

# RouterBOARD 500r5 Series

## User's Manual

Rev. Q (14-May-2007)



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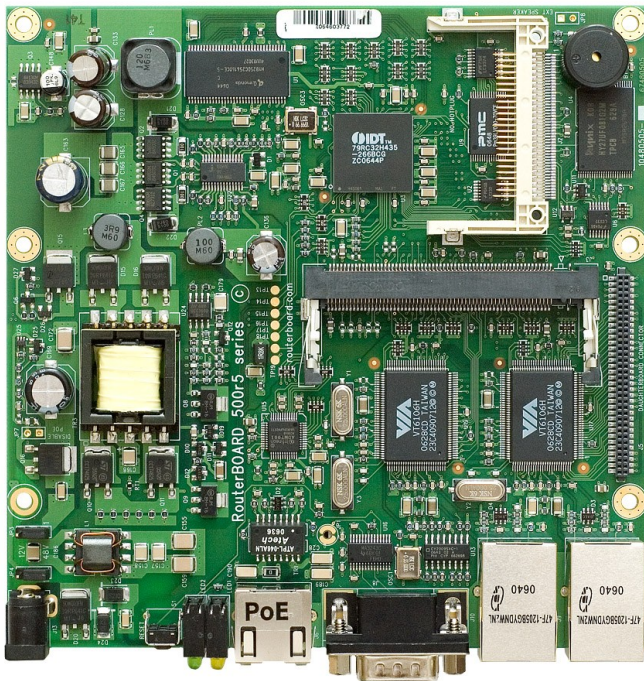
### Caution

To avoid damage of the system, use the correct DC input voltage range.

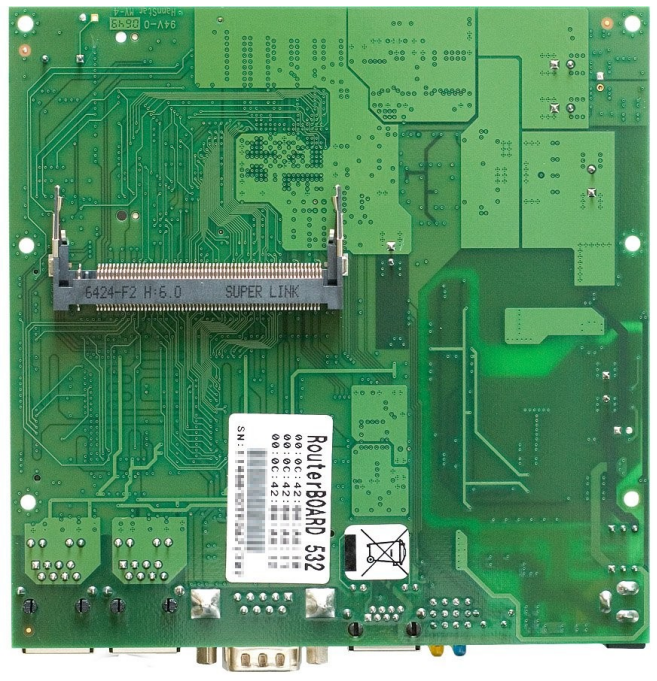
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## System Board View

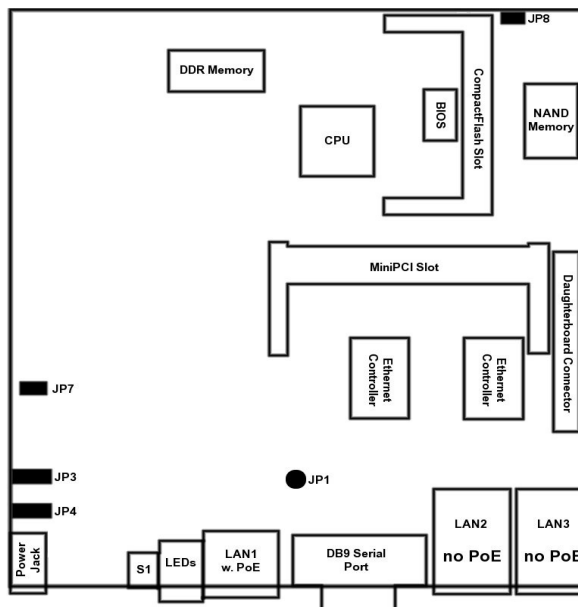


Top view



Bottom view

## System Board Layout



Note: on the other side of the board, there is only a MiniPCI connector, so no layout diagram shown.

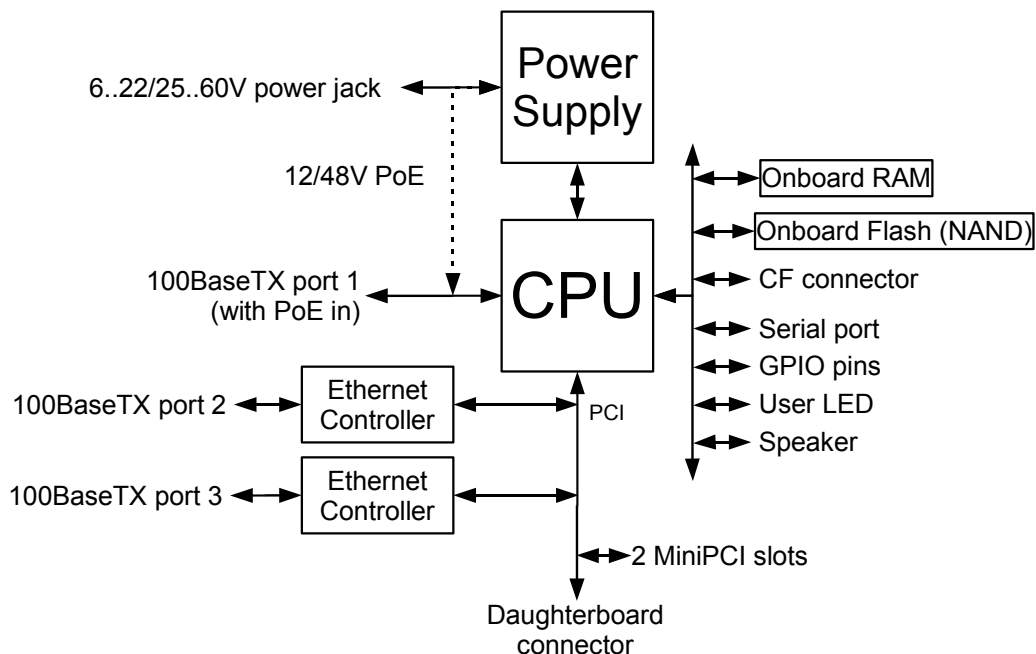
## Specifications

	RouterBOARD 532	RouterBOARD 532A
<b>CPU</b>	MIPS32 4Kc based 400MHz embedded processor	
<b>Memory</b>	32MB DDR onboard memory chip	64MB DDR onboard memory chip
<b>Boot loader</b>	RouterBOOT, 1Mbit Flash chip	
<b>Data storage</b>	128MB onboard NAND memory chip CompactFlash type I/II slot (also supports IBM/Hitachi Microdrive)	
<b>Ethernet</b>	One IDT Korina 10/100 Mbit/s Fast Ethernet port supporting Auto-MDI/X Two VIA VT6105 10/100 Mbit/s Fast Ethernet ports supporting Auto-MDI/X	
<b>MiniPCI slot</b>	Two MiniPCI Type IIIA/IIIB slots	
<b>Serial port</b>	One DB9 RS232C asynchronous serial port	
<b>LEDs</b>	Power, 2 LED pairs for MiniPCI slots, 1 user LED	
<b>Watchdog</b>	IDT internal SoC hardware watchdog timer	
<b>Speaker</b>	Mini PC-Speaker	
<b>Power options</b>	IEEE802.3af Power over Ethernet: 12V or 48V DC mode Power jack 6..22V (with overvoltage protection) or 25..60V DC - jumper selectable	
<b>Dimensions</b>	14.0 cm x 14.0 cm (5.51 in x 5.51 in)	
<b>Weight</b>	140 g (4.9 oz)	
<b>Temperature</b>	Operational: -20°C to +70°C (-4°F to 158°F)	
<b>Humidity</b>	Operational: 70% relative humidity (non-condensing)	
<b>Power consumption</b>	2-4W without extension cards, maximum - 24W (16.5W output to extension cards)	

## Daughterboard Options

	RouterBOARD 564	RouterBOARD 502
<b>Ethernet</b>	Six VIA VT6105 10/100 Mbit/s Fast Ethernet ports supporting Auto-MDI/X	No Ethernet ports
<b>MiniPCI slot</b>	Four MiniPCI Type IIIA/IIIB slots	Two MiniPCI Type IIIA/IIIB slots

## Block Diagram



# Hardware Guide

## Memory and Storage Devices

### Onboard Memory

The boards are equipped with one 32MB DDR memory chip. RB532A build version has 64MB DDR memory chip onboard.

### Onboard NAND Storage Device

The boards are equipped with one 128MB NAND nonvolatile memory chip.

### CompactFlash Interface

You can use any CompactFlash Type I or II cards, as well as IBM/Hitachi Microdrive hard drives. **Warning! The RouterBOARD 500 series boards do not support hot insert of CompactFlash/Microdrive devices.**

## Extension Slots

### MiniPCI Slot

MiniPCI Type IIIA slot has 3.3V only power signaling. This slot also accepts MiniPCI Type IIIB standard cards.

Supplied power for the extension cards (excluding CPU and onboard Ethernet ports):

+3.3V: 5A (16.5W)

## Input/Output Ports

### LAN1 Port with PoE

This Fast Ethernet port is recognized as first LAN interface in most OSs. It is fully compatible with IEEE802.3af Power over Ethernet standard and passive PoE (non-standard). The board accepts either 12 or 48 V DC input voltage according to the configuration. To use standard PoE power option on this interface, switch jumpers JP3 and JP4 to the **1-2** position. The PoE input can also be switched to 12V non-standard PoE powering (switching JP3 and JP4 to the **2-3** position).

The RouterBOARD 51 power injector may be used to power the board with up to 100m (330 ft) long Ethernet cable.

See **Connector Index** for pinout of the standard cable required for PoE. All cables made to EIA/TIA 568A/B cable specifications will work correctly with PoE. Note that this port supports automatic cross/straight cable correction (Auto MDI/X), so you can use either straight or cross-over cable for connecting to other network devices.

### LAN2 Port

This Fast Ethernet port is recognized as second LAN interface in most OSs. This port does not support Power over Ethernet.

See **Connector Index** for pinout of the standard cable. Note that this port supports automatic cross/straight cable correction (Auto MDI/X), so you can use either straight or cross-over cable for connecting to other network devices.

### LAN3 Port

This Fast Ethernet port is recognized as third LAN interface in most OSs. This port does not support Power over Ethernet.

See **Connector Index** for pinout of the standard cable. Note that this port supports automatic cross/straight cable correction (Auto MDI/X), so you can use either straight or cross-over cable for connecting to other network devices.

### DB9 Serial Port

The RS232C standard male DB9 asynchronous serial port may be used for initial configuration, or for

attaching a modem or any other RS232 serial device. TxD (pin 3) of this port has -12V DC power when idle.

## LEDs

### Power LED

LED is on when the board is powered

### User LED

User LED may be programmed at user's option. See **RouterBOARD 500 SDK** for more details.

### MiniPCI LEDs

2 pairs of MiniPCI LEDs are connected to MiniPCI slots (two LEDs per slot) according to standards.

## User's Guide

### Assembling the Hardware

First to use the board:

- In most cases you do not need to use any additional boot devices, as you can boot the RouterBOARD from the onboard NAND memory. You can also install a CompactFlash module or Microdrive hard drive, which you can use as an alternative boot device or an additional storage medium. **Warning! The RouterBOARD 500 series does not support hot insert of CompactFlash/Microdrive devices.**
- Configure jumpers. The board should have 2 jumpers already set in some positions. See the following section on how to choose the appropriate setting. Also the Jumper Index chapter of this manual describes all possible jumper positions
- Insert MiniPCI cards on the board itself, and on the Daughterboard if you have one
- Install the board in a case. Connect and secure the Daughterboard on top of it if you have one
- Connect other peripherals and cables

You can also order a pre-assembled system with RouterBOARD and extension cards of your choice already installed in a case.

## Grounding

Use pan head machine screws of correct diameter; internal star lock washers are recommended. Make sure all mounting holes on the board are connected (if you do not use MikroTik's standard mounting cases, which provide the connection by design) and provide a proper grounding from them to the grounding terminal (resistance of this connection must be less or equal to 1  $\Omega$ ). As an alternative, we can recommend using industrial made EMI suppressor or ferrite bead on UTP cable connected to the Ethernet port 1 on the board. Place it as close to the Ethernet connector as possible. At least two windings are recommended if ferrite bead is used. In case STP cable is used to connect the board, EMI suppressor/bead is not necessary but proper connection of the cable's shield to the grounding terminal must be ensured.

## Powering

Power options:

- J13 power jack:  
6..22V or 25..60V DC
- IEEE802.3af Power over Ethernet (PoE) on the first Ethernet port:  
48V DC  
12V DC non-standard PoE powering support

RouterBOARD 500 series boards are equipped with a reliable 24W onboard power supply that accepts a wide range of input voltage from either the power jack (5.5mm outside and 2mm inside diameter, female, pin positive plug) or the first Ethernet port. Both power inputs are always active. JP3 and JP4 choose input voltage (**1-2** for 25..60V DC, **2-3** for 6..22V DC). Note that because of wire resistance, PoE requires higher voltage (it is recommended to use 11V minimum). The low voltage mode has overvoltage protection circuit, so you will not damage the board if jumpers are set incorrectly, but the power is within 6..60 V DC range.

RouterBOARD 500 series boards are compliant with IEEE802.3af Power over Ethernet standard and accept



48V powering over up to 100m (330 ft) long Ethernet cable connected to the first Ethernet port (J6). The board also accepts 12V DC (or any other within the 11..22V range) non-standard PoE input voltage (see note above on how to use it).

### Booting options

First, RouterBOOT loader is started. It displays some useful information on the onboard RS232C asynchronous serial port, which is set to 115200bit/s, 8 data bits, 1 stop bit, no parity, hardware (RTS/CTS) flow control by default. The loader may be configured to boot the system from the onboard NAND module, an internal storage device, or from Ethernet network. See the respective section of this manual for how to configure booting sequence and other boot loader parameters.

### Onboard NAND Storage Device

The RouterBOARD may be started from the onboard NAND storage chip. As there is no partition table on the device, the boot loader assumes the first 4MiB form a YAFFS filesystem, and executes the file called "kernel" stored in the root directory on that partition. It is possible to partition the rest of the medium by patching the kernel source.

### Internal Storage Device

The RouterBOARD may be started from a CompactFlash module or a Microdrive hard drive. At least two partitions must exist on the device, first of which being the ELF image the board is to be booted from (normally, it is a Linux kernel, appended with the *kernparm* ELF section that specifies the root partition name and, optionally, other kernel parameters of your choice).

### Booting from network

Network boot works similarly to PXE or EtherBoot protocol, and allows you to boot the RouterBOARD 500 series computer from an executable image stored on a TFTP server. It uses BOOTP or DHCP (configurable in boot loader) protocol to get a valid IP address, and TFTP protocol to download an executable (ELF) kernel image combined with the initial RAM disk (inserted as an ELF section) to boot from (the server's IP address and the image name must be sent by the BOOTP/DHCP server).

To boot the RouterBOARD computer from Ethernet network you need the following:

- An ELF kernel image for the loader to boot from (you can embed the kernel parameters and *initrd* image as ELF sections called *kernparm* and *initrd* respectively)
- A TFTP server which to download the image from
- A BOOTP/DHCP server (may be installed on the same machine as the TFTP server) to give an IP address, TFTP server address and boot image name

See the RouterBOOT section on how to configure loader to boot from network.

Note that you must connect the RouterBOARD you want to boot, and the BOOTP/DHCP and TFTP servers to the same broadcast domain (i.e., there must not be any routers between them).

## Operating System Support

### System Architecture

RouterBOARD 500 series embedded boards are fully compatible with the standard MIPS32 architecture with PCI bus.

**CPU.** RouterBOARD 500 series has MIPS32 little-endian based embedded processor using MIPS 4Kc CPU core. It is fully binary-compatible with all software developed for MIPS32 little-endian (mipsel) instruction set architecture. The MIPS 4Kc core includes TLB Memory Management Unit and does not include Float Point Unit (so it is optimized for integer operations).

**Ethernet.** RouterBOARD 500 series has three onboard Ethernet ports. The first port is controlled by IDT Korina MAC embedded in the CPU and ADMtek PHY chip. The second and the third Ethernet ports are controlled by VIA VT6105 integrated MAC/PHY chips.

The **RouterBOARD 500 SDK** describes programming **LED, Watchdog, JP1 jumper and S1 button**.

### MikroTik RouterOS

MikroTik RouterOS (special RouterBOARD 500 edition, starting from version 2.9) is fully compatible with RouterBOARD 500 series embedded boards.

No additional patches required.

## Linux

RouterBOOT is tested to boot DELO Linux loader (other Linux loaders may also work). Linux kernel 2.4 was tested.

A special Linux kernel patch is needed for the board to boot and work correctly. It is available from [www.routerboard.com](http://www.routerboard.com)

## RouterBOOT

The RouterBOOT firmware (also referred as "boot loader" here) provides minimal functionality to boot an Operating System. It supports serial console via the onboard serial port at the boot time. The loader supports booting from the onboard NAND device, CompactFlash or IBM Microdrive, and from a network server (see the respective section for details on this protocol).

Supported OSs:

- MikroTik RouterOS starting with version 2.9
- GNU/Linux

## Boot Loader Configuration

Loader parameters may be configured through the onboard RS232C DB9 asynchronous serial interface. To connect to it, use a standard null-modem cable. By default, the port is set to 115200bit/s, 8 data bits, 1 stop bit, no parity, hardware (RTS/CTS) flow control. **Note** that some null-modem cables do not implement or implement incompletely the hardware (RTS/CTS) flow control, so it is suggested to try to disable hardware flow control in the terminal emulation program in case the serial console does not work as expected, and if it does not help, make a new cable using the pinout given in the Appendix.

To enter the loader configuration screen, press any key (or only [Delete] key (or [Backspace] key – see the note for the respective configurable option), depending on the actual configuration) just after the loader is asking for it:

```
RouterBOOT booter 2.7
```

```
RouterBoard 532
```

```
CPU frequency: 399 MHz
Memory size: 32 MB
```

Press any key within 2 seconds to enter setup.

```
RouterBOOT-2.7
```

```
What do you want to configure?
```

```
d - boot delay
k - boot key
s - serial console
o - boot device
u - cpu mode
f - try cpu frequency
c - keep cpu frequency
r - reset configuration
e - format nand
g - upgrade firmware
i - board info
p - boot protocol
t - do memory testing
x - exit setup
```

```
your choice:
```

To select a menu point, press the key written at the beginning of this line. Pressing [Enter] selects the option marked with '\*'.



## Configurable Options

**boot delay** – how much time to wait for a key stroke while booting (1..10 seconds; **1 second** by default).

**boot key** – which key will cause the loader to enter configuration mode during **boot delay** (any key | <Delete> key only; **any key** by default). Note that in some serial terminal programs, it is impossible to use the [Delete] key to enter the setup – in this case it might be possible to do this with the [Backspace] key.

**serial console** – to configure initial serial console bitrate (1200 | 2400 | 4800 | 9600 | 19200 | 38400 | 57600 | 115200; **115200** bps by default).

**boot device** – initial boot device (Etherboot | boot from NAND | boot from CF | boot Ethernet once, then NAND | boot Ethernet once, then CF; **boot from NAND** by default). You can also select **boot chosen device** option to boot from the device selected immediately, without saving the setting.

**cpu mode** – whether to enter CPU suspend mode on HLT instruction (power save | regular; **power save** by default). Most OSs use HLT instruction during CPU idle cycle. When CPU is in suspend mode, it consumes less power, but in low-temperature conditions (below 0°C) it is recommended to choose regular mode, so that overall system temperature would be higher.

**try cpu frequency** – try this CPU frequency on the next power cycle (199MHz | 266MHz | 333MHz | 399MHz; **399MHz** by default).

**keep cpu frequency** – permanently set the current CPU frequency (not the one set, but the one actually active).

**reset configuration** – whether to reset all the boot loader settings to their respective default values (yes | no; **no** by default).

**format nand** – perform a low-level NAND format. During this operation, all previously marked bad sectors are retested to find out if they are faulty indeed.

**upgrade firmware** – receive a new boot loader image using XModem protocol over serial line or using DHCP/BOOTP and TFTP protocols through the Ethernet network (upgrade firmware over ethernet | upgrade firmware over serial port).

**board info** – prints the serial number, boot loader version, CPU frequency, memory size and MAC addresses of the onboard Ethernet ports

**boot protocol** – network booting protocol (bootp protocol | dhcp protocol; **bootp protocol** by default).

**do memory testing** – performs a full memory test.

## Changing CPU Frequency

By default, the RouterBOARD 500 series boards are equipped with the processors, tested at 400MHz clock frequency, but you can select a lower frequency (200, 266 or 333) if the system is not cooled sufficiently and the heat, dissipated by the CPU, causes the system to overheat and work unstable. The bootloader is made so that you must first try a different frequency before it could be set permanently, and if you do not apply a frequency permanently, it would fall back to the previous setting on the next power cycle.

## Boot Loader Upgrading

The boot loader is needed to initialize all the hardware and boot the system up. Newer loader versions might have support for more hardware, so it's generally a good idea to upgrade the loader once a newer version is available. You can upgrade the loader through the onboard serial port using XModem protocol (programs available for all major OSs). For example, you can use HyperTerminal for Windows or Minicom for Linux to upload the boot loader. Alternatively if you have a DHCP/BOOTP and TFTP servers available, you can specify the loader image as a boot image and choose the **bios upgrade over ethernet** option in the boot loader configuration menu. The loader will get the image from the TFTP server and upgrade itself. The most current loader image is available for download on [www.routerboard.com](http://www.routerboard.com).

The boot loader upgrading is supported also from MikroTik RouterOS. The procedure is described in the MikroTik RouterOS manual.

Should the upgrade fail, you may try loading secondary boot loader, by turning the board on while the S1 button is pressed. If that works, you should try upgrading the loader again.

## Appendix

### Connector Index

J2	CompactFlash type I/II (with Microdrive support) slot
J3	MiniPCI Type type IIIA/B connector 1 (top side)
J4	MiniPCI Type type IIIA/B connector 2 (bottom side)
J5	RouterBOARD 500 daughterboard connector (proprietary pinout)
J6	RJ45 Fast Ethernet 100Base-TX port 1 with IEEE802.3af PoE extension
	1 Data TX+
	2 Data TX-
	3 Data RX+
	4 PoE power +
	5 PoE power +
	6 Data RX-
	7 PoE power -
8 PoE power -	
J8	RS232C male DB9 serial port
	2 RxD (Receive Data)
	3 TxD (Transmit Data)
	5 GND
	7 RTS (Request to Send)
8 CTS (Clear to Send)	
J9	RJ45 Fast Ethernet 100Base-TX port 2
	1 Data TX+
	2 Data TX-
	3 Data RX+
6 Data RX-	
J10	RJ45 Fast Ethernet 100Base-TX port 3
	1 Data TX+
	2 Data TX-
	3 Data RX+
6 Data RX-	
J13	Power jack (6..22V or 25..60V DC, positive contact is the central pin)
JP8	External speaker connector

## Jumper Index

JP1	User-defined jumper (GPIO3 / CTS signal – only useful when serial port is not used)	
JP3 JP4	Input voltage select	
	1-2	48V mode (25..60V DC)
	2-3	12V mode (6..22V DC), with overvoltage protection

## Button Index

S1	During the boot loader initialization, loads the secondary boot loader (in case the primary loader is damaged). User-defined button (GPIO1 / RxD signal – only useful when serial port is not used)
----	---

## Ethernet Cables

RJ45 Pin	Color	Function	RJ45 pin for Straight cable (MDI, EIA/TIA568A)	RJ45 pin for Crossover cable (MDI-X, EIA/TIA568B)
1	Green	TX+ Data	1	3
2	Green/White	TX- Data	2	6
3	Orange	RX+ Data	3	1
4	Blue	-	4	4
5	Blue/White	-	5	5
6	Orange/White	RX- Data	6	2
7	Brown	-	7	7
8	Brown/White	-	8	8

## Full Serial Null-modem (Console) Cable

DB9f	Function	DB9f	DB25f
1 + 6	CD+DSR	4	20
2	RxD	3	2
3	TxD	2	3
4	DTR	1 + 6	6 + 8
5	GND	5	7
7	RTS	8	5
8	CTS	7	4