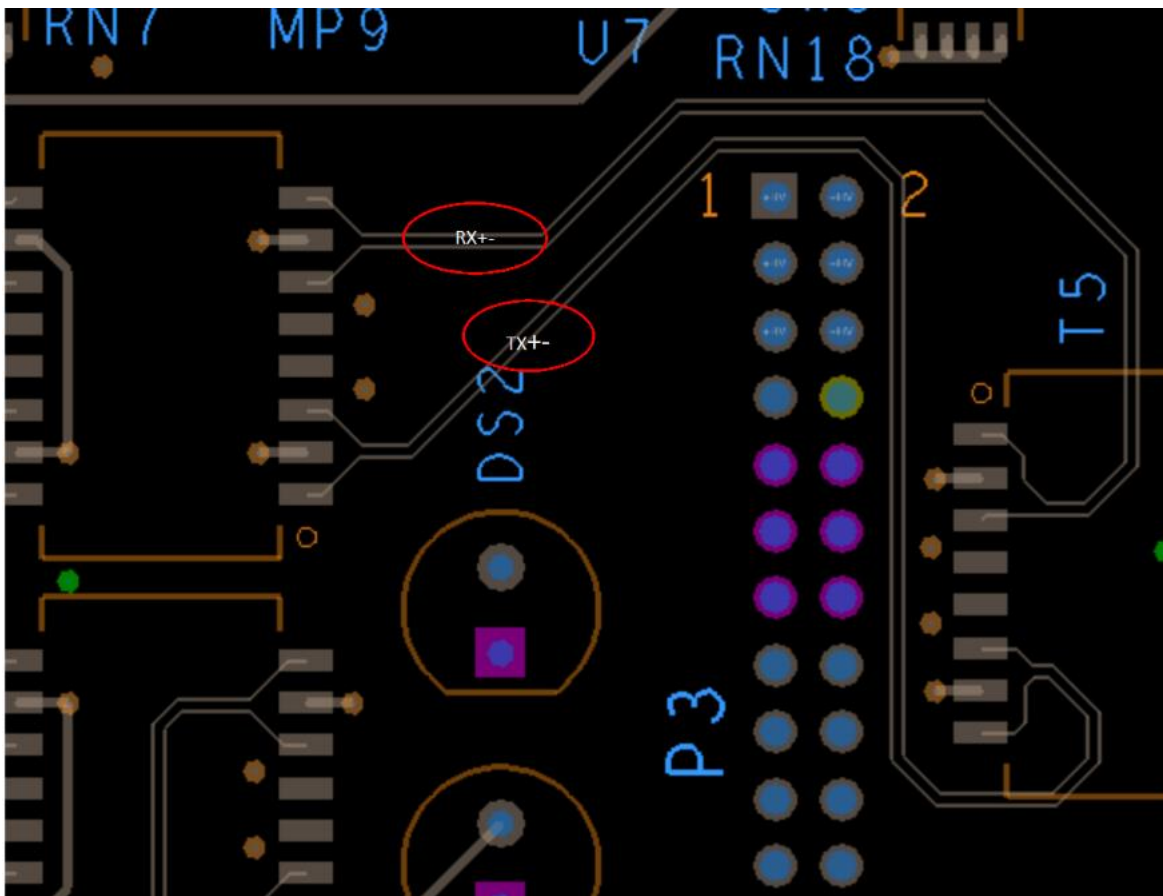
Capacitive coupling of 33nF capacitors could be used between internal connections if not using the Copley recommended magnetic coupling. The capacitor must be non-polarized, meet the AC/DC isolation requirements, and not allow difference between capacitance values. Use an NPO capacitor with 0.1% tolerance to minimize differences in capacitance. This will affect the differential signal causing deviations in signal rise and fall times, propagation delays, and common-mode noise. Follow IEEE 802.3 standards for Ethernet networks. Disable Auto-MDIX between ports with no magnetics. See Disabling Auto MDI-X section below.

A direct trace connection can be used for internal connection only when devices are sharing the same power/ground plane.



Trace Layout Rules

- TX+/- and RX+/- pairs should be routed as differential pairs.
- Different TX+/- and RX+/- pairs should be routed slightly away from each other if possible.
- Individual pairs should be routed as close together as possible with impedance control.
- Each differential pair traces should be matched in length.
- Differential pairs should be as short in length as possible.
- Differential pairs should be routed away from all other trace.
- No signals should cross unless properly separated by ground layer to avoid crosstalk.
- The use of vias and layer changes is not recommended. Keep differential pairs referenced to the same power/ground plane. If vias or layers changes become necessary, place ground, or return vias nearby to provide a short path to ground.



Disabling Auto MDI-X between ports with no magnetics

MDI (medium dependent interface) or MDI-X (medium dependent interface crossover) describes the Ethernet physical layer implementation to the physical medium used to carry the transmission. Auto MDI-X ports detect if the connection would require a crossover, and automatically chooses the MDI or MDI-X configuration to properly match the other end of the link.

0x121	RF	1	<p>Network options. This bit-mapped parameter is used to configure the amplifier's network. The details of it's meaning are dependent on the type of network implemented in the amplifier:</p> <p>EtherCAT:</p> <table border="1"> <thead> <tr> <th>Bit</th> <th>Description</th> </tr> </thead> <tbody> <tr> <td>0</td> <td>If set, disable some extra checks of the SYNC0 configuration which were added for improved network conformance.</td> </tr> <tr> <td>1</td> <td>If set, the drive will follow the EtherCAT state machine even when running in a non EtherCAT mode of operation.</td> </tr> <tr> <td>2</td> <td>If set, object 0x1002 is the bit-wise OR of all axes event status for multi-axis drives. If clear, 0x1002 is for axis 1 only.</td> </tr> <tr> <td>3</td> <td>If set, the value of parameter 0xC1 will be used as the network alias on power-up. If clear, the alias will be set from the address switches.</td> </tr> <tr> <td>4</td> <td>Disables Auto-MDIX on port 1 if set. Only available on some drives, useful when no magnetics are used between drives.</td> </tr> <tr> <td>5</td> <td>Disables Auto-MDIX on port 2 if set. Only available on some drives</td> </tr> <tr> <td>6-7</td> <td>reserved</td> </tr> <tr> <td>8</td> <td>If set. PDO mapping will be saved to flash when parameters are saved using object 0x1010</td> </tr> <tr> <td>9</td> <td>If set, use UDP command mode rather than standard EtherCAT operation.</td> </tr> <tr> <td>10-15</td> <td>reserved for future use</td> </tr> </tbody> </table> <p>Ethernet</p> <table border="1"> <thead> <tr> <th>Bit</th> <th>Description</th> </tr> </thead> <tbody> <tr> <td>0</td> <td>If set the drive will request an IP address from a DHCP server on the network</td> </tr> <tr> <td>1-8</td> <td>reserved for future use</td> </tr> <tr> <td>9</td> <td>Must be set for standard Ethernet protocols to be used</td> </tr> <tr> <td>10-15</td> <td>reserved for future use</td> </tr> </tbody> </table>	Bit	Description	0	If set, disable some extra checks of the SYNC0 configuration which were added for improved network conformance.	1	If set, the drive will follow the EtherCAT state machine even when running in a non EtherCAT mode of operation.	2	If set, object 0x1002 is the bit-wise OR of all axes event status for multi-axis drives. If clear, 0x1002 is for axis 1 only.	3	If set, the value of parameter 0xC1 will be used as the network alias on power-up. If clear, the alias will be set from the address switches.	4	Disables Auto-MDIX on port 1 if set. Only available on some drives, useful when no magnetics are used between drives.	5	Disables Auto-MDIX on port 2 if set. Only available on some drives	6-7	reserved	8	If set. PDO mapping will be saved to flash when parameters are saved using object 0x1010	9	If set, use UDP command mode rather than standard EtherCAT operation.	10-15	reserved for future use	Bit	Description	0	If set the drive will request an IP address from a DHCP server on the network	1-8	reserved for future use	9	Must be set for standard Ethernet protocols to be used	10-15	reserved for future use
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Disable unit Auto-MDIX.

node 1	set 0x121 to 0x20	Bit 5 Disables Auto MDI-X port 2
node 2 and node N	set 0x121 to 0x30	Bit 4,5 Disables Auto MDI-X port 1 and port 2
node N+1	set 0x121 to 0x10	Bit 4 Disables Auto MDI-X port 1

Revision History

Date	Version	Revision
07/13/2023	Rev 00	Initial release