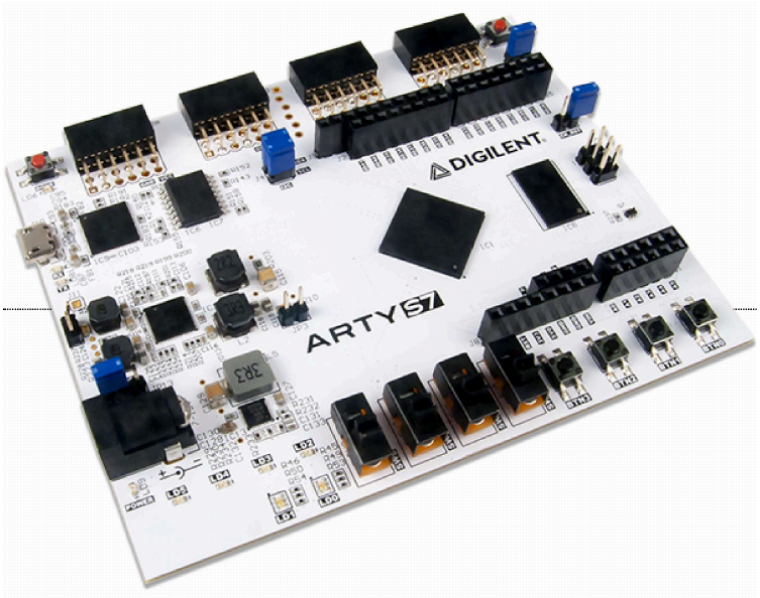
Linux at the Arty S7-50 serial port

A standalone MicroBlaze Linux console for the Digilent Spartan-7 board.



Arty S7 board family, pictured in the Digilent Arty S7 Reference Manual, page 1. The IronForge target is the S7-50. USB connector J10 carries JTAG and the serial console.

Platform	Engineering configuration
FPGA	AMD Spartan-7 XC7S50, CSGA324, speed grade −1
Processor	100 MHz little-endian MicroBlaze with an MMU and instruction and data caches
Memory	256 MiB DDR3L on a 16-bit bus
Boot	USB JTAG for development and 16 MiB SPI NOR for standalone operation
Console	AXI UARTLite over USB, 115200 baud, 8 data bits, no parity, one stop bit
Software	Linux 7.3.4 and statically linked BusyBox 1.38.0

From reset to shell

In Master SPI mode the FPGA reads its configuration from flash. Once DDR calibration completes, MicroBlaze starts in block RAM. The first stage loads U-Boot 2026.10 from SPI. U-Boot gives the operator five seconds to interrupt autoboot on the USB serial console. When the countdown expires, U-Boot reads the compressed kernel, device tree and RAM filesystem from SPI and starts Linux. The kernel unpacks the LZ4 initramfs, and init starts an interactive shell on the USB serial port.

U-Boot settings persist in two 64 KiB SPI environment sectors. The Linux filesystem lives in RAM. A reboot restores its packaged contents. The console starts without DHCP, a boot server or a login key. The engineering shell has root privileges for board bring-up.

Boot path	Operator workflow
JTAG	Load the FPGA design and the three RAM payloads through the programming cable. Open the USB UART to interact with Linux.
SPI	Program the complete flash image, select SPI boot, and power on. Attach the serial terminal to see the prompt.

Minimal console boot time from QSPI flash

20.45 seconds elapsed from the first-stage loader banner to the first interactive BusyBox prompt during a standalone SPI restart. The host timed both messages on COM8. This interval includes U-Boot's five-second countdown, flash reads, kernel decompression and Linux startup. The board uses its 16 MiB QSPI NOR in single-bit SPI mode. Power-on and FPGA configuration precede the first serial message and were outside the measurement.

Measurement	Result	Timing reference
First loader banner to BusyBox prompt	20.45 s	Host serial capture, SPI restart
Interruptible U-Boot countdown	5 s	Configured delay, observed counting from 5 to 0
Linux starts `/init`	4.39 s	Kernel timestamp, separate cold boot
Shell answers the first command sequence	4.90 s	Linux uptime sampled by the shell, same cold boot

The kernel and shell times share the Linux uptime clock and fall within boot. A separate persistence test interrupted autoboot, saved a setting in SPI, verified it after restart and cleared the test setting.

At the console

Run `uname -r` for the kernel release, `cat /proc/cpuinfo` for processor details, `free` for available memory and `mount` for the active filesystems.

Boot traces from the serial console

First stage and U-Boot during SPI restart

Selected COM8 lines show the loader, saved environment, countdown endpoints and reads of the kernel, device tree and BusyBox initramfs, in that order.

```
IronForge S7 SPI
Starting U-Boot
U-Boot 2026.10 (Nov 21 2026 - 18:10:58 +0000)
SF: Detected s25fl128s with page size 256 Bytes, erase size 64 KiB, total 16 MiB
Loading Environment from SPIFlash... OK
Hit any key to stop autoboot: 5
Hit any key to stop autoboot: 0
SF: 1280031 bytes @ 0x4e0000 Read: OK
SF: 8060 bytes @ 0x7e0000 Read: OK
SF: 609683 bytes @ 0x7f0000 Read: OK
   Verifying Checksum ... OK
   Uncompressing Kernel Image to 80000000
Starting kernel ...
```

Linux and BusyBox during cold boot

Selected lines from the physical power-cycle test show Linux unpacking the RAM filesystem and starting the shell. The serial test then read the kernel release, uptime and mounts and printed its completion marker.

```
[    0.402226] Unpacking initramfs...
[    1.804905] Freeing initrd memory: 592K
[    4.387740] Run /init as init process
IronForge Arty S7-50 | BusyBox serial console
starting pid 20, tty '/dev/ttyUL0': '/bin/sh -i'
BusyBox v1.38.0 (2026-11-21 17:31:35 UTC) built-in shell (ash)
7.3.4
4.90 0.14
rootfs / rootfs rw,size=127972k,nr_inodes=31993 0 0
S7_SERIAL_PASS
#
```

Bootloader and flash reads

These three terminal screens replay consecutive lines from the measured COM8 SPI restart. Serial output begins after FPGA configuration.

```
IronForge S7 SPI
Starting U-Boot
U-Boot 2026.10 (Nov 21 2026 - 18:10:58 +0000)
Model: IronForge Arty S7-50
DRAM:  256 MiB
Core:  6 devices, 6 uclasses, devicetree: embed
Loading Environment from SPIFlash...
SF: Detected s25fl128s with page size 256 Bytes, erase size 64 KiB, total 16 MiB
Loading Environment from SPIFlash... OK
In:    serial
Out:   serial
Err:   serial
Model: IronForge Arty S7-50
Hit any key to stop autoboot: 5
Hit any key to stop autoboot: 4
Hit any key to stop autoboot: 3
Hit any key to stop autoboot: 2
Hit any key to stop autoboot: 1
Hit any key to stop autoboot: 0
SF: Detected s25fl128s with page size 256 Bytes, erase size 64 KiB, total 16 MiB
device 0 offset 0x4e0000, size 0x13881f
SF: 1280031 bytes @ 0x4e0000 Read: OK
device 0 offset 0x7e0000, size 0x1f7c
SF: 8060 bytes @ 0x7e0000 Read: OK
device 0 offset 0x7f0000, size 0x94d93
SF: 609683 bytes @ 0x7f0000 Read: OK
## Booting kernel from Legacy Image at 82000000 ...
   Image Name:   IronForge S7 Linux
   Created:      2026-11-21  17:59:39 UTC
   Image Type:   MicroBlaze Linux Kernel Image (lz4 compressed)
   Data Size:    1279967 Bytes = 1.2 MiB
   Load Address: 80000000
   Entry Point:  80000000
   Verifying Checksum ... OK
## Flattened Device Tree blob at 84000000
   Booting using the fdt blob at 0x84000000
Working FDT set to 84000000
   Uncompressing Kernel Image to 80000000
WARNING:
The 'fdt_high' environment variable is set to ~0. This is known to cause
boot failures due to placement of DT at non-8-byte-aligned addresses.
This system will likely fail to boot. Unset the 'fdt_high' environment
variable and submit a fix upstream.
   Using Device Tree in place at 84000000, end 84004f7b
Working FDT set to 84000000
Starting kernel ...
```

Linux memory, interrupts and timer

```
[    0.000000] Ramdisk addr 0x84400000,
[    0.000000] FDT at 0x84000000
[    0.000000] Linux version 7.3.4 (ironforge@windows) (microblazeel-amd-linux-gcc.exe (
GCC) 13.4.0, GNU ld (GNU Binutils) 2.42.0.20240723) #3 2026-11-21 17:59:39 UTC
[    0.000000] setup_memory: min_low_pfn: 0x80000
[    0.000000] setup_memory: max_low_pfn: 0x90000
[    0.000000] setup_memory: max_pfn: 0x90000
[    0.000000] OF: reserved mem: Reserved memory: No reserved-memory node in the DT
[    0.000000] setup_cpuinfo: initialising
[    0.000000] setup_cpuinfo: Using full CPU PVR support
[    0.000000] wt_msr_noirq
[    0.000000] Zone ranges:
[    0.000000]   DMA      [mem 0x0000000080000000-0x000000008fffffff]
[    0.000000]   Normal   empty
[    0.000000] Movable zone start for each node
[    0.000000] Early memory node ranges
[    0.000000]   node   0: [mem 0x0000000080000000-0x000000008fffffff]
[    0.000000] Initmem setup node 0 [mem 0x0000000080000000-0x000000008fffffff]
[    0.000000] pcpu-alloc: s0 r0 d32768 u32768 alloc=1*32768
[    0.000000] pcpu-alloc: [0] 0
[    0.000000] Kernel command line: console=ttyUL0,115200 rdinit=/init quiet
[    0.000000] printk: log buffer data + meta data: 131072 + 409600 = 540672 bytes
[    0.000000] Dentry cache hash table entries: 32768 (order: 5, 131072 bytes, linear)
[    0.000000] Inode-cache hash table entries: 16384 (order: 4, 65536 bytes, linear)
[    0.000000] Built 1 zonelists, mobility grouping on.  Total pages: 65536
[    0.000000] mem auto-init: stack:all(zero), heap alloc:off, heap free:off
[    0.000000] SLUB: HWalign=32, Order=0-3, MinObjects=0, CPUs=1, Nodes=1
[    0.000000] NR_IRQS: 64, nr_irqs: 64, preallocated irqs: 0
[    0.000000] irq-xilinx: /axi/interrupt-controller@41200000: num_irq=2, edge=0x2
[    0.000000] clocksource: jiffies: mask: 0xffffffff max_cycles: 0xffffffff, max_idle_n
s: 19112604462750000 ns
[    0.000000] /axi/timer@42000000: irq=1
[    0.000000] clocksource: xilinx_clocksource: mask: 0xffffffff max_cycles: 0xffffffff,
 max_idle_ns: 19112604467 ns
[    0.000000] xilinx_timer_shutdown
[    0.000000] xilinx_timer_set_periodic
[    0.000044] sched_clock: 32 bits at 100MHz, resolution 10ns, wraps every 21474836475n
s
[    0.001171] Calibrating delay loop... 48.53 BogoMIPS (lpj=242688)
[    0.110423] pid_max: default: 4096 minimum: 301
[    0.113526] Mount-cache hash table entries: 1024 (order: 0, 4096 bytes, linear)
[    0.114098] Mountpoint-cache hash table entries: 1024 (order: 0, 4096 bytes, linear)
```

RAM filesystem and interactive shell

```
[    0.124760] VFS: Finished mounting rootfs on nullfs
[    0.184992] Memory: 255524K/262144K available (2035K kernel code, 458K rwdata, 208K r
odata, 123K init, 163K bss, 6200K reserved, 0K cma-reserved)
[    0.196616] devtmpfs: initialized
[    0.248653] posixtimers hash table entries: 512 (order: 0, 2048 bytes, linear)
[    0.249262] futex hash table entries: 16 (192 bytes on 1 NUMA nodes, total 0 KiB, lin
ear).
[    0.253202] DMA: preallocated 128 KiB GFP_KERNEL|GFP_DMA pool for atomic allocations
[    0.318545] clocksource: Switched to clocksource xilinx_clocksource
[    0.397694] Unpacking initramfs...
[    0.402663] workingset: timestamp_bits=30 (anon: 25) max_order=16 bucket_order=0 (ano
n: 0)
[    1.824124] Freeing initrd memory: 592K
[    3.896138] 40600000.serial: ttyUL0 MMIO:0x40600000 (irq = 2, base_baud = 0) is a uar
tlite
[    3.897288] printk: legacy console [ttyUL0] enabled
[    4.372809] clk: Disabling unused clocks
[    4.386176] Freeing unused kernel image (initmem) memory: 120K
[    4.391915] This architecture does not have kernel memory protection.
[    4.397857] Run /init as init process
[    4.401875]   with arguments:
[    4.404289]     /init
[    4.406539]   with environment:
[    4.409644]     HOME=/
[    4.411999]     TERM=linux
IronForge Arty S7-50 | BusyBox serial console
init started: BusyBox v1.38.0 (2026-11-21 17:31:35 UTC)
starting pid 20, tty '/dev/ttyUL0': '/bin/sh -i'
BusyBox v1.38.0 (2026-11-21 17:31:35 UTC) built-in shell (ash)
# uname -r; cat /proc/uptime; cat /proc/mounts; cat /proc/cmdline; echo S7_SERIA
L_$(echo PASS)
7.3.4
4.90 0.13
rootfs / rootfs rw,size=127972k,nr_inodes=31993 0 0
devtmpfs /dev devtmpfs rw,relatime,size=127972k,nr_inodes=31993,mode=755 0 0
proc /proc proc rw,relatime 0 0
sysfs /sys sysfs rw,relatime 0 0
console=ttyUL0,115200 rdinit=/init quiet
S7_SERIAL_PASS
#
```

Contact IronKernel

To discuss MicroBlaze integration, a reference design, or a custom boot or peripheral driver, send IronKernel your target board and project goal.

https://ironkernel.com/ · support@ironkernel.com