Quad Servo Decoder-Monitor – Part 1: Download Extra

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Interested in building your own QSDM?

If you would like to build your own QSDMs and associated modules, the first step is to purchase a set of printed circuit boards. In addition to the boards described so far, you will need a PCB to build a small keypad to set up the servo decoder section, as described in the original article on the QSDD (online.fliphtml5.com/buups/wpwb/index.html#p=49). If you have previously built a QSDD, you can just use the keypad you already have.

All the PCBs are available from OSH Park, a small company located in Lake Oswego, Oregon. They supply PCBs in multiples of three boards, with the cost based solely on the area of the PCB, including free shipping to any destination worldwide. You can see what OSH Park has to offer by following these links:

Quad-Servo_Decoder+Monitor	$29.75	oshpark.com/shared_projects/wSyQ3v3Y
QSDM-SetAddress	$4.55	oshpark.com/shared_projects/HtSfqW6E
QSDM-StatusView	$2.60	oshpark.com/shared_projects/s7i7xqR1
QuadServo-Keypad	$5.25	oshpark.com/shared_projects/7ATX5aqB
RJ12-RJ45-Panel	$10.95	oshpark.com/shared_projects/Y8NySuSt
RJ12-RJ45-Link	$3.65	oshpark.com/shared_projects/gjSHhLM6

A complete set of PCBs (three of each) will cost $56.75, or $51.50 if you already possess a QuadServo-Keypad.

On the OSH Park website, if you want to order a set of PCBs (in multiples of three or more), click the button labelled “Order Board” next to each, and follow instructions to set up an account with OSH Park and follow the ordering process. Your boards will be manufactured and delivered within two or three weeks depending on where you are in the world.

If you prefer to use an alternate PCB supplier, you can download a copy of the relevant file in Eagle board (.brd) format and send it to your preferred supplier.

Neither A-Train Systems nor I have any connection with OSH Park other than as a very satisfied customer of their services.

The parts required to build a complete QSDM (decoder-monitor plus keypad, including cable), and the additional units described, are listed in the two tables, [9] and [10], below.

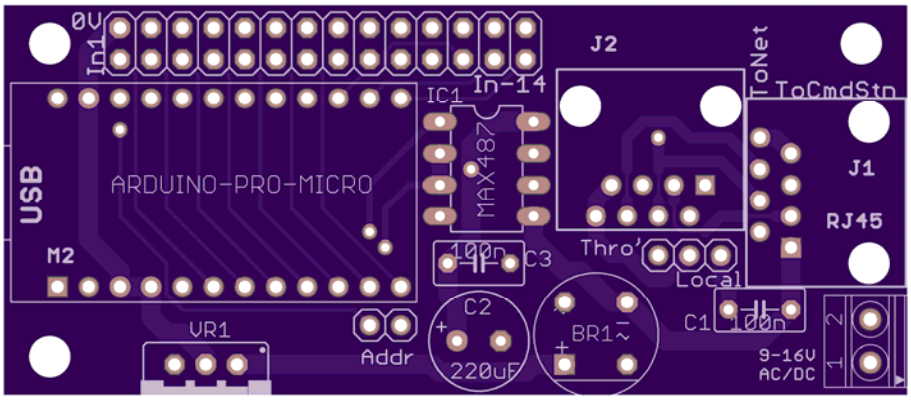
You can also build the QSDM without the decoder portion if you don’t need the quad servo decoder functions. Omit the Arduino Nano-3 Module (M1), the 6N137 optoisolator (OK1), diode D1, resistors R1 to R7, capacitors C4 and C5, and the 4x3, 5x2 and 2x1 headers next to the Nano-3, and skip the 2-position terminal block for DCC connections since the

monitor won't use it. Fitting the remaining components will provide you with a substitute for an NCE Auxiliary Input Unit.

Alternatively, if you would like to use a smaller (and cheaper) dedicated PCB to build the Monitor section on its own, then a set of three boards is available from OSH Park via the link –

Layout-Input-Monitor $18.10 oshpark.com/shared_projects/4eQ2rG2w

An outline of this board is shown in [8] below –



8. Layout-Input-Monitor board

Using the Layout-Input-Monitor PCB, as well as omitting the components mentioned above, you can also leave off capacitor C6 and the 2x1 header next to RJ45-8 socket J2, although these are still required on the larger QSDM PCB.

Part - Decoder-Monitor	Reference	Quantity	Value
Diode Bridge Rectifier	BR1	1	W01G
Capacitor - Polyester	C1, C3, C5, C6	3	100nF
" - Electrolytic	C2	1	220uF 35V
" - Disc Ceramic	C4	1	270pF
Resistor – Metal Film, 0.25 Watt	R1	1	1K2
" "	R2, R4-R7	5	10K
" "	R3	1	4K7
Diode	D1	1	1N4148
Voltage Regulator - 5 Volt	VR1	1	LM7805
Optoisolator	OK1	1	6N137
Arduino Module	M1	1	Nano-3
Arduino Module	M2	1	Pro-Micro
RS-485 Transceiver	IC1	1	MAX487CPA
Socket	J1, J2	2	RJ45-8
Terminal Block - 3.5mm pitch	DCC+Power In	2	1 x 2
Pin Header - 0.1" (2.54mm) pitch	JP1-JP4	4	1 x 3
"	JP5, JP6	2	1 x 5
"	JP7	1	1 x 2
"	JP8	1	2 x 14
"	JP9	1	1 x 2
"	JP10	1	1 x 2
"	JP11	1	1 x 3
Jumper Link Open - 0.1" pitch	-	4	
heat sink – to fit TO220 package	-	1	
CAT5/6 Ethernet Patch Cable	-	As req'd	
USB Cable - A Plug to Mini-B Plug	(Nano-3)	1	
USB Cable - A Plug to Micro-B Plug	(Pro-Micro)	1	

9. Quad Servo Decoder Monitor – List of components

Suggested suppliers for the parts listed above are RS Components (uk.rs-online.com/web/) or Farnell (uk.farnell.com/) for users in the UK, or Newark (www.newark.com/) for users in the USA (part of the same company as Farnell). Mouser (www.mouser.com/) or Digikey (www.digikey.com/) are alternative sources in the USA.

You can obtain Arduino Nano-3 and Pro-Micro modules from eBay. Alternatively, you can source the parts directly from China, using a website such as AliExpress, where you will benefit from substantially lower prices.

Part - Keypad	**Reference**	**Quantity**	**Value**
Resistor – Metal Film, 0.25 Watt	R1 – R5	5	220R
Light-Emitting Diode - Red	LED1	1	3mm Red
Light-Emitting Diode - Green	LED2 – LED5	4	3mm Green
Tactile Switch	S1 – S4	4	6mm
Socket Header - 0.1" (2.54mm) pitch	JP1	1	2 x 5
IDC Socket Ribbon Cable Connector		1	10-position (2 x 5)
IDC Plug Ribbon Cable Connector		1	Box Header (2 x 5)
Ribbon Cable – 0.05" (1.27mm) pitch		As req'd	10-conductor
Part - Set Address	**Reference**	**Quantity**	**Value**
Resistor – Metal Film, 0.25 Watt	R1	1	220R
Light-Emitting Diode - Green	LED1	1	3mm Green
Tactile Switch	S1	1	6mm
DIP Switch	S2	1	8-position
Socket Header - 0.1" (2.54mm) pitch	JP1	1	2 x 10
Part - Status View	**Reference**	**Quantity**	**Value**
Resistor – Metal Film, 0.25 Watt	R1 – R5	5	220R
Light-Emitting Diode - Red	LED1 – LED5	5	3mm Red
Socket Header - 0.1" (2.54mm) pitch	JP1	1	2 x 5
Part - RJ12-RJ45 Panel	**Reference**	**Quantity**	**Value**
Resistor – Metal Film, 0.25 Watt	R1	1	220R
Light-Emitting Diode - Green	LED1	1	3mm Green
Socket RJ12	J1, J3	2	RJ11-6
Socket RJ45	J2, J4	2	RJ45-8
Terminal Block - 3.5mm pitch	+12V Power In	1	1 x 2
Pin Header - 0.1" (2.54mm) pitch	JP1	1	1 x 3
Part - RJ12-RJ45 Link	**Reference**	**Quantity**	**Value**
Socket RJ12	J1	1	RJ11-6
Socket RJ45	J2	1	RJ45-8

10. QSDM subsidiary units – List of components

The tables below, [11] and [12], give suggested part numbers for each QSDM component from each of the listed suppliers. Click on the part number to view the relevant webpage with details of the part or, if the direct link does not work, copy the part number and paste it into the search box on the relevant supplier's website.

Ref-Decoder	RS Cmps	Farnell	Newark	Mouser	Digikey
BR1	7082668	2675385	99AC4581	625-W01G-E4	B250C1000G-E4/51GI-ND
C1, C3, C5-6	3121469	2429342	18AC7634	80-R82DC3100AA50J	399-19335-ND
C2	7111264	8126690	62W6211	80-ESK227M035AG3AA	P5166-ND
C4	7167226	2860060	57AC2084	594-S271K43SL0N6TK5R	BC2679CT-ND
R1	1650230	9341226	95W7689	71-CCF071K20GKE36	S1.2KCACT-ND
R2, R4 - R7	1651031	9341110	95W7695	71-CCF0710K0JKE36	S10KCACT-ND
R3	1650319	9341951	95W7764	71-CCF074K70GKE36	S4.7KCACT-ND
D1	7390290	2675146	05AC0533	512-1N4148	1N4148FSCT-ND
VR1	7931346	1467758	72K6018	511-L7805CV	497-1443-5-ND
OK1	8051267	2453244	31Y6274	859-6N137M	160-1791-ND
IC1	1900831	2518622	81Y9489	700-MAX487CPA	MAX487CPA+-ND
M1	eBay	eBay	eBay	eBay	eBay
M2	eBay	eBay	eBay	eBay	eBay
DCC+Power	8971332	3882615	68C9065	651-1985807	277-6043-ND
JP1 – JP4	2518632	1593422	08N6754	517-929834-01-24-RK	3M9457-24-ND
JP5, JP6	"	"	"	"	"
JP7 – JP11	"	"	"	"	"
Jumper	2518682	3226076	47AC9509	855-M7583-46	S9337-ND
RJ45 – J1, J2	2400935	1137974	56AC3196	530-SS-90000-001	277-1149868-ND
heat sink	7124257	1611415	81F046	532-507302B00	HS115-ND
CAT5/6 Cables	eBay	eBay	eBay	eBay	eBay
USB Cables	eBay	eBay	eBay	eBay	eBay
Ref-Keypad	**RS Cmps**	**Farnell**	**Newark**	**Mouser**	**Digikey**
R1 – R5	1650814	9341528	95W7736	71-CCF07220RJKE36	S220CACT-ND
LED1	1780909	1581111	14N9386	859-LTL-4211N	160-1139-ND
LED2 – LED5	1808502	1581114	14N9374	859-LTL-4231N-1	160-1958-ND
S1 – S4	3786476	1555982	95M4260	688-SKHHAM	450-1650-ND
JP1	2518222	1593490	08N6807	855-M20-7830546	S7108-ND
IDC Socket	8323483	2215247	45W6459	517-D89110-0131HK	732-2102-ND
IDC Plug	6741205	4139045	94F7977	710-61201025821	732-5452-ND
Ribbon Cable	eBay	eBay	eBay	eBay	eBay

11. QSDM and Keypad – Component supplier references

Ref-SetAddress	RS Cmps	Farnell	Newark	Mouser	Digikey
R1	1650814	9341528	95W7736	71-CCF07220RJKE36	S220CACT-ND
LED1	1808502	1581114	14N9374	859-LTL-4231N-1	160-1958-ND
S1	3786476	1555982	95M4260	688-SKHHAM	450-1650-ND
S2	1748287	2864304	60AJ4795	490-DS02C-254-1L08BE	2223-DS02C-254-1L-08BE-ND
JP1	2518244	1593494	08N6810	855-M20-7831046	S7078-ND
Ref-StatusView	**RS Cmps**	**Farnell**	**Newark**	**Mouser**	**Digikey**
R1 – R5	1650814	9341528	95W7736	71-CCF07220RJKE36	S220CACT-ND
LED1 – LED5	1780909	1581111	14N9386	859-LTL-4211N	160-1139-ND
JP1	2518222	1593490	08N6807	855-M20-7830546	S7108-ND
Ref-RJ12-45 Panel	**RS Cmps**	**Farnell**	**Newark**	**Mouser**	**Digikey**
R1	1650814	9341528	95W7736	71-CCF07220RJKE36	S220CACT-ND
LED1	1808502	1581114	14N9374	859-LTL-4231N-1	160-1958-ND
J1, J3	7350282	1137973	56AC3195	530-SS-90000-003	380-1043-ND
J2, J4	2400935	1137974	56AC3196	530-SS-90000-001	277-1149868-ND
Term Block	8971332	3882615	68C9065	651-1985807	277-6043-ND
JP1	2518632	1593422	08N6754	517-929834-01-24-RK	3M9457-24-ND
Ref-RJ12-45 Link	**RS Cmps**	**Farnell**	**Newark**	**Mouser**	**Digikey**
J1	7350282	1137973	56AC3195	530-SS-90000-003	380-1043-ND
J2	2400935	1137974	56AC3196	530-SS-90000-001	277-1149868-ND

12. QSDM subsidiary units – Component supplier references

Notes :

1. At the time of writing it is difficult to give a firm estimate for the cost of the parts listed above because of the current worldwide shortage of electronic components. Available stocks and prices fluctuate unpredictably, especially for semiconductor chips, where cost has often doubled compared to that before the Covid pandemic. However, my best estimate for the various units is given in the summary table [13].

Unit	Components	PCB	Total
Quad Servo Decoder-Monitor	$23.40	$9.92	$33.32
Keypad + Extension Cable	$6.85	$1.75	$8.60
Set Address	$2.00	$1.52	$3.52
Status View	$1.30	$0.87	$2.17
RJ12-RJ45 Panel	$4.75	$3.65	$8.40
RJ12-RJ45 Link	$2.10	$1.22	$3.32

13. QSDM units – Estimated costs

This is, I think, considerably less than the equivalent commercial items.

2. You may be able to source equivalent parts locally at a lower cost, using the details available for each suggested part by clicking on the links above (if you have sufficient electronics knowledge to understand the specifications). Although eBay is a very good source for components, especially for small quantities of passive components, headers, connectors, or hardware, you need to be wary of very low-cost parts, since these are often of low quality or may be manufacturers' substandard rejects. Similar considerations apply to buying from AliExpress.
3. Buying electronics components singly or in small quantities is much more expensive than buying in bulk (in quantities of 10 or more), so it is well worth considering carefully at the outset how many modules you might build, and then procuring all the required components in a single purchase. This will also reduce shipping charges.
4. Although you can buy individual pin headers to match all the sizes used, it is generally much cheaper to buy a single long strip of at least 24 pins, and carefully cut or snap it into the required sizes. Beware of buying the very cheapest headers on eBay, for example, since the plastic used tends to shatter easily, exposing the end pin and often failing to hold it in position.
5. The 4-position terminal block on the QSDM board is made up from two 2-position blocks since they are generally a cheaper option than purchasing a complete 4-position block.

Once you have acquired your PCBs and a full kit of components, the next step is to assemble the units you have decided to build. If you do not have any experience soldering electronic components, there are several guides available on the internet (such as at www.makerspaces.com/how-to-solder/) and on YouTube, although there is nothing to beat getting some copper stripboard from one of the component suppliers and practicing soldering wires (and a few spare components) to it before tackling the real module PCBs.

Use resin-cored solder in wire form only – never use solder with an acid flux (as sold for plumbing purposes) – and use a fine-tip soldering iron with a maximum power rating of 25 Watts (or 50 watts if the iron is temperature-controlled). All joints should be made as quickly as possible to avoid damaging the PCBs and components. The greatest enemy of electronics is heat.

Step-by-step details of the assembly and connection of the various QSDM units will be covered in Part 2 of this article.

Software for the Quad Servo Decoder-Monitor

For those not familiar with the Arduino hardware and software which form the basis for this project, the article by Geoff Bunza in the December 2016 issue of *MRH* "A modeler's introduction to the Arduino" (mrhpub.com/2016-12-dec/online/html5/index.html?page=132&noflash) provides a very good introduction.

The files provided in Bonus Extras for the December 2016 *MRH* (mrhmag.com/magazine/mrh-2016-12-dec/bonus-extras) include a guide to setting up the Arduino Integrated Development Environment (IDE) on your computer, including links to the Arduino website for downloads (www.arduino.cc/en/Main/Software) and a guide to getting started (www.arduino.cc/en/Guide/HomePage). There are also links to tutorials (create.arduino.cc/projecthub/Arduino_Genuino/getting-started-with-the-arduino-desktop-ide-623be4) and setting up the necessary hardware, including the Arduino Nano (www.arduino.cc/en/Guide/ArduinoNano) which is used here in the QSDM.

Once you have the Arduino IDE installed and set up on your computer, and you have mastered the basics by working through some of the examples supplied, you need to use the Include Library function from the Sketch menu in the IDE to add a couple of extra libraries to the system. These are the NmraDcc library (www.arduinolibraries.info/libraries/nmra-dcc) and the Bounce2 (www.arduinolibraries.info/libraries/bounce2).

Although Alex Shepherd's NceCabBus Arduino library provided the inspiration for the project, only a few of the constituent routines were required to implement the AIU functions, and I found that the library structure also made it quite difficult to add in some extra necessary functions. In the end, I decided not to use the library, but simply to write my own version of the routines within the Pro-Micro sketch.

You can now download the sketches for the Nano-3 (QuadServo_DCC-Decoder_5-3.ino) and for the Pro-Micro (QuadServo_DecoderMonitor_2-5.ino) from a special download section of my ATrain Systems website (www.a-train-systems.co.uk/qsdm-download) to any convenient folder on your computer, and then open it in the Arduino IDE.

When loading the sketch for the Pro-Micro, you should set the Board type (from the Tools menu) as 'Arduino AVR Boards/Arduino Leonardo'. The Board type for the Nano-3 is, obviously, 'Arduino Nano', and you will have to select the processor as either 'ATmega328P' or 'ATmega328P (Old Bootloader)' depending on the issue of Nano-3 module you purchased.

Check that the sketches will compile with the included libraries, by clicking the Verify button on the Arduino IDE toolbar. Any errors are most likely to be caused by the Arduino IDE failing to find the required libraries where it expects them to be, or that the Board, Processor, and Port settings under the Tools menu are not set correctly.

Part 2 of this article will cover all aspects of the necessary software upload, setup, and operation of both Arduino modules when they are connected to your NCE system.