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´î¤ÖDDR°O¾ÐÅéÅçÃÒt¸ü³Ð·s§K±µÀY¦¡ÅÞ¿è¤ÀªR»ö±´´ú§Þ³N

¡iBrock J.LaMeres¡j

DDR°O¾ÐÅé¤w¦¨¬°¨t²ÎDRAMªº¥Dn§Þ³N¡A¦ÓDDR¨t²Îªº ÅçÃÒ«h¬O·sªº¼Æ¦ì¨t²Î³]p¸û¨ã¬D¾Ô©Ê¥B¶O®Éªº¤n¤u¨ã¡A¦ý¦b¦¨¥»»ªÅ¶¡ªº¨îªU¡AÅÞ¿è¤ÀªR»ö±´´ú§Þ³NÅÜ¦¨¤F¤@ÓÈ±o²`«äªº°ÝÃD¡C

²z·Q¤W¡ADDRªº¥i´ú¸Õ©ÊÀ³¦¨¬°³Ì²×³]pªº¤@³¡¥÷¡A¥H§Q©ó¦b´ú¸Õ¥x¶i¡æ¨t²ÎªºÅçÃÒ¡A¦]¬°¦b¾ãÓ²£«~¥Í©R¶¡p»P©e¥~¥N¤u³£·|¼W¥[¦¨¥»¡CµM¦ÓÃª©óÅÞ¿è¤ÀªR»ö±´´úÂIªº¹q®ð-t¸ü»PªÅ¶¡»Ý¨D¡A³oºØ§@ªk½¨ì¤µ¤Ñ¤´£¥i¦æ¡C·sªº§K±µÀY¦¡ÅÞ¿è¤ÀªR»ö±´´ú§Þ³N¨ÏDDR¥i´ú¸Õ©Ê±o¥HµA¹ï¦¨¥»¡B¹q¸ôªOªÅ¶¡©Î«H¸¹§¹¾ã©Êªº¼vÅT¤Q¤À³¡C

§K±µÀY¦¡±´´ú§Þ³N

³Ìªñ¡A¤@¨ÇÅÞ¿è¤ÀªR»ö¼t°Ó±À¥X¤F¤@ºØ·sªº¡u§K±µÀY¦¡¡v(Connector-Less)´ú¸Õ±´Î¡A¥Ì±Ä¥ÎÀ£ÁY¤¬§Þ³N¡A¬Ù¥h¤F¦b¥Ø¼Ð¤W¨Ï¥Î±µÀYªº¤£«K¡C¨ú¥N±µÀYªº¬O¸m©ó«Ý´ú¹q¸ôªO¤Wªº¤pµÛ³º²k¹Ô(landing pa¡A´ú¸Õ±´Îªº¹q®ð¤¬³s·|³QÀ£ÁY¨ì³o¨Ç²k¹Ô¤W¡A¥Hºc¦¨¹q®ð±µÂI¡C®³±¼¦û±¿nªº±µÀY¡A·N¿×µÛµ²¦XÅÞ¿è¤¯à´î¤Ö´ú¸Õ±´´ÎªºÁ`t¸ü¡C¸û§Cªº´ú¸Õ±´´Î¹q®ðt¸ü(¡Õ0.7pF)¡Aªí¥Ü·í³s±µ´ú¸Õ±´´Î®É¡A«H¸¹¤£·|¨ü¨ì¹q®ðªº¤zÂZ±¨Ã¥¼¯d¦¦±µÀY¡A©Ò¥H¦b¥¼³s±µ´ú¸Õ±´´Î®É¡A¥u³Ñ¤UµÛ³º²k¹Ô¡A¦Ó³o¨Ç²k¹Ôªºt¸ü«D±`ªº¤p(¡ã80fF)¡C²{¦bp¤¤¤w¬O¹ê»Ú¥¡æªº§@ªk¡C

DDR¨t²Î´ú¸Õªº¡GªÅ¶¡B¦¨¥»¡B«H¸¹§¹¾ã¤Î¥i´ú¸Õ©Ê

DDR°O¾ÐÅé³Ì±`¨£ªº¤@ºØ¹ê§@¤è¦¡¡A´N¬O¨Ï¥Î´¡®y¦¡ªºDIMM©ÎSO-DIMM¡C¤uµ{®v±N¦hÓ184±µ¸}ªºDIMªºÀx¦s®e¶q¡C³oºØ¹ê§@¤è¦¡¨ã³Æ¤F¼u©ÊÂX¥Rªº¦n³B¡A¦]¦Ó¼sªxÀ³¥Î©ó¹q¸£¨t²Î¤¤¡C¦¹ºØ¹ê§@¤è¦¡¬Ý¦üÂ²æ¡A¹

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¦¨¥»ªº¥Dn¼vÅT¦b©ó¥²¶·´î¤Ö¥N´ú¹q¸ôªO¤Wªº¼h¼Æ¡C³\¦hDDR¨t²Î³£¬O¦b4¼hPCBªO¤W¹ê§@¡A¦Ó¥Ì¥u¦³2Ó«¦ì¦w±Æ¡A¦ýn®e¯ÇDDR¨t²Î¤]»Ýn³o¦UºØ¹q¸ôªä¹ê¬O¤@¤j¬D¾Ô¡C

¡»«H¸¹§¹¾ã©Ê

«H¸¹§¹¾ã©Ê¬O¤uµ{®v¥²¶·±¹ïªº¥t¤@Ó°ÝÃD¡C¤Ö¶qªº«H¸¹»P°ª¸ê®Æ³t²v¨ÏDDR¨t²Îªº¹ê§@ÅÜ±o«D±`§xÃø¡A
ªº±¡ªp±N·|«ùÄò¥X²{¡C

¡»¥i´ú¸Õ©Ê

³Ì«á¦ý«Ü«nªº¤@Ó°ÝÃD´N¬O¥i´ú¸Õ©Ê¡C¤uµ{®v¦b±¹ï¥H¤W©Ò¦³ªº-
¨î¤§«á¡A¨t²Î¤¤³q±`¤w¸g¨S¦³¤Ó¤jªºÅ¶¡¥i¥Hµ²¦X¥i´ú¸Õ©Ê¤F¡AµM¦Ó¥i´ú¸Õ©Ê«o¬O²£«~ÅçÃÒ»P§Ö³t¤W¥«ª
{¡C·í²£«~¦b¥Í²£¹Lµ{¤¤¦³©ÒÅÜ§ó®É¡A¥²¶·¦³¤@Ó§Ö³t¦Ó¥i¾aªº¤èªk¨ÓÅçÃÒ³o¨ÇÅÜ§ó¬O§_ïÅÜ¤F³]pªì©l¥
p¤¤¥[¤J¥i´ú¸Õ©Ê¡C±¹ï«ezªº°ÝÃD¡A§K±µÀY¦¡ÅÞ¿è¤ÀªR»ö±´´ú§Þ³N«K¯à¦³¨}¦nªº¸Ñ¨M¤èªk¡C

§K±µÀY¦¡±´´Î¦bDDRÅçÃÒªºÀ³¥Î

§K±µÀY¦¡ÅÞ¿è¤ÀªR»ö´ú¸Õ±´´Î¾A¦X¥Î©óDDR¨t²Îªº°£¿ù¡A¥Dnªº²z¥Ñ¥]¬A¦û¦ì±¿n¤p¡B³s±µ®Éªºt¸ü§C¡B¤£³s
¯à¤O¡C¬°»¡©ú³oÃÞ±´´ú§Þ³Nªº¯à¤O»P¦h¤¸©Ê¡A·í°t³Æ¦p¦w±¶Û¬ì§Þªº Soft Touchµ¥§K±µÀY¦¡´ú¸Õ±´´Î®É¡A¥

¹Ï1¬O¤@Ó¨Ï¥Î4´¡®y¡B184±µ¸}DIMMªºDDR¨t²Î¤§§G§½½d¨Ò¡C³oÓ¨t²Î§Q¥Î¦ì©ó²×ºÝ¤§¶¡ªº§K±µÀY¦¡´ú¸Õ±
ªº¤W¤è¸ô¥Ñ¡A¦Ó1x«H¸¹(¦ì§}©M±±¨î)«h¬O¦b¹q¸ôªO©³¡¥HÃÞ¦ü¤ºè¦¡¶Ç°e¡C¨C®ÚSoft Touch´ú¸Õ±´´Î©Ò¦ûªº
±¿n¡CPCB©³¡¥]§t2ÓSoft Touch¦û¦ì±¿n¡A¥i´ú¸Õ©Ò¦³ªº1x DDR«H¸¹¡C¬°ÁA¸Ñ§K±µÀY¦¡´ú¸Õ±´´Îªº¯à¤O¡A¥

§K±µÀY¦¡±´´Î¼W¥[ªºPCB±¿n¤p©ó10%

¼W¥[§K±µÀY¦¡´ú¸Õ±´´Îªº¦û¦ì±¿n¡A·|¨Ï°O¾ÐÅé¨t²Î©Ò»Ýªºª¶¡¡bX¶b¦h¥X0.39^¦T¡C´«¥y¸Ü»¡¡At¸ü²×ºÝ¹qªý¯ª
Ê¾¹IC©Ò²£¥Íªº¹q¸ôªOtrace¨ìt¸ü²×ºÝ¹qªý³Ì¥kÃäªº¬Û¹ï¡j¤p¡A¥i¥Hµo²{¨Ï¥Î§K±µÀY´ú¸Õ±´´Î©Ò¼W¥[ªºÅ¶¡¤p

§K±µÀY¦¡´ú¸Õ±´´Î¥t¤@ÓÈ±o´£¥Xªº ÀuÂI¡A´N¬Oflow-through routing¯à¤O¡CÅÞ¿è¤ÀªR»ö´ú¸Õ±´´Îªº¦û¦ì±¿n¡
´N¬O»¡¦bDDR¨t²Î¤¤¡A¤£»Ýn¨Ï¥ÎÃB¥~ªº¼h¨Óµ²¦XÅÞ¿è¤ÀªR»ö¥i´ú¸Õ©Ê¡C³o¹ï©ó¦b¼h¹q¸ôªO¤W¹ê§@ªº¨t²Î

¹q®ðªº¼vÅT

¦b¤W¤å¤¤¡AÃB¥~ªº¥i´ú¸Õ©Ê°§C¤F¨t²Îªº«H¸¹¾ã©Ê¡C¦bÅv¿Å¥i´ú¸Õ©Ê»PÁY¤pÃä¨âªÌªº«n©Ê®É¡A³oÓ°Ý
¡C¨å«¬ªº4¼hDDR¨t²Î¦bPCBªº¥~¼h¨Ï¥Î0.005^¦Tªº¹q¸ôªOtrace¼e«×¡C³o¨Ç¼h§¡³]p¦¨50£[¡A¹ï³oÃÞ·L¾É¤ù¹q¸ôªO
PªºÃB¥~t¸ü¡A½Ð¦Ò¼{³s±µ´ú¸Õ±´´Î»P¥¾³s±µ´ú¸Õ±´´Î¨âºØ±¡ªp¡C

¡»CASE 1¡G·í³s±µ´ú¸Õ±´´Î®É

¥i´ú¸Õ©Ê©Ò³y¦¨ªºÃB¥~¹q¸ôªOtrace = 0.390"

¹q¸ôªOtraceªº±H¥Í¹q®e=(0.390") x (3pF/inch) = 1.17pF

ÃB¥~ªº´ú¸Õ±´´Î¹q®e = 0.7pF (ªþµù¡G§t²k¹Ô)

¥i´ú¸Õ©Ê©Ò³y¦¨ªºÃB¥~Á`¹q®e = 1.17pF + 0.7pF = 1.87pF

¡»CASE 2¡G·í¥¼³s±µ´ú¸Õ±´´Î®É

¥i´ú¸Õ©Ê©Ò³y¦¨ªºÃB¥~¹q¸ôªOtrace = 0.390"

¹q¸ôªOtraceªº±H¥Í¹q®e=(0.390") x (3pF/inch) = 1.17pF

ÃB¥~ªº´ú¸Õ±´Î²k¹Ô¹q®e = 80fF

¥i´ú¸Õ©Ê©Ò³y¦¨ªºÃB¥~Á`¹q®e =1.17pF+ 0.08pF = 1.25pF

¬°ÁA¸Ñ³oÓ¹q®e¬O§_«n¡A¥²¶·°õ¦æ²Ä¤@¯Åªº¨t²Î¤ÀªR¡C

¡»ÅX°Ê¾¹©Ò·P´ú¨ìªºDDR¨t²Î¹q®e

ì©l¨t²Îªº¹q¸ôªOtraceÁ`ªø«× = 2.767" (ªþµù¡G¨Ï¥Î³Ìªøªº2x¹q¸ôªOtrace)

¹q¸ôªOtraceªº±H¥Í¹q®e= (2.767") x (3pF/inch) = 8.3pF

DIMMªº¶°Á`¹q®e = 5pF (ªþµù¡GDDR333¡BDQ¡BDQS¡BDM)

¶×¬y±Æ¤WªºDIMM¼Æ¶q = 4

DIMM©Ò³y¦¨ªº¹q®e = (4) x (5pF) = 20pF

DDR¨t²ÎªºÁ`¹q®e = 8.3pF + 20pF = 28.3pF

²Ä¤@¯Å¤ÀªRÅã¥Ü·í³s±µ´ú¸Õ±´´Î®É¡A¥u·¦bÅX°Ê¾¹©Ò·P´ú¨ìªº¹q®e¤¼W¥[6%¡A§ó«nªº¬O¡A·í¥¼³s±µ´ú¸Õ¡C³oªí¥Ü¦b³Ì²×ªº¥Í²£³]p¤¤¥[¤J§K±µÀY¦¡´ú¸Õ±´´Îªº¦û¦ì±¿n¡A¹ï¨t²Îªº«H¸¹§¹¾ã©Ê¨Ã¤£·|³y¦¨¤Ój ªº¼vÅT¡C¦b²£«~

¦¨¥»ªº¼vÅT

¦]¬°´ú¸ÕÂI¤£»Ý¨Ï¥Î±µÀY¡A¤º«ØªºDDR¥i´ú¸Õ©Ê¹ï©ó©Ò¦³±K¶°ªºÀ³¥Î¨Ó»¡¬O§K¶Oªº¡C·í³]p¶g´Á®É¶¡§Ö³tª ¤§¶¡¨ú±Ëªº ÃøÃD¡Cn¾Ö¦³¥i¾aªº¥i´ú¸Õ©Ê¡A°£¤FPCBªºÅ¶¡»P¨t²ÎÃä¥~¡AÁÙ»Ýn¨Æ«eªº¦Ò¼{»P³W¹º¡A©Ò© {¡CDDR¨t²Î¬O¶i¦æ³o¨Ç¤uµ{¨ú±Ëªº³Ì²Î½d¨Ò¡CnÃÒ©ú¦b³]- p¤¤µ²¦X©T©wªºÅÞ¿è¤ÀªR´ú¸ÕÂI¬O¦X²zªº¡A¨ä¹ê«D±`§xÃø¡A³o·í¤¤¯A¤Î¤F¹q¸ôªOªÅ¶¡¡B¸ô¥Ñ¼h»P±µÀY¦¨¥ Ý¥@¡A³o¶µÃÒ©ú¤u§@ÅÜ±o®e©ö¦h¤F¡C²{¦b¡ADDR¨t²Î¤w¸g¥i¦b³Ì²×³]p¤¤¶i¦æ§¹¾ã ªº´ú¸Õ¡A¨ä¹ï¨t²Îªº¤j¤p¡B

(¥»¤å§@ªÌ¥Ø«e²{¥ô¬°¦w±¶Û¬ì§ÞªºµwÅé³]p¤uµ{®v)

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