Low cost bench-top 5/6 axis general purpose articulated robot arm

Description

The R12-500 is a complete self-contained five (optional six) axis vertically articulated robot arm system designed as a cost effective solution for bench top automation. Applications include testing, sample handling, machine feeding. The hand terminates in a mounting plate to which can be mounted one of our low cost grippers, vacuum pickups or your own device.

R12 is a very low cost entry to robotics, fast, accurate and reliable and easy to program yet capable of the most complex tasks. It has a useful 500mm reach. Designed by a young engineer building on our existing R17 technology it is a breakthrough in bench top robotics. Like the R17 it is a 5 axis articulated robot arm but with a 500mm reach. It is lighter, faster and quieter, using high efficiency digital motors driving through steel reinforced polyurethane timing belts. Optional incremental optical encoders provide exceptional integrity as well as safety (see below).

Do not let the low cost mislead you - this is not a hobby robot. It is a professional tool made to industrial standards of quality, reliability and performance, machined from solid alloy and finished with aesthetic acrylic covers. The system is supplied complete with controller, all cables, connectors, software, comprehensive manuals, ready to unpack and use immediately.

The R12 package includes the K11 controller that is simple and reliable using a partnership of CPU and DSP micro-processors and compact micro-stepping drives. ROBOFORTH II embedded software gets you started easily yet permits the most complex motions, interfaces and peripherals to be programmed, assisted by ROBWIN project manager that brings everything together on one Windows screen.

Features

5-axis articulated format, optional 6th axis

Easy mounting of tools, grippers, sensors etc

Fully enclosed; pneumatics and wiring go through the arm, not strapped to the outside.

Free simple intuitive teach pad

User friendly software, English language commands

Input/output interfacing

Non-volatile memory

Complete with controller, software, on-screen manuals, cables, etc. Ready to go

Optional incremental encoder watchdogs

Ready to run -- robot, controller, all cables, Windows GUI project manager, teach pendant

On-screen manuals

Specifications

Drives:	High power micro-stepped hybrid stepping motors, optional encoder watchdogs
Reach:	500mm/20ins in any direction; 360 degree waist rotation
Repeatability:	0.1mm (see note)
Payload:	nominal 500g, max 1Kg (2.2lbs) at flange (repeatability and speed degrade with increasing payload and reach).
Compliance: droop at 250mm at nominal payload:	0.4mm
droop at max reach with max payload:	2.3mm
Maximum speed:	Waist 220 deg/sec, Shoulder 200 deg/sec, Elbow 500deg/sec, hand 600deg/sec, wrist roll 600 deg/sec. Max linear speed approx 800mm/s. Standard Cycle 2s
Max torque for pitch or roll:	1 Nm (repeatability figures degrade with increasing torque).
Weight	Robot 12.8Kg/28lbs Controller 11kg/25lbs
Power:	110/240v ac 420VA (standard controller)
Environment:	IP 54A, 0 - 40C (wider range optional)
MTBF:	15,000 hours (typically over a million cycles)
Safety:	Class 2 stop circuit, stall detect, LED awareness barrier, optional IR workspace monitor.
Noise:	Approx 40-50dB at 1m.

note: repeatability measured as a standard deviation of all 3 dimensions at 100% speed and zero payload over 24 hours after a 1 hour warming up period. Figures for ISO 9283 available on request.

Options

Encoders

The role of the encoders (as in the R17) and as an R12 level 1 option is as watchdogs. The loop is closed after completion of each individual motion which is not the same as servo control. The R12 encoder option comprises miniature optical incremental encoders fitted to each axis.

Without encoders the R12 will run accurately and indefinitely open loop without error thanks to micro-stepping drives and accurate transmission. But if the robot suffers a collision then the controller does not know and the robot must be recalibrated. Such collisions usually only occur accidentally during programming and rarely during normal running. It is simply necessary to run the calibrate routine after such a accident. With the encoder option the controller notices the discrepancy immediately, stops the robot and announces an error. The cost of this option may be saved if budget is tight.

Sixth Axis

This is a simple solution that makes the 6th axis entirely optional as opposed to being a permanent part of the design. Using a small motor and gearbox it is accurate and tough. Programming is an extension to the Cartesian functions of RoboForth. In this way the system can ensure the end effector points in the same direction (same orientation to X Y Z axes) as the robot moves around, or indeed in any direction you choose.
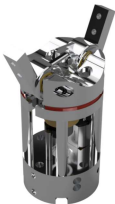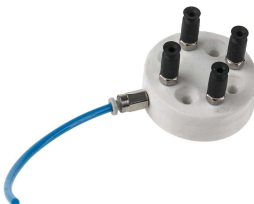
LED awareness barrier

Red LEDs shining from inside the covers catch your attention as the robot moves about and count as an additional safety measure.

Grippers

As standard the robot terminates in a mounting flange to which can be mounted an 'end effector'. Available end effectors:

P12 pneumatic gripper	E2 fulcrum action electric gripper	EG12 parallel action electric gripper	V12 vacuum pickup

Passive tool changer

If you have a range of tools possibly including your own the robot can change from one to another using our innovative tool changer.
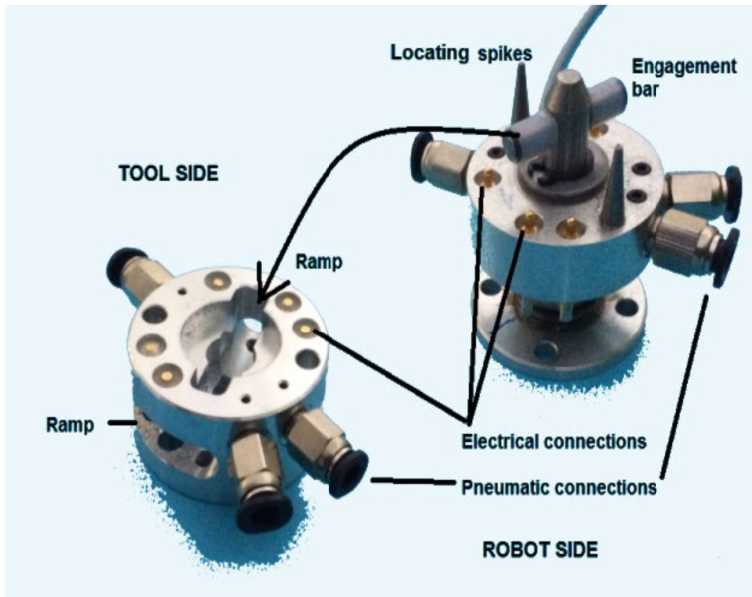

The tool changer comprises 2 parts: robot side and tool side. There has to be 1 tool side for every tool. Spare tools are located on a tool stand.

To connect to the tool the robot engages a locking bar then rotates the roll axis 90 degrees to lock in place. Spikes on the tool stand restrain the tool side during rotation. To unlock the procedure is reversed and the robot withdraws.

Linear Track

Made to order up to 3m length, using a powerful motor and two recirculating crossed roller bearings.

A non-magnetic version is also available.
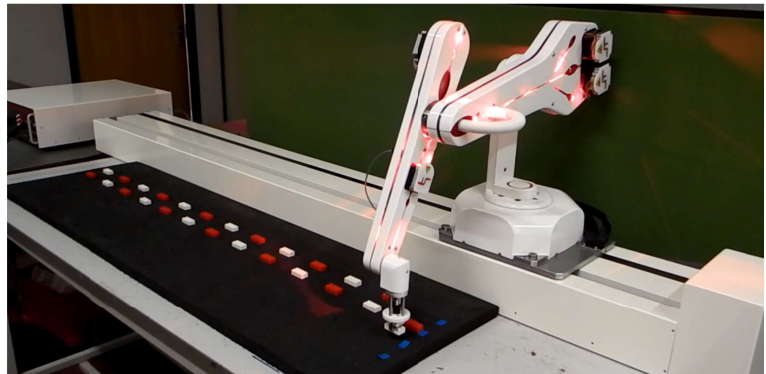
## 'Sentry' workspace safety monitor

Sentry works by having 3 IR beams across the work area. If a person or any other object intrudes into the workspace a stop signal is sent to the robot which stops at maximum deceleration. This is superior to methods involving actual collision detection such as torque trips etc because the robot never makes contact with the user.
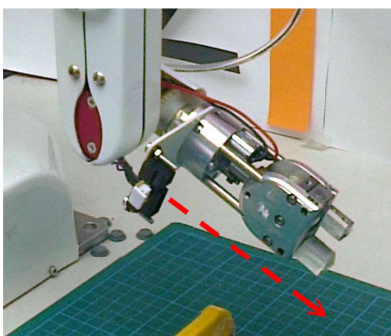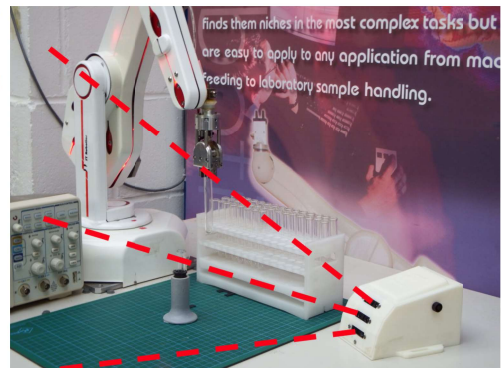
Alternatively a single sensor can be mounted directly on the robot to detect if the user gets in front of the robot's direction of travel.

Workspace

Arm comprises 2 limbs 250mm each plus 360 degrees base rotation.
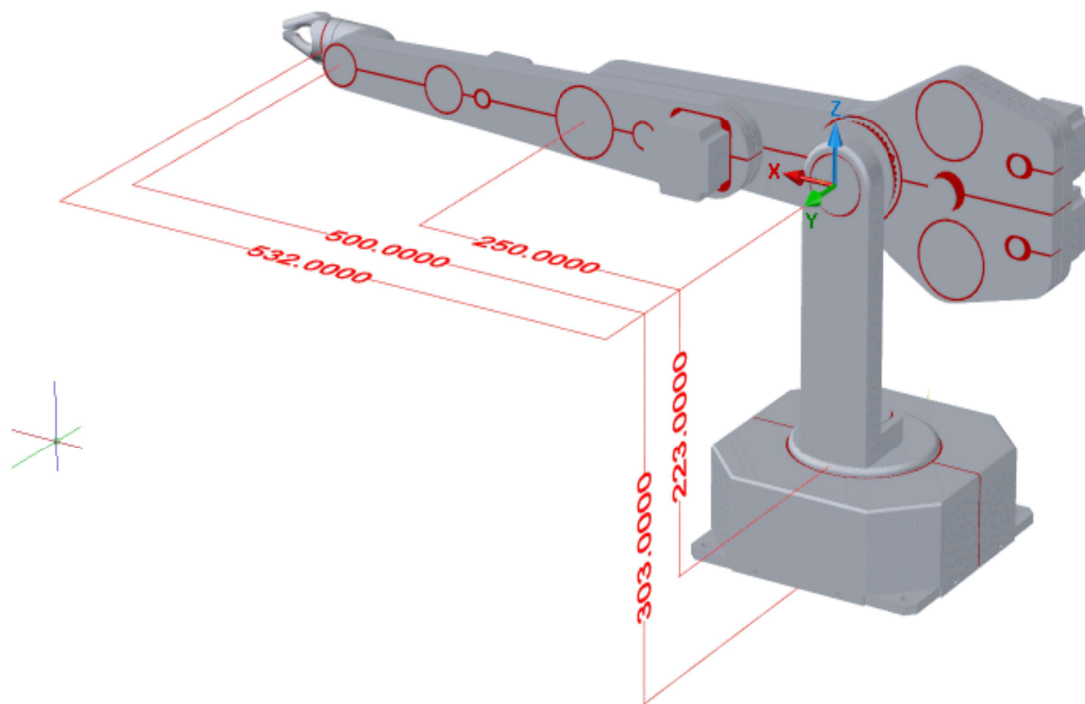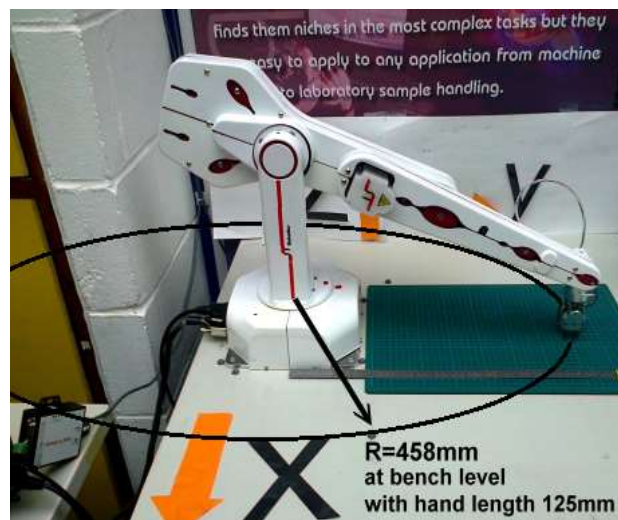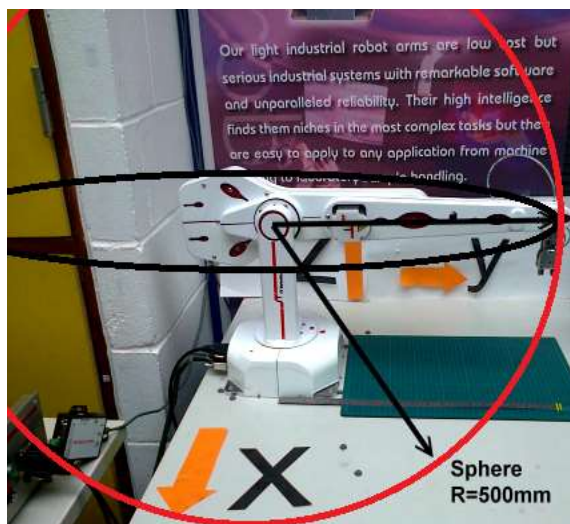

Therefore the workspace is a sphere 1000mm (40ins) in diameter.

This is measured from the center of rotation of the shoulder to the centre of rotation of the hand.

The hand will add to the total reach..

At bench level it will of course be less.

Sphere
R=500mm

R=458mm
at bench level
with hand length 125mm

The robot controller

Main Features

Multi-processor
High voltage micro-step drives
Extensive Input-Output - control everything else as well
Millisecond and microsecond timers and interrupts
External emergency stop circuit
Flash memory
Brown-out protection
Free teach pad
Connect via RS232, USB, Bluetooth or TCP/IP

Axis Drives

Axis drives are intelligent MOSFET chopper drives that energize the motors with PWM (pulse width modulated) constant current which recirculates at rest to prevent heating. Microprocessors automatically compensate for low and mid-range resonance. At low and medium speeds they vary phase current sinusoidally in a manner called micro-stepping. As speeds increase they 'morph' from micro-step to full step so that the motors maximum current rating is achieved. See the diagrams below - fig1 shows low speed sinusoidal control of position. You can see the PWM chopping. Fig2 shows the change to full step in progress.
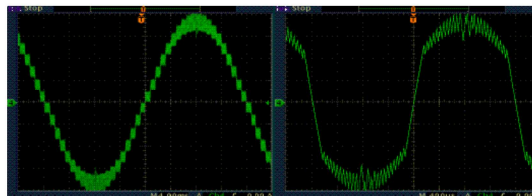
Free Teach Pendant

Although the majority of functions are invoked from the computer a simple teachpad is provided for fine positioning of the robot. The teachpad provides the means to select and move any joint or operate the gripper or any peripheral. Movement speed can be slowed right down for fine positioning of the robot.
Alternatively in Cartesian mode the teach pad allows 'jogging' in any X Y or Z direction in increments from 25mm at a time down to 0.1mm for accurate positioning, or to change the angle of pitch yaw or roll in increments from 0.1 deg to 25 deg. A desired robot pose can then be learned by pressing the tick key. A programmable function key is also provided. The stop key is linked in to the safety circuit.

Bluetooth Teach Console

The optional 7-inch tablet teach console with Android software allows the user to position the robot wirelessly using a touch screen. The Android pad connects to the controller via bluetooth. Features include the ability to jog the robot in X Y Z in increments from 0.1 to 100mm, and the hand pitch yaw and roll in increments from 0.1 to 10deg. The current Cartesian position is constantly updated on screen.
Increase/decrease increments,
Tool/World coordinates,
Grip/ungrip,
Add or delete positions in a route,
Operate peripherals,
Switch to PC and back to access higher levels,
Stop button (always live through bluetooth).

Software

Our software is called **RoboForth II** and **RobWin7**.
RoboForth is embedded in the controller flash memory. RobWin is a project manager that runs in your PC.
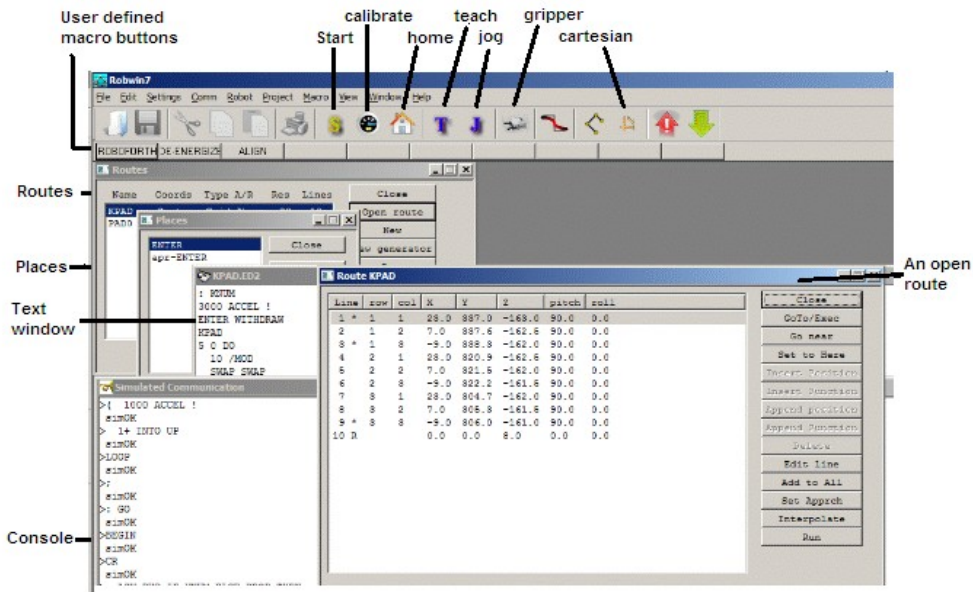
Teaching the robot

(in brief) may be achieved by choosing one of two 'entities':

1. A Route:

This is a list of spatial coordinates each of which is a row of numbers representing motors counts away from the zero (HOME) position or absolute Cartesian coordinates. The route is created by the user with his/her given name e.g. ROUTE I66. RobWin makes this simple with a dialog box that creates the entry in the controller as well as on disk. Coordinates are then added to the list by clicking 'insert position' or using the tick key on the teach pad. The robot moves from point to point with the command RUN, moving through them at optimum speed or at constant velocity. Associated commands provide editing and the ability to run parts of a route, or to retrace. A route is also used as a reference for discrete positions, for palletizing for example. Editing is achieved using dialog windows or with ROBOFORTH commands such as REPLACE which also permit self learning features, for example the robot can modify its own positions according to the programmed procedure.

A **grid** (matrix) is also a list, organized in 2 dimensions and a **row** is one-dimensional. The number of rows and columns are specified in dialog boxes. Learn the corners of the matrix and the system computes the rest of the positions and downloads them to the controller. This is useful accessing trays of items etc.

2. A Place:

This is a single named coordinate. It is self learning and self executing. It is created by the user with his/her given name using a dialog box or with a native command e.g. PLACE JIG.

To return the robot to this position later simply use the word JIG or include it in a list of other positions and actions possibly including input/output.

Finally all these learned and named entities are used in the procedure window to create new definitions or 'words' which determine how the positions are used, i.e. in what order, in what circumstances etc.

For example a word might be defined using a place named JIG and a matrix route named TRAY:

```
: GETPART
SWITCH 1 WAIT
TRAY INTO
GRIP
UP
JIG
UNGRIP
WITHDRAW
PUMP ON
1000 MSECS
PUMP OFF
;
```

Industrial users and Educational users love our software!

RoboForth and RobWin are acclaimed as being the easiest and quickest to learn robot software in the world. See these testimonials:

"The language is easy to use, especially after working on a *** or a ***. [major robot manufacturers names deleted]" – Eli Lilly Pharmaceuticals, USA

"We were all very impressed with how quickly we could get going with the robot system (especially Robwin and ROBOFORTH)" – The Technology Partnership (Cambridge, UK)

"This thing is awesome! ... 16 second video clip attached (was amazed at how easy it was to get program wrote for it). We used the added I/O to interface it with a PLC and have them working together beautifully. The documentation that you send with the robot made everything really easy to do." - Halifax CC, NC.

"We just finished the first course using the robot and everything worked great!
Students liked the robot a lot and found the programming interface easy to use and very intuitive." - Indiana Tech.

"This has been one of the best investments we have made, it does a great job for us." - Mesa Labs, USA

"I finally understand why you made RoboForth as is. It is extremely lean. When I worked with the big name robots, their robots require a ton of memory on windows to run their API... RoboForth is so lean and the performance on Linux is insanely good. There aren't any other industrial grade robots that have this kind of performance." - Waterloo University, Canada

Lab work book for educational users
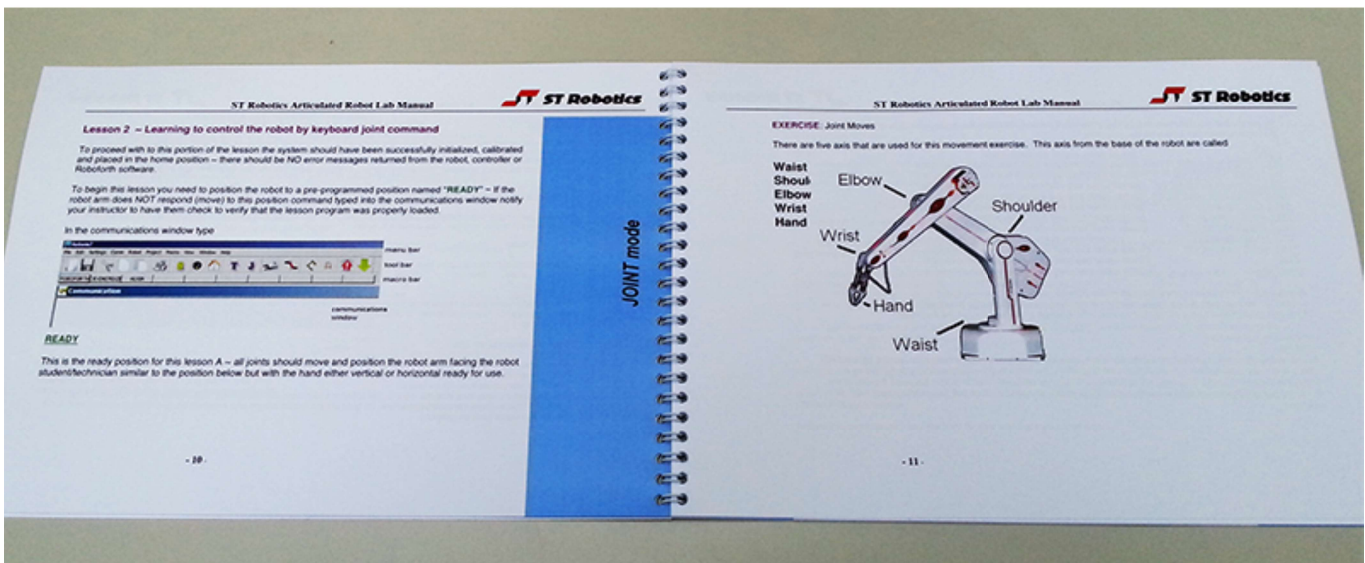
"Tell me and I will forget, show me and I will remember, involve me and I will understand"
– Aristotle