Virginia Tech
ECE 5484: Fundamentals of Computer Systems

Unsigned Number Conversion Examples

1. Convert $(101100)_2$ to decimal. Assume an unsigned integer.

   Solution: For binary-to-decimal conversion, sum the powers of 2 associated with each bit position containing a 1.

   $(101100)_2 = 2^5 + 2^3 + 2^2 = 32+8+4 = (44)_{10}$

   (Note that 1's are in positions 5, 3, and 2)

2. Convert $(1110001)_2$ to decimal. Assume an unsigned integer.

   Solution: For binary-to-decimal conversion, sum the powers of 2 associated with each bit position containing a 1.

   $(1110001)_2 = 64+32+16+1 = (113)_{10}$

3. Convert $(110110101)_2$ to decimal. Assume an unsigned integer.

   Solution: For binary-to-decimal conversion, sum the powers of 2 associated with each bit position containing a 1.

   $(110110101)_2 = 256 +128 + 32 + 16 +4 + 1 = (437)_{10}$

4. Convert the decimal number $(1230)_{10}$ to an unsigned binary value.

   Solution: For decimal-to-binary conversion, repeatedly divide by 2. The remainder is the next least significant bit in the binary number and the quotient is used for the next division by 2.

	Quotient	Remainder	Bit
$1230 \div 2$	615	0	$= b_0$
$615 \div 2$	307	1	$= b_1$
$307 \div 2$	153	1	$= b_2$
$153 \div 2$	76	1	$= b_3$
$76 \div 2$	38	0	$= b_4$
$38 \div 2$	19	0	$= b_5$
$19 \div 2$	9	1	$= b_6$
$9 \div 2$	4	1	$= b_7$
$4 \div 2$	2	0	$= b_8$
$2 \div 2$	1	0	$= b_9$
$1 \div 2$	0	1	$= b_{10}$

The process can terminate when the quotient is 0. The answer is then $(1230)_{10} = (10011001110)_2$.

5. Convert the decimal number $(401)_{10}$ to an unsigned binary value.

   Solution: Decimal-to-binary conversion can also be done "by inspection" by identifying the powers of 2 that make up the decimal number.

   $(401)_{10} = 256+128+16+1 = 2^8 + 2^7 + 2^4 + 2^0 = (110010001)_2$

6. Convert the decimal number $(1992)_{10}$ to an unsigned binary value.

   Solution: Solving "by inspection" as above.

$(1984)_{10} = 1024 + 512 + 256 + 128 + 64 + 8 = (11111001000)_2$

7. Convert $(7564)_{10}$ to radix r = 8 (octal) representation.

Solution: To convert from decimal to radix-r, perform the repeated division procedure described in the solution for example 4 above for radix r = 2. Here, r = 8.

	Quotient	Remainder	Bit
$7564 \div 8$	945	4	$= q_0$
$945 \div 8$	118	1	$= q_1$
$118 \div 8$	14	6	$= q_2$
$14 \div 8$	1	6	$= q_3$
$1 \div 8$	0	1	$= q_4$

The answer is $(7564)_{10} = (16614)_8$

8. Convert $(1947)_{10}$ to radix r = 16 (hexadecimal) representation.

Solution: To convert from decimal to radix-r, perform repeated division procedure with r = 16.

	Quotient	Remainder	Bit
$1947 \div 16$	121	11 (B)	$= h_0$
$121 \div 16$	7	9	$= h_1$
$7 \div 16$	0	7	$= h_2$

The answer is then $(1947)_{10} = (79B)_{16}$

9. Convert $(F3A4C1)_{16}$ to binary representation.

Solution: For conversion from hexadecimal to binary, determine the four-bit binary equivalent of each hex digit.

$(F3A4C1)_{16} = (1111\ 0011\ 1010\ 0100\ 1100\ 0001)_2$

10. Convert $(F3A4C1)_{16}$ to octal (r = 8) representation.

Solution: For conversion from hex to octal, use the binary representation just found, divide the bits into groups of three bits starting from the least significant (rightmost) bit, and then convert each group of three bits to the corresponding octal digit.

$$(F3A4C1)_{16} = (1111\ 0011\ 1010\ 0100\ 1100\ 0001)_2$$

$$= (111\ 100\ 111\ 010\ 010\ 011\ 000\ 001)_2$$

$$= (74722301)_8$$

11. Convert $(22.5625)_{10}$ to unsigned binary representation. Use fixed-point representation.

Solution: First, for the integer portion we could use repeated division, as in #4 above, or we could recognize that $22 = 16 + 4 + 2 = (10110)_2$

Next, find the fraction portion using repeated multiplication.

$0.5625 \times 2 = 1.125$	$B_{-1} = 1$
$0.125 \times 2 = 0.25$	$B_{-2} = 0$
$0.25 \times 2 = 0.5$	$B_{-3} = 0$
$0.5 \times 2 = 1.0$	$B_{-4} = 1$

Combining the two parts, $(22.5625)_{10} = (10110.1001)_2$

12. Convert the $(137.25)_{10}$ to unsigned binary representation. Use fixed-point representation.

Solution: Find the integer and fraction parts separately and then combine.

$137 = 128 + 8 + 1 = (10001001)_2$

$0.25 = 0.25 = (0.01)_2$

So, $137.25 = (10001001.01)_2$

13. Convert the $(10.3)_{10}$ to unsigned binary representation. Use fixed-point representation.

Solution: Find the integer and fraction parts separately and then combine.

$10 = 8 + 2 = (1010)_2$

Next, find the fraction part by using repeated multiplication.

$0.3\times2=0.6$	$B_{-1}=0$
$0.6\times2=1.2$	$B_{-2}=1$
$0.2\times2=0.4$	$B_{-3}=0$
$0.4\times2=0.8$	$B_{-4}=0$
$0.8\times2=1.6$	$B_{-5}=1$
$0.6\times2=1.2$	$B_{-6}=1$

Note that 0.6 has already been encountered, so bits B_{-2} through B_{-5} will repeat. So,

$0.3 = (.0\overline{1001})_2$.

Combining both parts gives $10.3 = (1010.0\overline{1001})_2$.

14. Convert the unsigned binary number 110101.101 to decimal representation.

Solution: Convert the integer and fraction parts separately.

$110101 = 32 + 16 + 4 + 1 = (53)_{10}$

$0.101 = 0.5 + 0.125 = (0.625)_{10}$

So, $110101.101 = (53.625)_{10}$

15. Convert the unsigned binary number 11.11 to decimal representation.

Solution: Convert the integer and fraction parts separately.

$11 = (3)_{10}$
$0.11 = 0.5 + 0.25 = (0.75)_{10}$

So, $11.11 = (3.75)_{10}$

16. Convert the unsigned binary number 10011.11 to decimal representation.

Solution: Convert the integer and fraction parts separately.

$10011 = 16 + 2 + 1 = (19)_{10}$

$0.11 = (0.75)_{10}$

So, $10011.11 = (19.75)_{10}$

17. Convert the unsigned binary number 1010.101 to decimal representation.

Solution: Convert the integer and fraction parts separately.

$1010 = 8 + 2 = (10)_{10}$
$0.101 = 0.5 + 0.125 = (0.625)_{10}$

So, $1010.101 = (10.625)_{10}$

18. Consider a computer that uses radix-3 (ternary) logic instead of radix-2 (binary) logic to represent unsigned integers.

a) What is the radix-3 representation of the decimal value 57?

Solution: This can be determined by repeated division by 3 (instead of repeated division by 2 which is done to convert to radix-2).

57/3 = 19, remainder 0	$D_0 = 0$
19/3 = 6, remainder 1	$D_1 = 1$
6/3 = 2, remainder 0	$D_2 = 0$
2/3 = 0, remainder 2	$D_3 = 2$

So, $(57)_{10} = (2010)_3$

b) What is the largest value that can represented by 8 digits?

Solution: The maximum value of one digit in radix-3 is 2. So, the maximum value for eight digits is $(22222222)_3$.

One way to convert this to decimal is to calculate $(22222222)_3 = 2\times3^7 + 2\times3^7 + ... + 2\times3^0$. A simpler approach is to realize that $(22222222)_3 = (100000000)_3 - 1 = 3^8 - 1 = 6561\text{-}1 = 6560$.

So, $(6560)_{10}$ is the largest possible number that can be represented using eight radix-3 digits.

. c) Why is binary logic much more commonly used than ternary logic?

Solution: The main reason is that devices to process and store binary symbols, 0 and 1, are easier to implement and, therefore, cheaper and more robust than similar devices for ternary logic. For example, a 1 or 0 can be represented easily by the polarity of a magnetic charge or the presence or lack of presence of electrical charge.