```
;;; demo_hea.asm
;;;
;;; demonstration app for zOS running two heap allocators launched by zOS_HEA
;;; to build: gpasm -D GPASM demo_hea.asm
;;;
;;; after starting job #1 as a job management shell (zOS_MAN() in zosmacro.inc)
;;; to demonstrate privileged mode (able to kill or otherwise tweak other tasks)
;;;
;;; it starts two instances of memory allocators as jobs #2 and 3, one for Large
;;; blocks of memory and one for Small (a distinction which is arbitrary but it
;;; helps to minimize fragmentation
;;;
;;; it then starts a job #4 to start making malloc() and free() calls in order
;;; to observet the action of the help allocators
;;;
;;; if only 4 of 5 possible task slots are used in this demo reducing the max
;;; allowed value by 1 will make scheduler run faster as well as freeing an extra
;;; 80 bytes for the heap itself:
;zOS_NUM        equ     4

        processor 16f1719
        include p16f1719.inc

        __CONFIG _CONFIG1,_FOSC_INTOSC & _WDTE_OFF & _PWRTE_OFF & _CP_OFF & _BOREN_
ON & _CLKOUTEN_ON & _IESO_ON & _FCMEN_ON
        __CONFIG _CONFIG2,_WRT_OFF & _PPS1WAY_OFF & _ZCDDIS_ON & _PLLEN_ON & _STVRE
N_ON & _BORV_LO & _LPBOR_OFF & _LVP_ON

;;; uncomment to reduce zOS footprint by 100 words (at cost of zOS_FRK/EXE/FND):
;zOS_MIN        equ     1

        include zos.inc
        include zosmacro.inc

OUTCHAR equ     zOS_SI3

SMALLOC equ     zOS_SI4
SFREE   equ     zOS_SI5
LMALLOC equ     zOS_SI6
LFREE   equ     zOS_SI7
MAXSRAM equ     0x2400

        pagesel main
        goto    main

NEXT    equ     0x10
NEXTHI  equ     0x11

i       equ     0x20
smalls  equ     0x21
larges  equ     0x24
temp    equ     0x25
insert  equ     0x26
inserth equ     0x27

newnode
        movwf   temp            ;uint8_t* newnode(void* *fsr0, // previous head
        movlw   2               ;                 void* *fsr1, uint8_t w) {
        zOS_ARG 0
        zOS_SWI SMALLOC
        movf    WREG            ; uint8_t temp = w; // job number to copy struct
        btfss   STATUS,Z        ;
        bra     nncopy          ; do {
        movf    zOS_ME          ;  zOS_ARG(0, 2); // 16 bytes from bank 0, 2 ptr
        zOS_ARG 0
        zOS_SWI zOS_YLD
        movf    temp,w          ;  if ((w = zOS_SWI(SMALLOC)) == 0) {
        bra     newnode         ;   zOS_ARG(0, bsr);
nncopy
```

```
        zOS_PTR FSR1
        movf    FSR0H,w         ;   zOS_SWI(zOS_YLD);}// hope coalescing happens
        movwi   NEXTHI[FSR1]    ; } while (w == 0);
        movf    FSR0L,w         ; *fsr1 = zOS_PTR(w);
        movwi   NEXT[FSR1]      ; w = temp;

        movf    temp,w          ; (*fsr1)->next = *fsr0;
        zOS_MEM FSR0,WREG,0x10
        addfsr  FSR1,0x10       ; zOS_MEM(fsr0,w,0x10); // 0x30, 0x40, ..., 0x70
nnloop
        moviw   --FSR0          ; (*fsr1) += 0x10;
        movwi   --FSR1          ; for (int j = 0; j < 16; j++)
        movf    FSR0L,w         ;
        andlw   0x0f            ;
        btfss   STATUS,Z        ;
        bra     nnloop          ;  *--(*fsr1) = *--(*fsr0);

        moviw   NEXT[FSR1]      ;
        movwf   FSR0L           ;
        moviw   NEXTHI[FSR1]    ; *fsr0 = (*fsr1)->next;
        movwf   FSR0H           ; // now fsr1 is new head, fsr0 is tail=old head

        moviw   zOS_HDH[FSR1]   ;
        btfsc   STATUS,Z        ;
        bra     discard         ; if (zOS_HDH[*fsr1]) {// head valid running job
        movf    FSR0H,f         ;  // compare the handles for the head and tail
        btfsc   STATUS,Z        ;  if (0xff00 & *fsr0 == 0)
        retlw   0               ;   return 0; // null tail, so in order by def’n
        andlw   0x7f            ;
        movwf   temp            ;
        moviw   zOS_HDH[FSR0]   ;
        andlw   0x7f            ;
        subwf   temp,w          ;  w = 0x7f&(HDH[*fsr1]) - 0x7f&(HDH[*fsr0]);
        btfss   STATUS,Z        ;  if ((**fsr1 & 0x7f00) != (**fsr0 & 0x7f00))
        return                  ;   return w;//>0 if in correct order, <0 if out

        moviw   zOS_HDL[FSR1]   ;
        movwf   temp            ;
        moviw   zOS_HDL[FSR0]   ;  w = 0x7f&(HDL[*fsr1]) - 0x7f&(HDL[*fsr0]);
        subwf   temp,w          ;  return w;//>=0 if in correct order, <0 if out
        return                  ; } else {
discard
        zOS_PAG FSR1            ;  zOS_ARG(0, zOS_PAG(*fsr1));
        zOS_ARG 0               ;  zOS_SWI(SFREE); // free the node back to heap
        zOS_SWI SFREE           ;  return (*fsr1 &= 0x00ff) >> 8;
        clrf    FSR1H           ; }
        retlw   0               ;} // newnode()

maklist
        clrf    FSR1H           ;void maklist(void) {
        movlw   zOS_NUM         ; fsr1 = (void*) 0;
        movwf   i               ; for (uint8_t i = zOS_NUM; i; i--) {
makloop
        movf    FSR1L,w         ;
        movwf   FSR0L           ;
        movf    FSR1H,w         ;
        movwf   FSR0H           ;  fsr0 = fsr1; // fsr0 is head of list
        movf    i,w             ;
        btfsc   STATUS,Z        ;
        return                  ;
        pagesel newnode         ;
        call    newnode         ;  // fsr1 will become new head, may need moving
        decfsz  i,f             ;
        btfss   WREG,7          ;
        bra     makloop         ;  if (newnode(&fsr0/*tail*/, &fsr1/*head*/, i)
srtloop
        movf    FSR0L,w         ;                 < 0) { // head is out of order
        movwf   insert          ;
        movf    FSR0H,w         ;
        movwf   inserth         ;   insert = fsr0;

        moviw   NEXT[FSR0]      ;
        movwf   temp            ;
        moviw   NEXTHI[FSR0]    ;
        btfsc   STATUS,Z        ;
        bra     linsert         ;   while (fsr0->next) { // march fsr0 down list
        movwf   FSR0H           ;
        movf    temp,w          ;
        movwf   FSR0L           ;    fsr0 = fsr0->next;

        moviw   zOS_HDH[FSR0]   ;
        andlw   0x7f            ;
        movwf   temp            ;
        moviw   zOS_HDH[FSR1]   ;
        andlw   0x7f            ;
        subwf   temp,w          ;    w = 0x7f&(HDH[*fsr0]) - 0x7f&(HDH[*fsr1]);

        btfss   WREG,7          ;    if (w < 0) // even latest node too small so
        btfsc   STATUS,Z        ;     continue;
        bra     srtloop         ;    else if (w > 0)
        bra     rewind          ;     break;

        moviw   zOS_HDL[FSR0]   ;
        andlw   0x7f            ;
        movwf   temp            ;
        moviw   zOS_HDL[FSR1]   ;
        andlw   0x7f            ;
        subwf   temp,w          ;    w = 0x7f&(HDL[*fsr0]) - 0x7f&(HDL[*fsr1]);

        btfsc   WREG,7          ;    if (w < 0) // even latest node too small so
        bra     srtloop         ;     continue; // haven’t found; next iteration
rewind
        movf    insert,w        ;
        movwf   FSR0L           ;    fsr0 = insert; // found one, roll back fsr0
        movf    inserth,w       ;    break;
        movwf   FSR0H           ;   }

;;; we get here when fsr0’s successor (as the first payload >= fsr1’s payload)
;;; needs to become fsr1’s successor, and the node at fsr0 will point to fsr1
;;; (being careful not to lose a pointer fsr1->next as the new list head node)

linsert
        moviw   NEXT[FSR1]      ;
        movwf   insert          ;
        moviw   NEXTHI[FSR1]    ;   // save head of list so we don’t lose it
        movwf   inserth         ;   insert = fsr1->next;

        moviw   NEXT[FSR0]      ;
        movwi   NEXT[FSR1]      ;
        moviw   NEXTHI[FSR0]    ;
        movwi   NEXTHI[FSR1]    ;   fsr1->next = fsr0->next;

        movf    FSR1L,w         ;
        movwi   NEXT[FSR0]      ;
        movf    FSR1H,w         ;
        movwi   NEXTHI[FSR0]    ;   fsr0->next = fsr1;

        movf    insert,w        ;  }
        movwf   FSR0L           ; }
        movf    inserth,w       ; return fsr0 = insert; // return new head
        movwf   FSR0H           ;}

        zOS_NAM "heap-churning loop"
myprog
        movf    zOS_ME          ;void myprog(void) {
        zOS_ARG 0
        zOS_SWI zOS_YLD         ; uint8_t i, smalls[3], larges[3];
        pagesel maklist
```

```
        call    maklist         ;
        zOS_LOC FSR1,BSR,larges ; zOS_ARG(0, bsr);
        zOS_LOC FSR0,BSR,smalls ; zOS_SWI(zOS_YLD); // let malloc(),free() init
        movlw   0x03            ; while (1) {
        movwf   i               ;  uint8_t* fsr1 = larges;
getbig
        movlw   0x08            ;  uint8_t* fsr0 = smalls;
        call    malloc          ;
        movf    WREG            ;  // grab three 128-byte cells
        btfsc   STATUS,Z        ;  for (i = 3; i; i--) {
        bra     getbig          ;   do {
        movwi   FSR1++          ;    w = malloc(128 >> 4);
        decfsz  i,f             ;   } while (!w); // eventually will fail
        bra     getbig          ;   *fsr1++ = w;
        movlw   0x03            ;  }
        movwf   i               ;
gettiny
        movlw   0x02            ;
        call    malloc          ;  // grab three 32-byte cells
        movf    WREG            ;  for (i = 3; i; i--) {
        btfsc   STATUS,Z        ;   do {
        bra     gettiny         ;    w = malloc(32 >> 4);
        movwi   FSR0++          ;   } while (!w);
        decfsz  i,f             ;   *fsr0++ = w;
        bra     gettiny         ;  }

        moviw   -3[FSR0]        ;  // free first two 32-byte cells
        call    free            ;  free(-3[fsr0]);

        moviw   -2[FSR0]        ;
        call    free            ;  free(-2[fsr0]);

        moviw   -3[FSR1]        ;  // free first two 128-byte cells
        call    free            ;  free(-3[fsr1]);

        moviw   -2[FSR1]        ;  free(-2[fsr1]);
        call    free            ; }
        bra     myprog          ;}

main
        banksel OSCCON          ;{
        movlw   0x70            ;    // SCS FOSC; SPLLEN disabled; IRCF 8MHz_HF;
        movwf   OSCCON          ;    OSCCON = 0x70;
        movlw   0x80            ;    // SOSCR enabled;
        movwf   OSCSTAT         ;    OSCSTAT = 0x80;
        movlw   0x00            ;    // TUN 0;
        movwf   OSCTUNE         ;    OSCTUNE = 0x00;
                                ;    // Wait for PLL to stabilize
        btfss   OSCSTAT,PLLR    ;    while(PLLR == 0)
        bra     $-1             ;     ;

        banksel ANSELA
        movlw   0xaf            ;
        movwf   ANSELA          ; ANSELA = 0xaf; // allow heartbeat GPIO, CLKOUT
        movlw   0x3c            ;
        movwf   ANSELC          ; ANSELC = 0x3c; // allow serial port

        banksel OPTION_REG
        bcf     OPTION_REG,PSA  ; OPTION_REG &= ˜(1<<PSA);// max timer0 prescale
        bcf     OPTION_REG,T0CS ; OPTION_REG &= ˜(1<<TMR0CS);// off Fosc not pin

        banksel TRISC
        bcf     TRISA,RA4       ; TRISA &= ˜(1<<RA4); // allow heartbeat output
;       bcf     TRISA,RA6       ; TRISA &= ˜(1<<RA6); // allow clock output
        movlw   0x7f
        movwf   TRISC

        banksel PPSLOCK
        movlw   0x55
        movwf   PPSLOCK
        movlw   0xaa
        movwf   PPSLOCK
        bcf     PPSLOCK,PPSLOCKED
        movlw   0x16
        movwf   RXPPS

        banksel RC7PPS
        movlw   0x14
        movwf   RC7PPS
        movlw   0x55
        movwf   PPSLOCK
        movlw   0xaa
        movwf   PPSLOCK
        bsf     PPSLOCK,PPSLOCKED

        zOS_CLC 0,.032000000/.000009600,PIR1,LATA,RA4,0
        movlw   OUTCHAR         ;
        movwi   0[FSR0]         ; zOS_CLC(/*TX*/0,32MHz/9600bps,PIR1,LATA,RA4);

        include zosalloc.inc

        zOS_INT 0,0
        zOS_ADR myprog,zOS_UNP
        zOS_LAU WREG

        zOS_RUN INTCON,INTCON

        end
```

```
#ifndef zOS_FRE
 error "must define zOS_FRE with lowest linear memory address available for heap be
fore including this file"
#endif

#ifndef MAXSRAM
 error "must define MAXSRAM with 1 + highest linear memory address available for he
ap before including this file"
#endif

HEAPRAM equ     MAXSRAM-zOS_FRE
HEAPSML equ     HEAPRAM/4
HEAPLRG equ     HEAPSML*3
HEAPTHR equ     7
HEAP1   equ     zOS_FRE
HEAP2   equ     zOS_FRE+HEAPSML

#ifdef LMALLOC

        zOS_HEA HEAP1,HEAPSML,SMALLOC,SFREE
        movlw   SMALLOC|SFREE
        zOS_ARG 3
        zOS_LAU WREG

        zOS_HEA HEAP2,HEAPLRG,LMALLOC,LFREE
        movlw   LMALLOC|LFREE
        zOS_ARG 3
        zOS_LAU WREG

#else
#ifdef SMALLOC
        zOS_HEA HEAP1,HEAPRAM,SMALLOC,SFREE
        movlw   SMALLOC|SFREE
        zOS_ARG 3
        zOS_LAU WREG

#else
 error "must define SMALLOC and SFREE software interrupt masks (and optionally LMAL
LOC and LFREE) before including this file"
#endif
#endif

        bra     endalloc

malloc
        zOS_ARG 0               ;void* malloc(uint8_t w) { // w is numbytes/16
#ifdef LMALLOC
#if (LMALLOC-SMALLOC)
#else
        zOS_ARG 1
        movlw   1
        movwf   zOS_AR0
#endif
        addlw   0-HEAPTHR       ; zOS_ARG(0, w); // turns interrupts off
        btfss   WREG,7          ; if (w <= HEAPTHR)
        bra     bigallo         ;  w = zOS_SWI(SMALLOC); // allocated address/16
#endif
        zOS_SWI SMALLOC
        movf    WREG            ; if ((w == 0) || (w > HEAPTHR)) // too big/full
        btfss   STATUS,Z        ;  w = zOS_SWI(LMALLOC); // allocated address/16
        return                  ; return w;
#ifdef LMALLOC
bigallo
        zOS_SWI LMALLOC
#endif
        return                  ;}


        ;; large-bytecount (128=16*HEAPTHR+16) table has fewer entries so faster
free
        zOS_ARG 0               ;uint8_t free(void* w) { // w is address/16
#ifdef LMALLOC
#if (LMALLOC-SMALLOC)
#else
        zOS_ARG 1
        clrf    zOS_AR0
#endif
        zOS_SWI LFREE
        btfss   STATUS,Z        ; zOS_ARG(0, w); // turns interrupts off
        return                  ; return (w=zOS_SWI(LFREE)) ? w: zOS_SWI(SFREE);
#endif
        zOS_SWI SFREE
        return                  ;}

endalloc
```

```
;;; zos.inc
;;; a lightweight, small-footprint, preemptively multitasking RTOS for Microchip
;;;  Technology's entire enhanced midrange 8-bit PIC microcontroller family:
;;;
;;; jobs (up to 5) are never allowed to manipulate the BSR directly, as that is
;;; the prerogative of zOS (it being used as the current job #) and the bank may
;;; never end up greater than zOS_NUM in user space with interrupts enabled!!!

;;; memory footprint:
;;;  ˜613 14-bit words for base RTOS i.e. main() starts at 0x0263
;;;  ˜511 words if zOS_MIN is defined to omit FRK/EXE/FND (thus SWI#4˜7=zOS_YLD)
;;;
;;; SRAM footprint:
;;; 86 bank-0 bytes claimed by RTOS, 30 bytes of stack scratch space relocatable
;;;
;;; available bytes    possible jobs with    local bytes/job (+any heap, besides
;;;  on PIC device     80 bytes RAM each     2 global bytes) if zOS_NUM set to 5
;;; ===============    ==================    ===================================
;;;      128                 0                          0 (+2)
;;;      256                 1                          0 (+130)
;;;      384                 3                          0 (+258)
;;;      512                 4                          0 (+386)
;;;      768                 5                          80 (+242)
;;;    1,024                 5                          80 (+498)
;;;    2,048                 5                          80 (+1522)
;;;    4,096                 5                          80 (+3570)

;;; you may redefine a constant zOS_NUM with the maximum job number (<6,
;;; as determined by where the general purpose register memory stops, as
;;; the guaranteed 2 bytes global memory isn't sufficient for most jobs)
#ifdef zOS_NUM
#else
zOS_NUM set     5
#endif

;;; you may redefine the location of the scratch space for restoring the stack
;;; after each context switch (by default it is 0x20 in bank zOS_NUM+1, but can
;;; be pulled in on small devices into unused local storage or pushed out if necc
#ifdef zOS_STK
#else
zOS_STK set     (((zOS_NUM+1)<<7)|0x20)
#endif
#ifdef zOS_FRE
#else
zOS_FRE set     (0x2000+((zOS_NUM+1)*0x50)+(0x001e))
#endif

;;; software interrupt infrastructure zOS is based on (even with interrupts off)

;;; 5 user-definable software interrupt lines:
zOS_SB7 equ     7
zOS_SI7 equ     (1<<zOS_SB7)
zOS_SB6 equ     6
zOS_SI6 equ     (1<<zOS_SB6)
zOS_SB5 equ     5
zOS_SI5 equ     (1<<zOS_SB5)
zOS_SB4 equ     4
zOS_SI4 equ     (1<<zOS_SB4)
zOS_SB3 equ     3
zOS_SI3 equ     (1<<zOS_SB3)

;;; 7 system software interrupts for job management:
zOS_FND equ     0x07            ; find a running job <=AR2 by its handle AR1:AR0
zOS_EXE equ     0x06            ; replace this job with a new job (unpriv'ed)
zOS_FRK equ     0x05            ; copy a running job into a new job
zOS_YLD equ     0x04            ; (in)voluntarily cede processor before next irq
zOS_RST equ     0x03            ; restart job at its start address (vs. END+NEW)
zOS_END equ     0x02            ; job killed, slot# available for NEW
zOS_SLP equ     0x01            ; indicate job waiting on its ISR, so don't run
```

```
zOS_NEW equ     0x00            ; create a job (FSR0==addr,AR1:0==isr,AR3:2==IM)

;;; global memory space for 2 scratch registers plus message-passing mailboxes
zOS_JOB equ     0x70            ; next job to run (0 if unknown)
zOS_MSK equ     0x71            ; masked-off sofware interrupt for ISR to handle
zOS_J1L equ     0x72            ;  (repurposeable as scratch after zOS_RFS call)
zOS_J1H equ     0x73
zOS_J2L equ     0x74
zOS_J2H equ     0x75
zOS_J3L equ     0x76
zOS_J3H equ     0x77
zOS_J4L equ     0x78
zOS_J4H equ     0x79
zOS_J5L equ     0x7a
zOS_J5H equ     0x7b
        ;; must disable interrupts e.g. with zOS_ARG(0) before writing SWI args:
zOS_AR0 equ     0x7c
zOS_AR1 equ     0x7d
zOS_AR2 equ     0x7e
zOS_AR3 equ     0x7f

;;; job/shadow register offsets from zOS_J0M, zOS_J1M,...
zOS_HDL equ     0x00            ; handle, the start address of the job
zOS_HDH equ     0x01            ;
zOS_PRB equ     7               ;  MSB of HDH indicates privilege(manage others)
zOS_RAM equ     0               ;
zOS_FLA equ     1               ;
zOS_UNP equ     0               ;
zOS_PCL equ     0x02            ; address to resume execution
zOS_PCH equ     0x03            ;  "impossible" PCH 0x00==not runnable
zOS_WAI equ     7               ;  MSB of PCH indicates sleeping (wait for int)
zOS_SST equ     0x04            ; shadow STATUS
zOS_SWR equ     0x05            ; shadow WREG
zOS_SSP equ     0x06            ; STKPTR to be restored (BSR implied by base)
zOS_SPH equ     0x07            ; PCLATH to be restored
zOS_SF0 equ     0x08            ; shadow FSR0
zOS_SF1 equ     0x0a            ; shadow FSR1
zOS_ISR equ     0x0c            ; interrupt service routine address for the job
zOS_ISH equ     0x0d            ; interrupt service routine address for the job
zOS_HIM equ     0x0e            ; mask for hardware interrupts to process (0=no)
zOS_SIM equ     0x0f            ; mask for software interrupts (low 3 always==1)

zOS_TOS equ     0x0e            ; STKPTR for full stack (0x0f reserved for ISRs)
zOS_BOS equ     0x0b            ; STKPTR for empty stack (first push is to 0x0c)

;;; bank 0 memory space for managing jobs, 1@0x20, 2@0x30, ... , 5@0x60
zOS_J1M equ     0x20
zOS_J2M equ     0x30
zOS_J3M equ     0x40
zOS_J4M equ     0x50
zOS_J5M equ     0x60

zOS_MEM macro   fsrnum,job,offset
        local   fsrn
        if (fsrnum & 3)
fsrn set 1
        else
fsrn set 0
        endif
        swapf   job,w           ;inline void zOS_MEM(int8_t* *fsrnum,
        addlw   0x10            ;                    const int8_t* job,
        andlw   0x70            ;                    const
        if (offset)
         addlw  offset          ;                    int8_t offset) {
        endif
        movwf   FSR#v(fsrn)L    ; *fsrnum = (((job + 1) & 0x07) << 4) + offset;
        clrf    FSR#v(fsrn)H    ;} // zOS_MEM()
        endm
```

```
;;; macro to wind the circular stack around from the running job# to the new job
;;; (before restoring the new job's STKPTR and copying its return address there)
;;; typically: zOS_ROL BSR_SHAD,JOB_NUM(BSR?),zOS_TMP,FSR0,zOS_STK
;;; note: caller is responsible for making sure the STKPTR/_SHAD bank is active
zOS_ROL macro   old,new,temp,fsrnum,base
        local fsrn,loop1,loop2,done
        if (fsrnum & 3)
fsrn set 1
        else
fsrn set 0
        endif
        movlw   low base        ;inline void zOS_ROL(const int8_t* old,
        movwf   FSR#v(fsrn)L    ;                    const int8_t* new,
        movlw   high base       ;                    int8_t* temp,
        movwf   FSR#v(fsrn)H    ;                    int16_t* *fsrnum,
        movf    new,w           ;                    int8_t* base) {
        subwf   old,w           ; //responsibility of caller to banksel STKPTR
        btfsc   STATUS,Z        ; if (*new == *old) // nothing to do
        bra     done            ;  return;
        decf    WREG,w          ; w = new - old - 1;
        btfsc   WREG,7          ; // set STKPTR to the current location of the
        addlw   5               ; // stack cell that needs to be rotated into
        movwf   STKPTR          ; // STK_TOP, then record this value in temp for
        lslf    STKPTR,f        ; // comparison to know when to exit the loop
        addwf   STKPTR,w        ; // that copies the entire stack (except 0x0f)
        addlw   2               ; // into 30-byte scratch in the unrolled order
        movwf   STKPTR          ;
        movwf   temp            ; for (STKPTR = *temp = 2+3*((w<0) ? (w+5) : w);
loop1
        movf    TOSL,w          ;      STKPTR != *temp + 1;
        movwi   FSR#v(fsrn)++   ;      STKPTR = (STKPTR>0) ? (STKPTR-1):zOS_TOS)
        movf    TOSH,w          ;
        movwi   FSR#v(fsrn)++   ;  *(*fsrnum)++ = (TOSH << 8) | TOSL;
        decf    STKPTR,f        ;
        movlw   zOS_TOS         ;
        btfsc   STKPTR,4        ;
        movwf   STKPTR          ;
        movf    temp,w          ;
        xorwf   STKPTR,w        ;
        btfss   STATUS,Z        ; // now rebuild the unrolled stack
        bra     loop1           ;
        clrf    STKPTR          ; for (STKPTR = 0;
loop2
        moviw   --FSR#v(fsrn)   ;      STKPTR <= zOS_TOS;
        movwf   TOSH            ;      STKPTR++) {
        moviw   --FSR#v(fsrn)   ;  TOSH = *(*fsrnum) >> 8;
        movwf   TOSL            ;  TOSL = *--(*fsrnum) & 0x00ff;
        incf    STKPTR,w        ; }
        movwf   STKPTR          ;
        sublw   zOS_TOS         ;
        btfss   WREG,7          ;
        bra     loop2           ;} // zOS_ROL()
done
        endm

#ifdef GPASM
zOS_RTL equ     (STATUS_SHAD-FSR1H_SHAD-2)
zOS_RTH equ     (STATUS_SHAD-FSR1H_SHAD-1)
zOS_RTS equ     (STATUS_SHAD-FSR1H_SHAD+2)
#else
zOS_RTL equ     ((STATUS_SHAD-FSR1H_SHAD-2)&0x3f)
zOS_RTH equ     ((STATUS_SHAD-FSR1H_SHAD-1)&0x3f)
zOS_RTS equ     ((STATUS_SHAD-FSR1H_SHAD+2)&0x3f)
#endif

;;; running job#: 1         2         3         4         5
;;; stack pos 15: 3rd(1)    3rd(2)    3rd(3)    3rd(4)    3rd(5)
;;; stack pos 14: 2nd(1)    2nd(2)    2nd(3)    2nd(4)    2nd(5)
;;; stack pos 13: 1st(1)    1st(2)    1st(3)    1st(4)    1st(5)
;;; stack pos 12: 0th(1)    0th(2)    0th(3)    0th(4)    0th(5)
;;; stack pos 11: 2nd(5)    2nd(1)    2nd(2)    2nd(3)    2nd(4)
;;; stack pos 10: 1st(5)    1st(1)    1st(2)    1st(3)    1st(4)
;;; stack pos 9:  0th(5)    0th(1)    0th(2)    0th(3)    0th(4)
;;; stack pos 8:  2nd(4)    2nd(5)    2nd(1)    2nd(2)    2nd(3)
;;; stack pos 7:  1st(4)    1st(5)    1st(1)    1st(2)    1st(3)
;;; stack pos 6:  0th(4)    0th(5)    0th(1)    0th(2)    0th(3)
;;; stack pos 5:  2nd(3)    2nd(4)    2nd(5)    2nd(1)    2nd(2)
;;; stack pos 4:  1st(3)    1st(4)    1st(5)    1st(1)    1st(2)
;;; stack pos 3:  0th(3)    0th(4)    0th(5)    0th(1)    0th(2)
;;; stack pos 2:  2nd(2)    2nd(3)    2nd(4)    2nd(5)    2nd(1)
;;; stack pos 1:  1st(2)    1st(3)    1st(4)    1st(5)    1st(1)
;;; stack pos 0:  0th(2)    0th(3)    0th(4)    0th(5)    0th(1)

;;; continue with next iteration of HWI-searching loop (mustn't clobber FSR0!)
;;; when searching for the correct hardware interrupt handler, without stack hit
zOS_RET macro
        pagesel zos_nhw
        goto    zos_nhw         ;#define zOS_RET() goto zos_nhw
        endm

;;; at the end of any interrupt handler goes back to scheduler without stack hit
zOS_RFI macro
        pagesel zos_noc
        goto    zos_noc         ;inline void zOS_RFI(void) { goto zos_noc; }
        endm

zOS_RFS macro   retreg
        pagesel zos_sch         ;inline void zOS_RFS(int8_t* retreg) {//from SWI
        if (retreg-WREG)
         movf   retreg,w        ; w = *retreg; goto zos_sch;//clobbers WREG_SHAD
        endif
        goto    zos_sch         ;} // zOS_RFS()
        endm

;;; find something runnable (i.e. PCH != 0, but sleep MSB is OK), at job+/-1
;;; according to incr then branch to unf if job-1 == 0 or job+1 > zOS_NUM,
;;; with fsrnum pointing to job's bank 0 structure and then incremented +/-16
zOS_LIV macro   fsrnum,job,incr,unf
        local   fsrn,loop
        if (fsrnum & 3)
fsrn set 1
        else
fsrn set 0
        endif
loop
        if (incr)
         movlw  0x10            ;inline int8_t zOS_LIV(int8_t* *fsrnum,
        else
         movlw  0-0x10          ;     uint8_t *job, int8_t incr, void *(unf)()) {
        endif
        addwf   FSR#v(fsrn)L,f  ; do {
        if (incr)
         incf   job,f           ;  *fsrnum += incr ? 0x10 : -0x10;// next struct
         movlw  0xff-zOS_NUM    ;  job += incr ? 1 : -1; // next job#
         addwf  job,w           ;  if ((job == 0) || (job >= zOS_NUM+1)) {//past
         btfss  WREG,7          ;
        else
         decf   job,f           ;   goto unf; // Z was set
         btfsc  STATUS,Z        ;  } else if (zOS_PCH[fsrnum]) // found runnable
        endif
        bra     unf             ;   return w = zOS_PCH[fsrnum]; // Z was cleared
        moviw   zOS_PCH[FSR#v(fsrn)]
        btfsc   STATUS,Z        ; } while (1); // job is runnable (or unf was 0)
        bra     loop            ;} // zOS_LIV()
        endm

#ifdef FSR0
#else
```

```
FSR0     equ    FSR0L
#endif
#ifdef FSR1
#else
FSR1     equ    FSR1L
#endif

        ;; a job switch is attempted with every incoming interrupt
        ;; user jobs are responsible for processing their own interrupts
        ;; with an interrupt handler registered at the time of creation

        org     0x0000
        pagesel zos_ini
        goto    zos_ini         ;<--zos_ini is run upon reset to bootstrap zOS

        org     0x0002
        pagesel zos_swj
        goto    zos_swj         ;<--zOS_SWI is call to 0x0002, a jump to zos_swj

        ;; enter handler which will zOS_RFI() to zos_sch if it’s the correct one
        ;; (and we’re not still in the bank-0 initialization before interrupts),
        ;; after clearing the interrupt flag...else zOS_RET() back up to zos_nhw

        org     0x0004
        ;; find first willing handler for an enabled interrupt matching _xIM bit
#ifdef PIE0
zOS_PIE  equ    PIE0
#else
zOS_PIE  equ    INTCON
#endif
zos_004
        movlw   zOS_NUM+1       ;__isr void zos_004(void) {
        movwf   zOS_JOB         ; zOS_JOB = zOS_NUM+1;// search from high to low
        zOS_MEM FSR0,zOS_JOB,0  ; fsr0 = 0x10 * (1 + zOS_JOB);
zos_nhw
        zOS_LIV FSR0,zOS_JOB,0,zos_004
        clrwdt                  ; do { // until serviceable by running ISR since
        banksel zOS_PIE
        moviw   zOS_HIM[FSR0]   ;  int8_t w = 0;  // no runnable job schedulable
        andwf   zOS_PIE,w       ;  clrwdt();
        btfss   STATUS,Z        ;  while (zOS_LIV(&fsr0, &zOS_JOB, 0)) {
        bra     zos_cmp         ;  //match enabled interrupts against HIM fields
#ifdef PIE1
        moviw   zOS_HIM[FSR0]   ;   if ((w = zOS_HIM[fsr0] & zOS_PIE))
        banksel PIE1
        andwf   PIE1,w          ;    break;
        btfss   STATUS,Z        ;   if ((w = zOS_HIM[fsr0] & zOS_PIE1))
        bra     zos_cmp         ;    break;
#endif
#ifdef PIE2
        moviw   zOS_HIM[FSR0]   ;
        andwf   PIE2,w          ;
        btfss   STATUS,Z        ;   if ((w = zOS_HIM[fsr0] & zOS_PIE2))
        bra     zos_cmp         ;    break;
#endif
#ifdef PIE3
        moviw   zOS_HIM[FSR0]   ;
        andwf   PIE3,w          ;
        btfss   STATUS,Z        ;   if ((w = zOS_HIM[fsr0] & zOS_PIE3))
        bra     zos_cmp         ;    break;
#endif
#ifdef PIE4
        moviw   zOS_HIM[FSR0]   ;
        andwf   PIE4,w          ;
        btfss   STATUS,Z        ;   if ((w = zOS_HIM[fsr0] & zOS_PIE4))
        bra     zos_cmp         ;    break;
#endif
#ifdef PIE5
        moviw   zOS_HIM[FSR0]   ;
```

```
        andwf   PIE5,w          ;
        btfss   STATUS,Z        ;   if ((w = zOS_HIM[fsr0] & zOS_PIE5))
        bra     zos_cmp         ;    break;
#endif
#ifdef PIE6
        moviw   zOS_HIM[FSR0]   ;
        andwf   PIE6,w          ;
        btfss   STATUS,Z        ;   if ((w = zOS_HIM[fsr0] & zOS_PIE6))
        bra     zos_cmp         ;    break;
#endif
#ifdef PIE7
        moviw   zOS_HIM[FSR0]   ;
        andwf   PIE7,w          ;
        btfss   STATUS,Z        ;   if ((w = zOS_HIM[fsr0] & zOS_PIE7))
        bra     zos_cmp         ;    break;
#endif
#ifdef PIE8
        moviw   zOS_HIM[FSR0]   ;
        andwf   PIE8,w          ;
        btfss   STATUS,Z        ;   if ((w = zOS_HIM[fsr0] & zOS_PIE8))
        bra     zos_cmp         ;    break;
#endif
#ifdef PIE9
        moviw   zOS_HIM[FSR0]   ;
        andwf   PIE9,w          ;
        btfss   STATUS,Z        ;   if ((w = zOS_HIM[fsr0] & zOS_PIE9))
        bra     zos_cmp         ;    break; // found a potential handler for any
#endif
        bra     zos_nhw         ;  }      // interrupt flag in this bit position
zos_cmp
        clrf    zOS_MSK         ;  if (w) {
        moviw   zOS_ISH[FSR0]   ;   zOS_MSK = 0; //indicates HWI (not SWI) type
        movwf   PCLATH          ;   *(zOS_ISR[fsr0])();
        moviw   zOS_ISR[FSR0]   ;  }
        movwf   PCL             ; } // if handler refuses, loops to the next job

        ;; scheduler begins here, called either after HWI/SWI done or zOS_RUN():
zos_sch
        banksel WREG_SHAD
        movwf   WREG_SHAD       ;zos_sch: // w sent via zOS_RFS()
zos_noc
        banksel WREG_SHAD
        movf    BSR_SHAD,w      ;  WREG_SHAD = w;zos_noc://lobber from zOS_RFI()
        btfsc   STATUS,Z        ;  // stay in _SHAD/STKPTR/TOS bank until retfie
        bra     zos_don         ;  if ((zOS_JOB = BSR_SHAD)!= 0)//2x max or ’004
        movwf   zOS_JOB         ;   for (zOS_MSK = 2; zOS_MSK; zOS_MSK--) {
        movlw   3               ;
        movwf   zOS_MSK         ;    //zOS_MSK=2 first time through,1 after wrap
        bra     zos_1st         ;    zOS_MEM(fsr0,zOS_JOB,0);
zos_itr
        zOS_LIV FSR0,zOS_JOB,1,zos_wra
        clrwdt                  ;   //zOS_LIV leaves PCH in WREG, test runnable?
        btfsc   WREG,zOS_WAI    ;    while(zOS_LIV(fsr0,zOS_JOB,1)&(1<<zOS_WAI))
        bra     zos_itr         ;     clrwdt();

        ;; if this point is reached, a runnable job was found with job# zOS_JOB
        ;; (but we skip a whole bunch of trivial copies if zOS_JOB==BSR_SHAD)
        movf    BSR_SHAD,w      ;
        xorwf   zOS_JOB,w       ;
        btfsc   STATUS,Z        ;
        bra     zos_don         ;    if (zOS_JOB != BSR_SHAD) {

        ;; copy the interrupted job’s (BSR_SHAD) criticals into its bank 0 slot;
        zOS_MEM FSR0,BSR_SHAD,zOS_PCL
        movf    TOSL,w          ;     fsr0 = 0x10 * (1+BSR_SHAD) + zOS_PCL;
        movwi   FSR0++          ;     *fsr0++ = TOSL; // return address from IRQ
        movf    TOSH,w          ;
        movwi   FSR0++          ;     *fsr0++ = TOSH;
        movf    STATUS_SHAD,w   ;
        movwi   FSR0++          ;     *fsr0++ = STATUS_SHAD;
        movf    WREG_SHAD,w     ;
        movwi   FSR0++          ;     *fsr0++ = WREG_SHAD;
        movf    STKPTR,w        ;
        movwi   FSR0++          ;     *fsr0++ = STKPTR; // not BSR_SHAD
        movf    PCLATH_SHAD,w   ;
        movwi   FSR0++          ;     *fsr0++ = PCLATH_SHAD;
        movf    FSR0L_SHAD,w    ;
        movwi   FSR0++          ;     *fsr0++ = FSR0L_SHAD;
        movf    FSR0H_SHAD,w    ;
        movwi   FSR0++          ;     *fsr0++ = FSR0H_SHAD;
        movf    FSR1L_SHAD,w    ;
        movwi   FSR0++          ;     *fsr0++ = FSR1L_SHAD;
        movf    FSR1H_SHAD,w    ;
        movwi   FSR0++          ;     *fsr0++ = FSR1H_SHAD;

        ;; by pure chance this clobbers the "unused" range 0x72˜0x7b on 1st run!
        movlw   0x7c            ;
        xorwf   FSR0L,f         ;
        btfss   STATUS,Z        ;
        bra     zos_no0         ;     if (fsr0 == 0x007c) {
        movlw   0x0a            ;
        movwf   FSR0H           ;
        movlw   0x72            ;
        movwf   FSR0L           ;      fsr0 = 0x0072;
        clrw                    ;      for (uint8_t i; i < 10; i++)
zos_re0
        movwi   FSR0++          ;       *fsr0 = 0;
        decfsz  FSR0H,f         ;
        bra     zos_re0         ;     }
zos_no0

        ;; get stack spun around to where zOS_JOB expects it on return from ISR
        zOS_ROL BSR_SHAD,zOS_JOB,zOS_MSK,FSR1,zOS_STK

        ;; copy zOS_JOB’s criticals out of its bank 0 slot
        zOS_MEM FSR0,zOS_JOB,zOS_SST
        moviw   FSR0++          ;     fsr0 = 0x10 * (1+zOS_JOB) + zOS_SST;
        movwf   STATUS_SHAD     ;     STATUS_SHAD = *fsr0++;
        moviw   FSR0++          ;
        movwf   WREG_SHAD       ;     WREG_SHAD = *fsr0++;
        movf    zOS_JOB,w       ;     //point to correct 80-byte local SRAM page
        movwf   BSR_SHAD        ;     BSR_SHAD = zOS_JOB; // not STKPTR
        moviw   ++FSR0          ;     //^^ notice BSR = zOS_JOB upon retfie! ^^
        movwf   PCLATH_SHAD     ;     PCLATH_SHAD = *++fsr0;
        moviw   ++FSR0          ;
        movwf   FSR0L_SHAD      ;     FSR0L_SHAD = *++fsr0;
        moviw   ++FSR0          ;
        movwf   FSR0H_SHAD      ;     FSR0H_SHAD = *++fsr0;
        moviw   ++FSR0          ;
        movwf   FSR1L_SHAD      ;     FSR1L_SHAD = *++fsr0;
        moviw   ++FSR0          ;
        movwf   FSR1H_SHAD      ;     FSR1H_SHAD = *++fsr0;

        ;; set new job stack pointer, last step before completing context switch
        moviw   zOS_RTS[FSR0]   ;
        movwf   STKPTR          ;     STKPTR = zOS_SSP[FSR0-11];
        moviw   zOS_RTL[FSR0]   ;     TOSL = zOS_PCL[FSR0-11];
        movwf   TOSL            ;     TOSH = zOS_PCH[FSR0-11];
        moviw   zOS_RTH[FSR0]   ;     return (void)__isr;
        movwf   TOSH            ;    }
zos_don
        retfie                  ;    //if this point is reached, search wrapped:
zos_wra
        clrf    zOS_JOB         ;    fsr0 = 0x10 * (1 + (zOS_JOB = 0));
zos_1st
        zOS_MEM FSR0,zOS_JOB,0  ;   }// wrap around only once, else wait for IRQ
        decfsz  zOS_MSK,f       ; } while (1); // (since no job is schedulable)
```

```
        bra     zos_itr         ;} // zOS_004()
        bra     zos_004         ;int8_t zos_swj(int8_t w){ // call vector at 002

        ;; software interrupt processing reached by jumping to 0x0002 with W set
        ;; which then calls to zos_swj, or by jumping to zos_skp after already
        ;; processing a previous interrupt (since there is only 1 level of SHAD)
        ;; to skip the copy into the shadow registers
zos_skp
        movwf   zOS_MSK         ;
        bra     zos_sk2         ;
zos_swj
        ;; save the shadow registers (for the ones that have them) to use retfie
        bcf     INTCON,GIE      ; INTCON &= ˜(1<<GIE); // interrupt would be bad
        movwf   zOS_MSK         ; zOS_MSK = WREG; // the software interrupt type
        movf    STATUS,w        ;
        movwf   zOS_JOB         ; // only convenient temporary global for STATUS
        movf    BSR,w           ;
        banksel BSR_SHAD        ; // BSR = the job# that made the interrupt call
        movwf   BSR_SHAD        ; BSR_SHAD = BSR;
        movf    zOS_JOB,w       ;
        movwf   STATUS_SHAD     ; STATUS_SHAD = zos_job = STATUS;
        movf    PCLATH,w        ;
        movwf   PCLATH_SHAD     ; PCLATH_SHAD = PCLATH;
        movf    FSR0L,w         ;
        movwf   FSR0L_SHAD      ; FSR0L_SHAD = FSR0L;
        movf    FSR0H,w         ;
        movwf   FSR0H_SHAD      ; FSR0H_SHAD = FSR0H;
        movf    FSR1L,w         ;
        movwf   FSR1L_SHAD      ; FSR1L_SHAD = FSR1L;
        movf    FSR1H,w         ;
        movwf   FSR1H_SHAD      ; FSR1H_SHAD = FSR1H;
zos_sk2
        ;; see if the interrupt type is a system one (<8)
        pagesel zos_swh
        movlw   zOS_SI7|zOS_SI6|zOS_SI5|zOS_SI4|zOS_SI3
        andwf   zOS_MSK,w       ; if (0 == /* call-type number: */ WREG_SHAD &
        btfss   STATUS,Z        ;   (zOS_SI7|zOS_SI6|zOS_SI5|zOS_SI4|zOS_SI3)) {
        goto    zos_swh         ;  // handle a system zOS_SWI call:

        ;; zOS_NEW requires us to search for a BSR value first among empty slots
        movf    BSR_SHAD,w      ;
        movwf   BSR             ;  // BSR unchanged from what it had been at call
        movf    zOS_MSK,f       ;
        btfss   STATUS,Z        ;  if (zOS_MSK == zOS_NEW /*==0*/) {
        bra     zos_swp         ;  zos_cre:
zos_cre
        clrf    zOS_JOB         ;   zos_job = 0;
        zOS_MEM FSR1,zOS_JOB,0
zos_emp
        movlw   0x10            ;   for (fsr1 = 0x10*(1+zos_job);
        addwf   FSR1L,f         ;
        incf    zOS_JOB,f       ;        zos_job++ <= zOS_NUM;
        movlw   0xff-zOS_NUM    ;
        addwf   zOS_JOB,w       ;
        btfsc   STATUS,Z        ;        fsr1 += 0x10) {
        bra     zos_err         ;    if (zOS_PCH[FSR1] == 0)
        moviw   zOS_PCH[FSR1]   ;     break;
        btfss   STATUS,Z        ;   }
        bra     zos_emp         ;   if (zos_job <= zOS_NUM) {
zos_dup
        movf    FSR0L,w         ;    // save handle now so we can re-use fsr0
        movwi   zOS_HDL[FSR1]   ;    // (no harm if we don’t validate it as PCH)
        movf    FSR0H,w         ;    zOS_HDL[fsr1] = fsr0 & 0x00ff;
        movwi   zOS_HDH[FSR1]   ;    zOS_HDH[fsr1] = fsr0 >> 8;
        movf    BSR,f           ;    if (bsr == 0)
        btfsc   STATUS,Z        ;     goto zos_swk; // job#0 (launcher) has perm
        bra     zos_swk         ;    fsr0 = 0x10 * (1+bsr); // struct for caller
        zOS_MEM FSR0,BSR,0
        moviw   zOS_HDH[FSR0]   ;    if (zOS_HDH[fsr0] & (1<<zOS_PRB))
        btfsc   WREG,zOS_PRB    ;     goto zos_swk; // job has privileged perms
        bra     zos_swk         ;   }
zos_err
        clrf    zOS_JOB         ;   zos_job = 0;
        zOS_RFS zOS_JOB         ;   zOS_RFS(zOS_JOB); // perms error or no empty

        ;; see if we're not running inside a job context (1 <= job# <= zOS_NUM)
        ;; in which case need to grab the targeted job from AR0 (if not zOS_NEW)
        ;; or find a targetable slot (if zOS_NEW)
        ;; unprivileged jobs can only do most things to themselves
zos_swp
        movf    BSR,w           ;  } else {
        movwf   zOS_JOB         ;   zos_job = bsr;
        btfsc   STATUS,Z        ;   if (bsr != 0) {
        bra     zos_elv         ;    fsr1 = 0x10 * (1+bsr); // struct for job
        zOS_MEM FSR1,BSR,0
        moviw   zOS_HDH[FSR1]   ;    if (zOS_HDH[fsr1] & (1<<zOS_PRB) == 0)
        btfss   WREG,zOS_PRB    ;     goto zos_swk; // disallowed job in zOS_AR0
        bra     zos_swk         ;   }

        ;; desired job# (instead of this one) into BSR from AR0 (if not zOS_NEW)
zos_elv
        movf    zOS_AR0,w       ;   // access granted, bring the patient to me
        movwf   BSR             ;   bsr = zOS_AR0;
        zOS_MEM FSR1,BSR,0
zos_swk
        movf    zOS_MSK,w       ;  }
        brw                     ;  switch (zOS_MSK) { // guaranteed < 8
        bra     zos_sw0         ;
        bra     zos_sw1         ;
        bra     zos_sw2         ;
        bra     zos_sw3         ;
        bra     zos_sw4         ;
        bra     zos_sw5         ;
        bra     zos_sw6         ;
        bra     zos_sw7         ;  case zOS_NEW:
zos_sw0
        movf    zOS_AR0,w       ;
        movwi   zOS_ISR[FSR1]   ;   zOS_ISR[fsr1] = zOS_AR0;
        movf    zOS_AR1,w       ;
        movwi   zOS_ISH[FSR1]   ;   zOS_ISH[fsr1] = zOS_AR1;
        movf    zOS_AR2,w       ;
        movwi   zOS_HIM[FSR1]   ;   zOS_HIM[fsr1] = zOS_AR2;
        movf    zOS_AR3,w       ;
        movwi   zOS_SIM[FSR1]   ;   zOS_SIM[fsr1] = zOS_AR3;
        bra     zos_sw3         ;   goto zos_sw3;
zos_sw1
        moviw   zOS_PCH[FSR1]   ;  case zOS_SLP:
        iorlw   0x80            ;   zOS_PCH[fsr1] |= 0x80;
        movwi   zOS_PCH[FSR1]   ;   zOS_RFS(zOS_JOB);
        zOS_RFS zOS_JOB
zos_sw2
        movf    BSR,w           ;  case zOS_END:
        banksel PCLATH_SHAD     ;
        xorwf   BSR_SHAD,w      ;
        btfsc   STATUS,Z        ;   if (bsr == BSR_SHAD) // if killing self wipe
        clrf    TOSH            ;    TOSH = 0; // stack so PC can't get restored
        xorwf   BSR_SHAD,w      ;
        movwf   BSR             ;
        clrw                    ;   zOS_PCH[fsr1] = 0; // so scheduler won't see
        movwi   zOS_PCH[FSR1]   ;   zOS_RFS(zOS_JOB); // killing is so quick
        zOS_RFS zOS_JOB
zos_sw3
        moviw   zOS_HDL[FSR1]   ;  case zOS_RST: zos_sw3:
        movwi   zOS_PCL[FSR1]   ;   // retain HDL MSB (which indicate privilege)
        moviw   zOS_HDH[FSR1]   ;   zOS_PCL[fsr1] = zOS_HDL[fsr1];
        andlw   0x7f            ;   // clear PC MSB (which indicates sleepiness)
        movwi   zOS_PCH[FSR1]   ;   zOS_PCH[fsr1] = zOS_HDH[fsr1] & 0x7f;
        movlw   zOS_BOS         ;   zOS_SSP[fsr1] = zOS_BOS;
```

```
        movwi   zOS_SSP[FSR1]   ;

        lslf    zOS_JOB,w       ;
        iorlw   0x70            ;
        movwf   FSR1L           ;   fsr1 = 0x70 | (zOS_JOB << 1);
        clrw                    ;   0[fsr1] = 1[fsr1] = 0; // mailbox guar'ed 0
        movwi   0[FSR1]         ;  case zOS_YLD:
        movwi   1[FSR1]         ;   zOS_RFS(zOS_JOB);
zos_sw4

#ifdef zOS_MIN
zos_sw5
zos_sw6
zos_sw7
        zOS_RFS zOS_JOB
#else
        zOS_RFS zOS_JOB
zos_sw5
        ;; copy job BSR's 0x20-0x6f into every non-running bank first
        clrf    FSR1L           ;  case zOS_FRK:
        clrf    FSR1H           ;   fsr1 = 1 << 7;
        clrf    zOS_JOB         ;   for (zos_job = 1;
zos_cp1
        movlw   0x80            ;        zos_job++ <= zOS_NUM; fsr1 += 0x80) {
        andwf   FSR1L,f         ;    fsr1 &= 0xff80;
        addwf   FSR1L,f         ;
        clrw                    ;
        addwfc  FSR1H,f         ;    fsr1 += 0x80;
        incf    zOS_JOB,f       ;
        movlw   0xff-zOS_NUM    ;
        addwf   zOS_JOB,w       ;
        btfsc   STATUS,Z        ;
        bra     zos_cpd         ;

        zOS_MEM FSR0,zOS_JOB,0
        moviw   zOS_PCH[FSR0]   ;    fsr0 = 0x10 * (1+zOS_JOB);
        btfss   STATUS,Z        ;    if (zOS_PCH[fsr0] == 0)
        bra     zos_cp1         ;     continue; // can't touch a running job

        lsrf    BSR,w           ;
        movwf   FSR0H           ;
        clrf    FSR0L           ;
        rrf     FSR0L,f         ;
        movlw   0x6f            ;
        iorwf   FSR0L,f         ;    fsr0 = (BSR << 7) | 0x6f;
        iorwf   FSR1L,f         ;    for (fsr1 |= 0x6f; fsr1 & 0x7f >= 0x20;

zos_cp2
        moviw   FSR0--          ;
        movwi   FSR1--          ;         *fsr1-- = *fsr0--)
        movlw   0x60            ;
        andwf   FSR0L,w         ;
        btfss   STATUS,Z        ;
        bra     zos_cp2         ;     ;
        bra     zos_cp1         ;   }
zos_cpd
        ;; now copy job BSR's bank0 struct to the zOS_AR registers and zOS_NEW()
;;;FIXME: should copy the rest of state, i.e. memory variables to be a true fork
;;;FIXME: disallow fork if any HWI is defined for the process (assume conflicts)
        movf    BSR,w           ;
        movwf   zOS_JOB         ;   zOS_JOB = BSR;
        zOS_MEM FSR1,zOS_JOB,0
        moviw   zOS_PCH[FSR1]   ;   fsr1 = zOS_MEM(&fsr1, zOS_JOB, 0);
        btfsc   STATUS,Z        ;
        bra     zos_sw4         ;   if ((w = zOS_PCH[fsr1]) != 0) {
        moviw   zOS_HDL[FSR1]   ;
        movwf   FSR0L           ;
        moviw   zOS_HDH[FSR1]   ;
        movwf   FSR0H           ;    fsr0 = (zOS_HDH[fsr1]<<8) | zOS_HDL[fsr1];
        moviw   zOS_ISR[FSR1]   ;
        movwf   zOS_AR0         ;    zOS_AR0 = zOS_ISR[fsr1];
        moviw   zOS_ISH[FSR1]   ;
        movwf   zOS_AR1         ;    zOS_AR1 = zOS_ISH[fsr1];
        moviw   zOS_HIM[FSR1]   ;
        movwf   zOS_AR2         ;    zOS_AR2 = zOS_HIM[fsr1];
        moviw   zOS_SIM[FSR1]   ;
        movwf   zOS_AR3         ;    zOS_AR3 = zOS_SIM[fsr1];
        banksel WREG_SHAD
        clrf    WREG_SHAD       ;    WREG_SHAD = zOS_NEW;
        movlb   0               ;    zOS_MSK = 0; //spoof having passed zOS_NEW
        clrf    zOS_MSK         ;    goto zos_cre;//spoof privilege to fork self
        bra     zos_cre         ;   } else zOS_RFS(w);
zos_sw6
        movf    BSR,w           ;  case zOS_EXE:
        movwf   zOS_JOB         ;   zOS_JOB = BSR;
        zOS_MEM FSR1,zOS_JOB,0
        banksel WREG_SHAD       ;   fsr1 = 0x10 * (1+zOS_JOB);
        clrf    WREG_SHAD       ;   WREG_SHAD = zOS_NEW;
        movlb   0               ;   //spoof privilege to overwrite
        bra     zos_dup         ;   goto zos_dup;
zos_sw7
        movf    zOS_AR2,w       ;  case zOS_FND:
        btfss   STATUS,Z        ;
        movlw   zOS_NUM         ;
        addlw   1               ;
        movwf   zOS_JOB         ;
        addlw   0xfe-zOS_NUM    ;   if (zOS_AR2 && ((uint8_t)zOS_AR2<=zOS_NUM))
        btfsc   WREG,7          ;    zOS_JOB = zOS_AR2 + 1;
        movlw   1+zOS_NUM       ;   else
        movwf   zOS_JOB         ;    zOS_JOB = zOS_NUM + 1;
        zOS_MEM FSR1,zOS_JOB,0  ;   fsr1 = 0x10 * (1 + zOS_JOB);
zos_nxt
        zOS_LIV FSR1,zOS_JOB,0,zos_bad
        moviw   zOS_HDL[FSR1]   ;   while (zOS_LIV(&fsr1, &zOS_JOB, 0)) {
        xorwf   zOS_AR0,w       ;
        btfss   STATUS,Z        ;
        bra     zos_nxt         ;
        moviw   zOS_HDH[FSR1]   ;    void (*a)() = (zOS_AR1<<8)|zOS_AR0;
        xorwf   zOS_AR1,w       ;    void (*b)() = (zOS_HDH[fsr1]<<8)|zOS_HDL[fsr1]
;
        andlw   0x7f            ;
        btfss   STATUS,Z        ;    if (a & 0x7f == b & 0x7f)
        bra     zos_nxt         ;     zOS_RFS(zOS_JOB);
        zOS_RFS zOS_JOB         ;   }
zos_bad
        clrw                    ;
        zOS_RFS WREG            ;   zOS_RFS(w = 0);
#endif

        ;; else handle the software interrupt with the first registered handler
zos_swh
        banksel BSR_SHAD
        incf    BSR_SHAD,w      ; // a swi number of 0xff is special now, will
        incfsz  zOS_MSK,f       ; // cause the calling job to invoke its own
        movlw   1+zOS_NUM       ; // handler without knowledge of its SWI code!
        decf    zOS_MSK,f       ; // (at the cost of 4 extra instruction cycles)
        movwf   zOS_JOB         ; zos_job =1+((zos_msk==0xff)?BSR_SHAD:zOS_NUM);

        zOS_MEM FSR0,zOS_JOB,0  ; while (zOS_LIV(&fsr0, &zOS_JOB, 0)) { //search
zos_swl
        zOS_LIV FSR0,zOS_JOB,0,zos_swm
        moviw   zOS_SIM[FSR0]   ;
        andwf   zOS_MSK,w       ;
        btfsc   STATUS,Z        ;
        bra     zos_swl         ;  if ((zos_msk & zOS_SIM[fsr0]) != 0) { //found
        movwf   zOS_MSK         ;   zos_msk &= zOS_SIM[fsr0];
        moviw   zOS_ISH[FSR0]   ;   goto (void*)(zOS_ISR[fsr0]); // will zOS_RFS
        movwf   PCLATH          ;  }
```

```
        moviw   zOS_ISR[FSR0]   ; }
        movwf   PCL             ; zOS_RFS(WREG = 0);

        ;; no registered SWI handler: jump into the hardware interrupt scheduler
zos_swm
        zOS_RFS WREG

zos_ini
        ;; clear out page 0 to reflect no running tasks, set global data to 0’s
        movlb   0               ; "invalid" job# used to get perms for zOS_NEW
        movlw   0x7f            ; bsr = 0;
        movwf   FSR0L           ;
        clrf    FSR0H           ; for (fsr0 = 0x007f; fsr >= 0x0020; fsr--)
zos_zer
        clrw                    ;
        movwi   FSR0--          ;  *fsr = 0; // only zOS_PCH is critical
        movlw   0x60            ;
        andwf   FSR0L,w         ;
        btfss   STATUS,Z        ;
        bra     zos_zer         ;

        ;; your program starts here, with a series of launcher instructions for
        ;; 1) setting up oscillators, timers, other peripherals, etc.
        ;;    (with the appropriate and ineviatable bank switching)
        ;; 2) starting jobs with calls to zOS_NEW or its zOS_LAU wrapper
        ;;    (being sure to stay in bank 0 or using job macros zOS_CON/zos_MON)
        ;; 3) calling zOS_RUN (which will enable interrupts) to start job 1
```

```
;;; zosmacro.inc
;;; potentially useful (but not mandatory) macros for zOS
;;;
;;; total memory footprint (for a PIC16F1847, including the zOS base):
;;; no memory words used upon inclusion (before expansion of a macro)
;;;  ˜256 14-bit words if only zOS_CON() job is started to buffer console output
;;;  _??_ 14-bit words for full-featured monitor zOS_MON()
;;;  _??_ 14-bit words for job manager shell zOS_MAN()

#ifdef UCFG
#define zOS_ME BSR,w : xorlw 0x8; // advance zOS use past DPSRAM; FIXME:untested
#else
#define zOS_ME BSR,w            ; // "movf/andwf/xorwf zOS_ME" can't clobber BSR
#endif

zOS_GLO macro   fsrnum,job
        local   fsrn
        if (fsrnum & 3)
fsrn set 1
        else
fsrn set 0
        endif
        if (job)
         lslf   job,w           ;inline void zOS_GLO(int8_t**fsrnum,int8_t*job){
        else
         lslf   zOS_ME          ;
        endif
        andlw   0x0e            ; int8_t w = 0x70 | ((job ? *job : bsr) << 1);
        iorlw   0x70            ;
        movwf   FSR#v(fsrn)L    ;// documentation suggests 5 but BSR now 6 bits!
        movlw   0x1f            ; *fsrnum = (*fsrnum & 0x1f00) | w;
        andwf   FSR#v(fsrn)H,f  ;} // zOS_GLO()
        endm

zOS_MY2 macro   fsrnum          ;inline int8_t zOS_MY2(int8_t**fsrnum){
        zOS_GLO fsrnum,0        ; return zOS_GLO(fsrnum, 0);
        endm                    ;} // zOS_MY2()

zOS_LOC macro   fsrnum,job,offset
        local   fsrn
        if (fsrnum & 3)
fsrn set 1
        else
fsrn set 0
        endif
        if (offset)
         movlw  offset<<1       ;inline int8_t zOS_LOC(int8_t* *fsrnum,
         movwf  FSR#v(fsrn)L    ;        int8_t* job, uint8_t offset) {
        else
         clrf   FSR#v(fsrn)L    ;
        endif
        if (job - FSR#v(fsrn)H)
         lsrf   job,w           ;
         movwf  FSR#v(fsrn)H    ; return (*fsrnum = (job<<7) | offset) >> 8;
        else
         lsrf   job,f
        endif
        rrf     FSR#v(fsrn)L,f  ;} // zOS_LOC()
        endm

zOS_ADR macro   adr,msb
        movlw   low adr         ;inline void zOS_ADR(void* a) {
        movwf   FSR0L           ; if (msb) fsr0 = 0x8000 | a;
        movlw   high adr        ; else fsr0 = 0x7fff & a;
        movwf   FSR0H           ;} // zOS_ADR()
        if (msb)
         bsf    FSR0H,7
        else
         bcf    FSR0H,7
```

```
        endif
        endm

zOS_INT macro   lhw,lsw
        if (lhw|lsw)
        movf    FSR0L,w         ;inline void zOS_INT(const lhw, const lsw) {
        zOS_ARG 0
        movf    FSR0H,w         ; if (lhw == 0 && lsw == 0) fsr0 = 0;
        zOS_ARG 1
        movlw   lhw             ; zOS_ARG(0, fsr0 & 0x00ff);
        zOS_ARG 2
        movlw   lsw             ; zOS_ARG(1, fsr0 >> 8);
        zOS_ARG 3
        else
        clrw                    ; zOS_ARG(2, lhw);
        movwf   FSR0L           ; zOS_ARG(3, lsw);
        movwf   FSR0H           ;} // zOS_INT()
        zOS_ARG 0
        zOS_ARG 1
        zOS_ARG 2
        zOS_ARG 3
        endif
        endm

zOS_SWI macro   type            ;inline void zOS_SWI(const int8_t type) {
        movlw   type            ;
        movlp   0x00            ; zos_swj(type);
        call    0x02            ;} // zOS_SWI()
        endm

zOS_TAI macro   type            ;inline void zOS_TAI(const int8_t type) {
        movlw   type            ; w = type; goto zos_skp;
        pagesel zos_skp
        goto    zos_skp         ;} // zOS_TAI()
        endm

zOS_LAU macro   stash           ;inline void zOS_LAU(int8_t* stash) {
        local retry
retry
        zOS_SWI zOS_NEW
        bcf     INTCON,GIE      ; do {  w = zOS_SWI(zOS_NEW);
#ifdef CAUTIOUS
        movf    BSR,f           ;  INTCON &= ˜(1<<GIE); // prevent deadlock
        btfss   STATUS,Z        ;  if (bsr)             // arising from an
        bsf     INTCON,GIE      ;   INTCON &= 1<<GIE;   // interrupt right now
#endif
        movf    WREG,w          ;
        btfsc   STATUS,Z        ;
        bra     retry           ; } while (w == 0);
        if (stash - WREG)
         movwf  stash           ; *stash = w;
        endif
        endm                    ;} // zOS_LAU()

zOS_INI macro   fsrnum,val0,val1
        if (fsrnum & 3)
fsrn     set 1
        else
fsrn     set 0
        endif
;after: zOS_LAU FSR#v(fsrn)L
        lslf    FSR#v(fsrn)L,f  ;inline void zOS_INI(uint8_t* fsrnum, uint8_t
        movlw   0x70            ;                      val0, uint8_t val1) {
        iorwf   FSR#v(fsrn)L,f  ; //fsrnum starts and ends as a launched job#
        clrf    FSR#v(fsrn)H    ; fsrnum = 0x70 | (fsrnum << 1);
        movlw   val0            ; // change global mailbox to non-0 if desired
        movwi   FSR#v(fsrn)++   ; fsrnum[0] = val0;
        movlw   val1            ;
        movwi   FSR#v(fsrn)--   ; fsrnum[1] = val1;
        lsrf    FSR#v(fsrn),w   ; fsrnum = (fsrnum >> 1) & 0x07; // unchanged
        andlw   0x07            ;}
        endm


zOS_DIS macro   fsrnum,job      ;inline void zOS_DIS(int8_t* *fsr, int8_t job) {
        if (fsrnum & 3)
fsrn     set 1
        else
fsrn     set 0
        endif
        if (job)
        zOS_MEM FSR#v(fsrn),job,zOS_HDH ; *fsr = 0x10 * (1+job) + zOS_HDH;//priv
         btfsc  INDF#v(fsrn),zOS_PRB    ; if (**fsr & (1<<zOS_PRB))
        endif
        bcf     INTCON,GIE      ;  INTCON &= ~(1<<GIE);
        endm                    ;} // zOS_DIS()

zOS_ENA macro                   ;inline void zOS_ENA(void) {
        bsf     INTCON,GIE      ; INTCON |= 1<<GIE;
        endm                    ;} // zOS_ENA()

zOS_ARG macro   arg
        local num
num set (arg & 0x03)
        if (num == 0)
         bcf    INTCON,GIE      ;inline void zOS_ARG(const int8_t arg, int8_t w)
        endif
        movwf   zOS_AR#v(num)   ;{if (!arg) INTCON &=~(1<<GIE); zOS_AR0[arg]=w;}
        endm

zOS_RUN macro   t0enable,t0flags
        ;; start a TMR0 interrupt since none found (most in INTCON, others PIE0)
zOS_T0E equ     t0enable
zOS_T0F equ     t0flags
        if (zOS_T0E)
         banksel zOS_T0E
         bsf    zOS_T0E,T0IE    ;inline void zOS_RUN(uint8_t* t0enable) {
          if (zOS_T0E - INTCON)
           bsf  INTCON,PEIE     ; if (t0enable) { *t0enable |= 1<<T0IE;
         endif
        endif
        ;; advance the stack pointer to allow 5 stacks of 3 each (+1 if running)
        banksel STKPTR          ;  if (t0enable !=  INTCON) INTCON |= 1<<PEIE;
        movlw   zOS_BOS         ; }
        movwf   STKPTR          ; STKPTR = zOS_BOS; // every job bottom of stack

        ;; set the active job to the first (and potentially only), interrupts ON
        movlw   1+zOS_NUM       ; bsr_shad = w = 1+zOS_NUM; // will wrap around
        movwf   BSR_SHAD        ; boot(); // run the scheduler to grab its PC
        pagesel boot            ;} // zOS_RUN()
        call    boot            ;
boot
        bsf     INTCON,GIE      ;void boot(void) { INTCON |= 1<<GIE; zOS_RFI();}
        zOS_RFI
        endm

zOS_DBG macro
        local   loop
        banksel STKPTR
        clrf    STKPTR          ;inline void zOS_DBG(void) {
        clrw                    ; for (int8_t w = STKPTR = 0;
loop
        clrf    TOSH            ;      w < 16; w++){
        movwf   TOSL            ;  TOSH = 0;
        incf    STKPTR,w        ;  TOSL = w;
        andlw   0x0f            ;
        movwf   STKPTR          ;  STKPTR = (STKPTR + 1) % 16;
        btfss   STATUS,Z        ; }
```

```
        bra     loop            ; STKPTR = -1;
        decf    STKPTR,f        ; // still in job "0"
        movlb   0               ;} // zOS_DBG()
        endm

#ifdef  PID1CON
;;; 16x16bit signed multiply zOS_AR1:0 * zOS_AR3:2, core yielded during 7ms math
zOS_MUL macro   fsrnum
        local fn,inout,fac0L,fac0H,fac1L,fac1H,zeroH,start,con,setup,enb,bsy
        if (fsrnum & 3)
fn       set 1
        else
fn       set 0
        endif
inout   set     0x1f80 & PID1SETL
fac0L   set     0x1f & PID1K1L
fac0H   set     0x1f & PID1K1H
fac1L   set     0x1f & PID1SETL
fac1H   set     0x1f & PID1SETH
zeroH   set     0x1f & PID1INH
start   set     0x1f & PID1INL
con     set     0x1f & PID1CON
out0    set     0x1f & PID1OUTLL
out1    set     0x1f & PID1OUTLH
out2    set     0x1f & PID1OUTHL
out3    set     0x1f & PID1OUTHH
setup   set     (1<<PID1MODE1)
enb     set     PID1EN
bsy     set     PID1BUSY

        movlw   low PID1CON     ;void zOS_MUL(int16_t** fsr) {
        movwf   FSR#v(fn)L      ; *fsr = &PID1CON;
        movlw   high PID1CON    ;
        movwf   FSR#v(fn)H      ; do {
spinget
        btfss   INDF#v(fn),enb  ;  while ((**fsr&(1<<enb))&& // MATHACC for sure
        bra     notbusy         ;         (**fsr&(1<<bsy)))  // ours if not busy
        btfss   INDF#v(fn),bsy  ;  {                         // or never enabled
        bra     notbusy         ;   zOS_ARG(0, bsr);
        movf    zOS_ME          ;   zOS_SWI(zOS_YLD);
        zOS_ARG 0
        zOS_SWI zOS_YLD         ;  }
        bra     spinget         ;  // interrupts now enabled if zOS_SWI called
notbusy
        bcf     INTCON,GIE      ;  INTCON &= ~(1<<GIE);
        btfsc   INDF#v(fn),enb  ;  // begin critical section (seizing MATHACC)
        bra     spinget         ;
        bsf     INDF#v(fn),bsy  ;
        bra     spinget         ; } while ((**fsr&(1<<enb))||(**fsr&(1<<bsy)));
        movlw   setup           ;
        movwf   indf#v(fn)      ; **fsr = 1<<PIDMODE1; // unsigned mult no accum
        bsf     indf#v(fn),enb  ; **fsr |= 1<<PID1EN; // selected, then enabled
        movlw   low inout       ;
        movwf   FSR#v(fn)L      ;
        movlw   high inout      ;
        movwf   FSR#v(fn)H      ; *fsr = &PID1SETL & 0x1f80; // just bank bits
        movf    zOS_AR3,w       ;
        movwi   fac0H[FSR#v(fn)]; (0x1f & PID1K1H)[*fsr] = zOS_AR3;
        movf    zOS_AR2,w       ;
        movwi   fac0L[FSR#v(fn)]; (0x1f & PID1K1L)[*fsr] = zOS_AR2;
        movf    zOS_AR1,w       ;
        movwi   fac1H[FSR#v(fn)]; (0x1f & PID1SETH)[*fsr] = zOS_AR1;
        movf    zOS_AR0,w       ;
        movwi   fac1L[FSR#v(fn)]; (0x1f & PID1SETL)[*fsr] = zOS_AR0;
        clrw                    ; (0x1f & PID1INH)[*fsr] = 0;
        movwi   zeroH[FSR#v(fn)]; (0x1f & PID1INL)[*fsr] = 0; // start multiply
        movwi   start[FSR#v(fn)]; // end critical section (seizing MATHACC)
        bsf     INTCON,GIE      ; INTCON |= 1<<GIE;
        movlw   low PID1CON     ;
        movwf   FSR#v(fn)L      ;
        movlw   high PID1CON    ; *fsr = &PID1CON;
        movwf   FSR#v(fn)H      ; do {
spinmul
#if 0
        clrwdt                  ;  clrwdt();
#endif
        movf    zOS_ME          ;  zOS_ARG(0, bsr);
        zOS_ARG 0
        zOS_SWI zOS_YLD
        btfss   INDF#v(fn),bsy  ;  zOS_YLD();
        bra     spinmul         ; } while (**fsr & 1<<PID1BUSY);
        bcf     INTCON,GIE      ; INTCON &= ~(1<<GIE);
        bcf     INDF#v(fn),enb  ; // begin critical section (copying result)
        movlw   low inout       ; **fsr &= ~(1<<enb); // disable MathACC to free
        movwf   FSR#v(fn)L      ;
        movlw   high inout      ;
        movwf   FSR#v(fn)H      ; *fsr = &PID1SETL & 0x1f80; // just bank bits
        moviw   out3[FSR#v(fn)] ; zOS_AR3 = (0x1f & PID1OUTHH)[*fsr];
        movwf   zOS_AR3         ;
        moviw   out2[FSR#v(fn)] ; zOS_AR2 = (0x1f & PID1OUTHL)[*fsr];
        movwf   zOS_AR2         ;
        moviw   out1[FSR#v(fn)] ; zOS_AR1 = (0x1f & PID1OUTLH)[*fsr];
        movwf   zOS_AR1         ;
        moviw   out0[FSR#v(fn)] ; zOS_AR0 = (0x1f & PID1OUTLL)[*fsr];
        movwf   zOS_AR0         ; // end critical section (when ARx copy’s done)
;;      bsf     INTCON,GIE      ;} // zOS_MUL()
        endm
#endif

zOS_PAG macro   fsrnum
        local   fsrn
        if (fsrnum & 3)
fsrn set 1
        else
fsrn set 0
        endif

        swapf   FSR#v(fsrn)L,w  ;uint8_t zOS_PAG(void* fsrnum) {
        andlw   0x0f            ;
        bcf     FSR#v(fsrn)H,5  ;
        swapf   FSR#v(fsrn)H,f  ;
        iorwf   FSR#v(fsrn)H,w  ;
        swapf   FSR#v(fsrn)H,f  ; return w = (fsrnum >> 4);
        bsf     FSR#v(fsrn)H,5  ;} // zOS_PAG()
        endm

zOS_PTR macro   fsrnum
        local   fsrn
        if (fsrnum & 3)
fsrn set 1
        else
fsrn set 0
        endif

        swapf   WREG,w          ;void zOS_PTR(void** fsrnum, uint8_t w) {
        movwf   FSR#v(fsrn)H    ;
        movwf   FSR#v(fsrn)L    ;
        movlw   0x0f            ;
        andwf   FSR#v(fsrn)H,f  ;
        bsf     FSR#v(fsrn)H,4  ;
        movlw   0xf0            ; *fsrnum = 0x2000 | w<<4;
        andwf   FSR#v(fsrn)L,f  ;} // zOS_PTR()
        endm

;;; must be defined with 2 SWI flags: one for malloc(), a different for free()
;;; (typically instantiated with base=0x2210, size = memory size - base)
;;; SWI behavior for malloc(w) is to return pointer in w of 2 middle nybbles
;;;  in linear address space, e.g. 0x21 for first cell on a 5-job system, or 0
```

```
;;;  in w if no free memory of size zOS_AR0*16 bytes was available
;;; SWI behavior for free(w) is to return in w the number of bytes now free/16
;;;  intersecting with the address whose middle nybble is zOS_AR0, or 0 in w if
;;;  zOS_AR0 didn’t point to a valid (i.e. previously allocated) block of bytes

zOS_HEA macro   base,size,mi,fi ;void zOS_HEA(void* base, void* size, uint8_t
        local   isr,decl,task   ;             mi/*malloc*/,uint8_t fi/*free*/) {

        bra     decl            ; goto decl;

        local   maxnon0,alloced,always0,temp,adrarry,tblsize
        local   tblrows,sizarry,memroun,mem3nyb,membase,memsize
maxnon0 set     0x6c
alloced set     0x6d
always0 set     0x6e
temp    set     0x6f
adrarry set     0x20
tblsize set     0x50
tblrows set     tblsize/2
sizarry set     adrarry+tblrows
memroun set     base+0xf
mem3nyb set     memroun&0xfff
membase set     mem3nyb>>4
memsize set     size>>4

isr
        local   mloop,mcandid,mexact,mnotall,groloop
        local   free,floop,ffound,invalid,done

        movf    zOS_JOB,w       ; isr:
        movwf   BSR             ; bsr = zOS_JOB;

        zOS_MY2 FSR1            ; fsr1 = 0x70|(bsr<<1);
        moviw   FSR1++          ;
        iorwf   INDF1,w         ;
        btfsc   STATUS,Z        ; if (0[fsr1] | 1[fsr1])
        bra     invalid         ;  goto invalid;// not init’ed according to mbox

#if (mi - fi)
        movf    zOS_MSK,w       ;
        andlw   mi              ; //////////////////////////////////////////////
        btfsc   STATUS,Z        ; /////             malloc()                  //
        bra     free            ; if (((mi != fi) && (zOS_MSK & mi)) ||
#else
        movf    zOS_AR1,w       ;    ((mi == fi) && (zOS_AR0=/*sic*/zOS_AR1))) {
        movf    zOS_AR0,f       ;  // can either assign separate SWIs for malloc
        movwf   zOS_AR0         ;  // and free or if nearing the SWI limit of 5,
        btfsc   STATUS,Z        ;  // put the parameter in ARG1 instead of ARG0
        bra     free            ;  // and ARG0!=0 for malloc() or ==0 for free()
#endif
        zOS_LOC FSR0,BSR,adrarry;  for (fsr0 = (bsr<<7)+adrarry,
        zOS_LOC FSR1,BSR,sizarry;       fsr1 = (bsr<<7)+sizarry;
mloop
        moviw   FSR0++          ;       (alloced = temp = *fsr0++);// next poss.
        btfsc   STATUS,Z        ;       fsr1++) {
        bra     invalid         ;
        movwf   temp            ;
        movwf   alloced         ;
        moviw   FSR1++          ;   w = *fsr1++; // number of bytes used,0=freed
        btfss   STATUS,Z        ;
        bra     mloop           ;   if (w == 0) { // allocatable
mcandid
        moviw   0[FSR0]         ;    w = *fsr0;// upper limit to allocating here
        btfsc   STATUS,Z        ;    if (w == 0)
        bra     invalid         ;     goto invalid; // past the highest address

        bsf     STATUS,C        ;    // temp is now the address of this candidate
        comf    temp,f          ;    // w is now the next address past candidate
        addwfc  temp,w          ;
        movwf   temp            ;
        subwf   zOS_AR0,w       ;    else if ((w = zOS_AR0 - (temp = w-temp))>0)
        btfsc   STATUS,Z        ;
        bra     mexact          ;    // -w now holds extra space beyond requested
        btfss   WREG,7          ;    // temp now holds total available at alloced
        bra     mloop           ;
        bra     mnotall         ;     continue; // not enough allocatable here

mexact
        movf    zOS_AR0,w       ;    if (w == 0) { // exactly enough!
        movwi   -1[FSR1]        ;     -1[fsr1] = zOS_AR0; // allocated size
        moviw   -1[FSR0]        ;     w = -1[fsr0]; // recycled handle
        bra     done            ;     goto done;
mnotall
        movf    maxnon0,f       ;    } else if (adrarry[tblrows-2] != 0) // full
        btfss   STATUS,Z        ;     goto invalid;
        bra     invalid         ;

        movf    zOS_AR0,w       ; // w == addr to insert, temp == size to insert
        movwi   -1[FSR1]        ;    -1[fsr1] = zOS_AR0; // record it as granted
        clrf    temp            ;    temp = 0;
        addwf   alloced,w       ;    for (w = -1[fsr0] + temp; *fsr0; fsr0++,fsr1++
) {
groloop
        xorwf   INDF0,f         ;   // w  == contents for inserted cell for fsr0
        xorwf   INDF0,w         ;   // *fsr0 == contents to overwrite in fsr0
        xorwf   INDF0,f         ;     swap(&w, fsr0);

        xorwf   temp,f          ;   // w == contents just overwritten in fsr0
        xorwf   temp,w          ;   // temp == contents for inserted cell (fsr1)
        xorwf   temp,f          ;     swap(&w, &temp);

        xorwf   INDF1,f         ;   // w == contents for inserted cell in fsr1
        xorwf   INDF1,w         ;   // *fsr1 == contents to overwrite in fsr1
        xorwf   INDF1,f         ;     swap(&w, fsr1);

        xorwf   temp,f          ;   // w == contents just overwritten in fsr1
        xorwf   temp,w          ;   // temp == contents just overwritten in fsr0
        xorwf   temp,f          ;     swap(&w, &temp);

        addfsr  FSR0,+1         ;   // w == contents just overwritten in fsr0
        addfsr  FSR1,+1         ;   // temp = contents just overwritten in fsr1

        movf    INDF0,f         ;
        btfss   STATUS,Z        ;
        bra     groloop         ;    }

        movwi   0[FSR0]         ;    // append the final overwritten contents
        movf    temp,w          ;    *fsr0 = w; // this will be maxnon0 for last
        movwi   0[FSR1]         ;    *fsr1 = w = temp;
        movf    alloced,w       ;    w = alloced;
        bra     done            ;    goto done; // return the fsr0 address added

free
        movf    zOS_MSK,w       ; //////////////////////////////////////////////
        andlw   fi              ; //////////       free()                ///////
        btfsc   STATUS,Z        ;
        bra     invalid         ; } else if (zOS_MSK & fi)

        zOS_LOC FSR0,BSR,adrarry
floop
        moviw   FSR0++          ;  for (fsr0 = (bsr<<7) + adrarry;
        xorwf   zOS_AR0,w       ;       fsr0 < adrarry + tblrows;//FIXME:sorted!
        btfsc   STATUS,Z        ;       fsr0++)              //could quit early!
        bra     ffound          ;
        movlw   adrarry+tblrows ;
        xorwf   FSR0L,w         ;
        andlw   0x7f            ;
        btfss   STATUS,Z        ;
        bra     floop           ;

        bra     invalid         ;   if (*fsr0 == zOS_AR0) {
ffound
        if (tblrows & 0x20)
         addfsr FSR0,0x1f       ;
         addfsr FSR0,tblrows-0x1f;
        else
         addfsr FSR0,tblrows    ;    fsr0 = sizarry + (fsr0 - adrarry);
        endif
        moviw   --FSR0          ;    w = *--fsr0;
        clrf    INDF0           ;    *fsr0 = 0;
        bra     done            ;   }
invalid
        clrw                    ; else invalid: w = 0; // can’t malloc nor free
done
        zOS_RFS WREG            ; done: return w;

        zOS_NAM "heap allocator"
;       zOS_NAM "malloc(),free(),garbage coll"
task
        local   iniarry,coalesc,coaloop,coscoot

        bcf     INTCON,GIE      ;task:
        zOS_LOC FSR0,BSR,0x70
iniarry
        clrw                    ; INTCON &= ˜(1<<GIE);
        movwi   --FSR0          ; for (fsr0 = (bsr<<7)|(adrarry+tblsize);
        movlw   adrarry         ;      fsr > adrarry; fsr--)
        xorwf   FSR0L,w         ;  *fsr = 0; // zero each address and size entry
        andlw   0x7f            ;
        btfss   STATUS,Z        ;
        bra     iniarry         ;

        zOS_MY2 FSR1

        movlw   membase         ; // except first address entry is start of heap
        movwi   0[FSR1]         ; (0x70|(bsr<<1))[0] =
        movwi   0[FSR0]         ; adrarry[0] = membase; // first allocatable
        movlw   membase+memsize ; // and second addres entry is the end of heap
        movwi   1[FSR1]         ; (0x70|(bsr<<1))[1] =
        movwi   1[FSR0]         ; adrarry[1] = membase+memsize;//max allocatable

coalesc
        movf    zOS_ME          ; do { // combine adjacent rows whose size are 0
        zOS_ARG 0
        zOS_SWI zOS_YLD
        zOS_LOC FSR0,BSR,adrarry+1
        zOS_LOC FSR1,BSR,sizarry
coaloop
        bcf     INTCON,GIE      ;  zOS_ARG(0, bsr);
        moviw   ++FSR0          ;  zOS_SWI(zOS_YLD); // only 1 pass per schedule
        btfsc   STATUS,Z        ;  INTCON &= ˜(1<<GIE); // critical section (
        bra     coalesc         ;  for (fsr0 = &adrarry[1], fsr1 = &sizarry[0];
        moviw   FSR1++          ;       *++fsr0; fsr1++)
        btfss   STATUS,Z        ;   if (0[fsr1] === 0 && 1[fsr1] == 0) {
        bra     coaloop         ;    INTCON |= 1<<GIE;
        moviw   0[FSR1]         ;    do {// fsr1->redun row siz,trails fsr0->adr
        btfss   STATUS,Z        ;     INTCON &= ˜(1<<GIE); // critical section (
        bra     coaloop         ;     uint8_t w = *++fsr1;
coscoot
        moviw   ++FSR1          ;     -1[fsr1] = w;
        movwi   -1[FSR1]        ;     w = *fsr0++;
        moviw   FSR0++          ;    } while ((-2[fsr0] = w) != 0);
        movwi   -2[FSR0]        ;    break; // ) critical section ended by SWI
        btfss   STATUS,Z        ;   }
        bra     coscoot         ; } while (1);
        bra     coalesc         ;decl:
```

```
decl
        zOS_ADR task,zOS_UNP    ; fsr0 = task & 0x7fff;// MSB 0 => unprivileged
        movlw   low isr         ; w = zOS_ARG(0, isr & 0x00ff);
        zOS_ARG 0
        movlw   high isr        ; w = zOS_ARG(1, isr>>8);
        zOS_ARG 1
        movlw   0               ; w = zOS_ARG(2, 0); // no hardware interrupts
        zOS_ARG 2
        movlb   0               ; // still in job "0": don’t forget this!!!!
        endm                    ;} // zOS_HEA()

;;; simple output-only console job with circular buffer
zOS_HEX macro
        andlw   0x0f            ;
        addlw   0x06            ;
        btfsc   WREG,4          ;inline char zOS_HEX(uint8_t w) {
        addlw   0x07            ; return (w & 0x0f > 9) ? ’0’+w : ’A’+w-10;
        addlw   0x2a            ;} // zOS_HEX()
        endm

zOS_IHF macro   ofs,fsrsrc,fsrdst
        local   src,dst
        if (fsrsrc & 3)
src set 1
        else
src set 0
        endif
        if (fsrdst & 3)
dst set 1
        else
dst set 0
        endif

        moviw   ofs[FSR#v(src)] ;inline void zOS_IHF(int8_t ofs, int fsrnum,
        swapf   WREG,w          ;                                char* file) {
        zOS_HEX
        movwi   FSR#v(dst)++    ; file[0] = zOS_HEX(ofs[fsrnum] >> 4);
        moviw   ofs[FSR#v(src)] ; file[1] = zOS_HEX(ofs[fsrnum]);
        zOS_HEX
        movwi   FSR#v(dst)++    ;} // zOS_IHF()
        endm


zOS_UNW macro   job             ;inline void zOS_UNW(int8_t job) { }
        zOS_MEM FSR0,job,zOS_PCH; fsr0 = 0x10 * (1 + job) + zOS_PCH;
        bcf     INDF0,zOS_WAI   ; *fsr0 &= ˜(1 << zOS_WAI); // now runnable
        endm                    ;} // zOS_UNW()

zOS_OUT macro   swinum,str,temp
        local   agent,pre,post,setup,len,sloop,loop
        bra     setup           ;inline void zOS_OUT(uint8_t swinum, char* str,
agent
        brw                     ;                    uint8_t* temp) { // no ’\0’
pre
        dt      str
post
len     set     post-pre
        if (len > 254)
         error "string too long"
        endif

        if (len)
setup
         movlw  len             ; zOS_SWI(zOS_YLD); // get buffer empty as poss.
         movwf  temp            ; for (*temp = strlen(str); *temp; --*temp) {
sloop
         movf   zOS_ME          ;
        zOS_ARG 0
        zOS_SWI zOS_YLD
```

```
loop
         movf   temp,w          ;  zOS_ARG(0, w = str[strlen(str) - *temp]);
         sublw  len             ;  while (zOS_SWI(swinum) != 1) { // buffer full
        pagesel agent
         call   agent           ;   zOS_SWI(zOS_YLD); // flush buffer, retry
        zOS_ARG 0

        else
sloop
        movf    zOS_ME          ;
        zOS_ARG 0
        zOS_SWI zOS_YLD
setup
         if (temp - zOS_AR0)
          if (temp - WREG)
           movf temp,w          ;
          endif
          zOS_ARG 0
         endif
        endif

        zOS_SWI swinum
        decfsz  WREG            ;   zOS_ARG(0, w = str[strlen(str) - *temp]);
        bra     sloop           ;  }

        if (len)
         decfsz temp,f          ; }
         bra    loop            ;} // zOS_OUT()
        endif
        endm

zOS_PSH macro   reg
        movf    zOS_ME          ;inline void zOS_PSH(uint8_t* reg) {
        ;; bcf  INTCON,GIE
        banksel TOSH
        incf    STKPTR,f        ; STKPTR++;// caller should’ve masked interrupts
        movwf   TOSH            ; TOSH = bsr;// must store bsr so we can go back
        if (reg-BSR)
         movf   reg,w           ; if (reg != &bsr)
         movwf  TOSL            ;  TOSL = *reg;
         movf   TOSH,w          ; bsr = TOSH;
        endif
        movwf   BSR             ;} // zOS_PSH()
        ;; bsf  INTCON,GIE
        endm

zOS_POP macro   reg
        ;; bcf  INTCON,GIE
        banksel STKPTR
        if (reg-BSR)
         movf   TOSL,w          ;inline void zOS_POP(uint8_t* reg) {
         movwf  reg             ; if (reg != &bsr) *reg = TOSL;
        endif
        movf    TOSH,w          ; bsr = TOSH;
        decf    STKPTR,f        ; STKPTR--;// caller should’ve masked interrupts
        movwf   BSR             ;} // zOS_POP()
        ;; bsf  INTCON,GIE
        endm

zOS_RDF macro
#ifdef EEADRL
zOS_ADL equ     EEADRL
zOS_ADH equ     EEADRH
zOS_RDL equ     EEDATL
zOS_RDH equ     EEDATH
        banksel EECON1
        bcf     EECON1,CFGS     ;inline void zOS_RDF(void) { // for EEADR micros
        bsf     EECON1,EEPGD    ; EECON1 &= ˜(1<<CFGS);
        bsf     EECON1,RD       ; EECON1 |= 1<<EEPGD;
        nop                     ; EECON1 |= 1<<RD;
        nop                     ;} // zOS_RDF()
#else
#ifdef PMADRL
zOS_ADL equ     PMADRL
zOS_ADH equ     PMADRH
zOS_RDL equ     PMDATL
zOS_RDH equ     PMDATH
        banksel PMCON1
        bcf     PMCON1,CFGS     ;inline void zOS_RDF(void) { // for PMADR micros
        bsf     PMCON1,RD       ; PMCON1 &= ˜(1<<CFGS);
        nop                     ; PMCON1 |= 1<<RD;
        nop                     ;} // zOS_RDF()
#else
#ifdef NVMADRL
zOS_ADL equ     NVMADRL
zOS_ADH equ     NVMADRH
zOS_RDL equ     NVMDATL
zOS_RDH equ     NVMDATH
        banksel NVMCON1
        bcf     NVMCON1,NVMREGS ;inline void zOS_RDF(void) { // for NVM micros
        bsf     NVMCON1,RD      ; NVMCON1 &= ˜(1<<CFGS); NVMCON1 |= 1<<RD;
#endif
#endif
#endif
        endm                    ;} // zOS_RDF()

zOS_STR macro   swinum
        local loop,done
        bcf     INTCON,GIE      ;inline void zOS_STR(const char* fsr0,
        zOS_PSH BSR
        banksel zOS_ADL
        movf    FSR0L,w         ;                    uint8_t swinum) {
        movwf   zOS_ADL         ; INTCON &= ˜(1<<GIE);
        movf    FSR0H,w         ; zOS_PSH(&bsr); // need a bank change for reads
        movwf   zOS_ADH         ; for (zOS_AD = fsr0; *zOS_AD; zOS_AD++) {
loop
        zOS_RDF
        rlf     zOS_RDL,w       ;  zOS_RDF(); // read packed 14-bit contents
        rlf     zOS_RDH,w       ;
        btfsc   STATUS,Z        ;
        bra     done            ;  if ((w = (zOS_RDH<<1)|(zOS_RDL>>7)) != '\0'){
        movwf   zOS_AR0         ;   zOS_ARG(0, w);
        zOS_POP BSR
        zOS_OUT swinum,"",zOS_AR0
        bcf     INTCON,GIE      ;   zOS_POP(&bsr); // back to the expected bank
        zOS_PSH BSR
        banksel zOS_RDL
        movf    zOS_RDL,w       ;   zOS_OUT(swinum,"",zOS_AR0); // print ASCII
        andlw   0x7f            ;   INTCON &= ˜(1<<GIE); // undo SWI GIE toggle
        btfsc   STATUS,Z        ;   zOS_PSH(&bsr);
        bra     done            ;   if ((w = zOS_RDL & 0x7f) != '\0') {
        movwf   zOS_AR0         ;    zOS_ARG(0, w);
        zOS_POP BSR
        zOS_OUT swinum,"",zOS_AR0
        bcf     INTCON,GIE      ;    zOS_POP(&bsr); // back to the expected bank
        zOS_PSH BSR
        banksel zOS_ADL
        incfsz  zOS_ADL,f       ;    zOS_SWI(swinum,"",zOS_AR0); // print ASCII
        bra     loop            ;    INTCON &= ˜(1<<GIE); // undo SWI GIE toggle
        incf    zOS_ADH,f       ;    zOS_PSH(&bsr);
        bra     loop            ;   } else break;
done
        zOS_POP BSR             ;  } else break;
        bsf     INTCON,GIE      ; } zOS_POP(&bsr); INTCON |= 1<<GIE;
        endm                    ;} // zOS_STR()

zOS_PUT macro   fsrnum,max,wrap,p
        local   fsrn
```

```
        if (fsrnum & 3)
fsrn set 1
        else
fsrn set 0
        endif
        movwi   FSR#v(fsrn)++   ;inline int8_t zOS_PUT(char**fsrnum,uint7_t max,
        movf    FSR#v(fsrn)L,w  ;                 char* wrap, char* p, char w) {
        andlw   0x7f            ; *(*fsrnum)++ = w;
        xorlw   max             ; // w gets put in buffer regardless, but caller
        swapf   wrap,w          ; // only updates the local pointer if not full
        btfss   STATUS,Z        ; // (i.e. Z not set) by xor return value with p
        swapf   FSR#v(fsrn)L,w  ; *fsrnum = (*fsrnum&0x7f==max) ? wrap :*fsrnum;
        swapf   WREG            ; return (*fsrnum & 0x00ff) ^ p; //0 if full, or
        movwf   FSR#v(fsrn)L    ;              // new pointer value xor p if not
        xorwf   p,w             ;} // zOS_PUT()
        endm

zOS_BUF macro   fsrnum,max,ptr
        local   ascii,err1,done
        local   fsrn
        if (fsrnum & 3)
fsrn set 1
        else
fsrn set 0
        endif
        lsrf    zOS_ME          ;inline int8_t zOS_BUF(char**fsrnum,uint7_t max,
        movwf   FSR#v(fsrn)H    ;          char** ptr, char w) { // p0, p1, wrap
        movf    1+ptr,w         ; // must be in job bank already, interrupts off
        movwf   FSR#v(fsrn)L    ; fsr0 = (bsr<<7) | ptr[1]; // insertion pointer

        movf    zOS_AR0,w       ; if ((w = zOS_AR0) == 0) { // 2-digit hex byte
        btfss   STATUS,Z        ;  w = zOS_HEX(zOS_AR1>>4); // convert high nyb
        bra     ascii           ;  w = zOS_PUT(fsrnum, max, ptr[0], w); // room?

        swapf   zOS_AR1,w       ;  if (w == 0)
        zOS_HEX
        zOS_PUT fsrnum,max,2+ptr,ptr
        btfsc   STATUS,Z        ;   return 0; // buffer was full
        bra     done            ;  ptr[1] = w^ptr[0]; // correctly updated
        xorwf   ptr,w           ;  w = zOS_HEX(zOS_AR1);// convert low nybble
        movwf   1+ptr           ;  w = zOS_PUT(fsrnum, max, ptr[0], w); // room?

        movf    zOS_AR1,w       ;  if (w == 0)
        zOS_HEX
        zOS_PUT fsrnum,max,2+ptr,ptr
        btfsc   STATUS,Z        ;   return 1; // buffer filled after first char
        bra     err1            ;  ptr[1] = w^ptr[0]; // correctly updated
        xorwf   ptr,w           ;  w = 2;
        movwf   1+ptr           ; } else { // print an ascii character
        movlw   2               ;  if ((w = zOS_PUT(fsrnum,max,ptr[0],w)) == 0)
        bra     done            ;   return 0; // buffer was full
ascii
        zOS_PUT fsrnum,max,2+ptr,ptr
        btfsc   STATUS,Z        ;  ptr[1] = w^ptr[0]; // correctly updated
        bra     done            ;  w = 1;
        xorwf   ptr,w           ; }
        movwf   1+ptr           ; return w; // num of characters added to buffer
err1
        movlw   1               ;} // zOS_BUF()
done
        endm

zOS_NUL macro   hwflag          ;void zOS_NUL(void) { // replacement for zOS_CON
        bra     decl            ; goto decl;
        local   task,isr,decl   ; task: do {
task
        movf    zOS_ME          ;  zOS_ARG(0, bsr);
        zOS_ARG 0
        zOS_SWI zOS_YLD         ;  zOS_SWI(zOS_YLD);
        bra     task            ; } while (1);

isr
        banksel zOS_T0F         ; isr:
        bcf     zOS_T0F,T0IF    ;  zOS_T0F &= ˜(1<<T0IF);// clear interrupt flag
        zOS_RFI                 ;  zOS_RFI(); // and go back to scheduler

decl
        zOS_ADR task,zOS_UNP    ; fsr0 = task & 0x7fff;// MSB 0 => unprivileged
        movlw   low isr         ; w = zOS_ARG(0, isr & 0x00ff);
        zOS_ARG 0
        movlw   high isr        ; w = zOS_ARG(1, isr>>8);
        zOS_ARG 1               ; w = zOS_ARG(2, 1<<T0IF);
        movlw   hwflag          ; w = zOS_ARG(3, 0 /* no SWI */);
        zOS_ARG 2
        clrw                    ;} // zOS_NUL()
        zOS_ARG 3
        movlb   0               ; // still in job "0": don’t forget this!!!!
        endm

zOS_CON macro   p,rat,rts,hb,pin;inline void zOS_CON(int8_t p,int8_t rat,int8_t
        local   contask,conisr,inited,conloop,condecl
        bra     condecl         ;                    rts,int8_t* hb,int8_t pin){

        ;; initialize constants and variables
        local   t0div,t0rst
t0div   set 0
t0rst   set 1

        local   p0,p1,wrap,t0scale,isradrl,isradrh,tskadrl,tskadrh,optadrl
        local   optadrh,accumul,accumuh,numbase,destreg,destreh,char_io,buf,max

        ;; 0x20˜24 reserved for zOS_CON
p0      set     0x20
p1      set     0x21
wrap    set     0x22
t0scale set     0x23

        ;; 0x24˜28 reserved for zOS_INP
isradrl set     0x24
isradrh set     0x25
tskadrl set     0x26
tskadrh set     0x27

        ;; 0x28˜2F reserved for zOS_MON and derivations e.g. zOS_MAN
optadrl set     0x28
optadrh set     0x29
accumul set     0x2a
accumuh set     0x2b
numbase set     0x2c
destreg set     0x2d
destreh set     0x2e
char_io set     0x2f
buf     set     0x30
max     set     0x70

;copy the preceding lines rather than including this file, as definitions for
;zOS_MON()-derived macros referring to these local variables wouldn’t open it
;until expansion and would throw an undefined-var error during the processing

        local   uatbase,uatxmit
        if (p == 0)
uatbase  set    TXREG & 0xff80
uatxmit  set    TXREG & 0x001f ; mask off just the SFR space
rtsflag  set    TXIF
        else
uatbase  set    TX#v(p)REG & 0xff80
uatxmit  set    TX#v(p)REG & 0x001f ; mask off just the sfr SFR
rtsflag  set    TX#v(p)IF
```

```
        endif
        zOS_NAM "console (output-only)"
contask
        movlw   high uatbase    ; goto decl;
        movwf   FSR0H           ;task:// all init that requires knowledge of BSR
        zOS_MY2 FSR0
        moviw   t0div[FSR0]     ; do {
        btfss   STATUS,Z        ;  fsr0 = (uatbase & 0xff00) | 0x0070 |(bsr<<1);
        bra     inited          ;  if (1[fsr0] == 0) { // not initialized yet
        zOS_DIS GIE,0
        movlw   0xff            ;  zOS_DIS(&fsr0, zOS_JOB); // interrupts off!
        movwi   t0div[FSR0]     ;  0[fsr0] = 0xff;// live TMR0 postscaler divider
        movlw   0x00            ;
        movwi   t0rst[FSR0]     ;  1[fsr0] = 0x00; // live reset value for TMR0
        rrf     zOS_ME          ;
        clrw                    ;  const char* max = 0x70;
        rrf     WREG            ;  static char *p0, *p1, buf[]; //p0:task, p1:ISR
        iorlw   buf             ;  const char* wrap = ((bsr&1)<<7) | buf;
        movwf   wrap            ;  p0 = p1 = wrap; // reset value if they max out
        movwf   p0              ;  zOS_ENA(); // interrupts on after init done
        movwf   p1              ;  puts("\r\nWelcome to zOS\r\n");
        zOS_ENA ;//FIXME: superfluous due to subsequent SWI
        zOS_OUT 0xff,"\r\nWelcome to zOS\r\n",char_io
inited
        movf    zOS_ME          ;  zOS_ARG(0, bsr);
        zOS_ARG 0
        zOS_SWI zOS_YLD         ;
        movlw   low uatbase     ;  const int8_t* uatbase = uatxmit & 0xff80;
        movwf   FSR0L           ;  fsr0 = uatbase;
        movlw   high rts        ;  zOS_ARG(0, bsr);
        movwf   FSR1H           ;  zOS_SWI(zOS_YLD);
        movlw   low rts         ;  // wait for SWI to store char(s) in buf[]
        movwf   FSR1L           ;
        btfss   INDF1,rtsflag   ;  if (*(fsr1 = rts) & (1<<rtsflag) == 0) //full
        bra     conloop         ;   continue; //yield (still sending or no char)
        lsrf    zOS_ME          ;
        movwf   FSR1H           ;  // READY TO SEND, AND...
        zOS_DIS GIE,0
        movf    p0,w            ;  // begin critical section (freeze pointers)
        movwf   FSR1L           ;
        xorwf   p1,w            ;  fsr1 = (bsr<<7) | p0;
        btfsc   STATUS,Z        ;  if (p0 == p1)
        bra     conloop         ;   continue; // nothing to do
        moviw   FSR1++          ;
        movwi   uatxmit[FSR0]   ;  uatxmit[fsr0] = *fsr1++; // send a character
        movf    FSR1L,w         ;
        movwf   p0              ;  p0 = fsr1 & 0x00ff; // wrap around to buf+0
        andlw   0x7f            ;
        xorlw   max             ;
        btfss   STATUS,Z        ;
        bra     conloop         ;  if (p0 & 0x7f == max) // ignore low bank bit
        movf    wrap,w          ;   p0 = wrap; // =buf xor the lowest bank bit
        movwf   p0              ;  // end critical section
conloop
        zOS_ENA
        zOS_MEM FSR0,BSR,0
        moviw   zOS_HDH[FSR0]   ;
        movwf   PCLATH          ;
        moviw   zOS_HDL[FSR0]   ;
        movwf   PCL             ; } while (1); // e.g. might run zOS_INP’s task

        ;; HWI will be coming from a tmr0 expiration, for the blinking heartbeat
        ;;
        ;; SWI will be coming from a job that wants to send a character
        ;;  in which case the ISR stores it, advancing p1 and returning the
        ;;  number of characters stored in the buffer
        ;; Note: caller needs to make sure to check status of return value for
        ;; != 0, just in case job is in between sleeps or with a full buffer
conisr
```

```
        local   done,do_swi,nottmr

        ;; if it’s a simple and frequent timer overflow interrupt finish quickly
        banksel zOS_T0F
        btfss   zOS_T0F,T0IF    ; if (/*presumed true:(zOS_T0E & (1<<T0IE)) &&*/
        bra     nottmr          ;     (zOS_T0F & (1<<T0IF))) { // timer overflow
        bcf     zOS_T0F,T0IF    ;  zOS_T0F &= ~(1<<T0IF);// clear interrupt flag

        ;; get fsr0 pointing to tmr0 postscaler/reset value
        movf    zOS_JOB,w       ;isr:
        movwf   BSR             ; bsr = zos_job;
        zOS_MY2 FSR0L           ; fsr0 = 0x70 | (bsr < 1);

        ;; with fsr0 pointing to global pair, point fsr1 to local mem("t0scale")
        zOS_LOC FSR1,zOS_JOB,t0scale
        banksel TMR0
        moviw   t0rst[FSR0]     ;  fsr1 = (zOS_JOB << 7) | t0scale;
        btfss   WREG,7          ;  bsr = TMR0 >> 7;//now invalid for this branch
        movwf   TMR0            ;  if (t0rst[fsr0] < 128)// max 7 bit TMR0 reset
        decfsz  INDF1,f         ;   TMR0 = t0rst[fsr0]; // or chance of deadlock
        bra     done            ;  if (--*fsr1 == 0) {

        banksel hb
        movf    INDF0,w         ;
        btfsc   STATUS,Z        ;
        movlw   1               ;   if (*fsr0 == 0) // disallow zero postscaler
        movwf   INDF0           ;    *fsr0 = 1;
        movwf   INDF1           ;   *fsr1 /*countdown*/ = *fsr0 /*postscaler*/;
        movlw   (1<<pin)        ;
        xorwf   hb,f            ;   hb ^= 1 << pin;
        bra     done            ; } else {

        ;; check for validated SWI first since it will be in zOS_MSK, else a HWI
nottmr
        movf    zOS_MSK,f       ;  if (zOS_MSK) { // a SWI to buffer a character
        btfss   STATUS,Z        ;   w = zOS_BUF(&fsr0, max, p0); // zOS_AR0,_AR1
        bra     do_swi          ;   zOS_RFS(w); } else zOS_RET(); // not ours(!)
        zOS_RET

        ;; point fsr0 to uatbase (again?), point fsr1 to p0
do_swi
        movf    zOS_JOB,w       ;
        movwf   BSR             ;
        zOS_BUF FSR0,max,p0     ; }
        zOS_RFS WREG            ; zOS_RFI(); // HWI finished
done
        zOS_RFI                 ;

        ;; intialize the UART peripheral, job handle and first three arguments
condecl
        banksel uatbase
        bcf     RCSTA,SPEN      ;decl: // all init that is BSR independent here
        bcf     RCSTA,CREN      ; RCSTA &= ~((1<<SPEN)|(1<<CREN));
        bcf     TXSTA,TXEN      ; TXSTA &= ~(1<<TXEN);
        local brgval,brgvalm,brgvalh,brgvall
#ifdef BRG16
brgval  set     rat>>2
brgvalm set     brgval-1
brgvalh set     high brgvalm
brgvall set     low brgvalm
        bsf     BAUDCON,BRG16   ; // section 26.1.2.8 of 16F1847 steps below:
#ifdef SYNC
        bcf     TXSTA,SYNC      ; // (1) "Initialize..the desired baud rate"
#else
        bcf     TXSTA,SYNC_TXSTA
#endif
        bsf     TXSTA,BRGH      ; BAUDCON |= 1<<BRG16; // 16-bit generator
        movlw   brgvall         ; TXSTA &= ~(1<<SYNC); // async mode
        movwf   SPBRGL          ; TXSTA |= 1<<BRGH;    // high speed
```

```
        movlw   brgvalh         ;
        movwf   SPBRGH          ; SPBRG = (rat/4) - 1;
        bcf     BAUDCON,SCKP    ; BAUDCON &= ~(1<<SCKP); // "SCKP..if inverted"
#else
brgval  set     rat>>4
brgvalm set     brgval-1
brgvalh set     0
brgvall set     low brgvalm
        bsf     TXSTA,BRGH      ; TXSTA |= 1<<BRGH; // (1) the desired baud rate
        movlw   brgvall         ;
        movwf   SPBRG           ; SPBRG = (rat/16) - 1;
#endif
        bsf     RCSTA,SPEN      ; // (3) "Enable..by setting..SPEN"
        bcf     RCSTA,RX9       ; RCSTA &= ~(1<<RX9);  // (5) "9-bit..set..RX9"
        bsf     RCSTA,CREN      ; RCSTA |= (1<<SPEN) | (1<<CREN); // (6) "CREN"
        bsf     TXSTA,TXEN      ; TXSTA |= 1<<TXEN; // (5) "Enable..by..TXEN"
        banksel PIE1
        bsf     PIE1,RCIE       ; PIE1 |= 1<<RCIE; //(4) "Set..RCIE..and..PEIE"
        zOS_ADR contask,zOS_PRB ; fsr0 = contask & 0x7fff;// MSB 1 => privileged
        movlw   low conisr      ; w = zOS_ARG(0, conisr & 0x00ff);
        zOS_ARG 0
        movlw   high conisr     ; w = zOS_ARG(1, conisr>>8);
        zOS_ARG 1               ; w = zOS_ARG(2, (0<<TXIF)|(1<<T0IF));
        movlw (0<<TXIF)|(1<<T0IF)
        zOS_ARG 2
        movlb   0               ; // still in job "0": don’t forget this!!!!
        endm                    ;} // zOS_CON()

        ;; remnants of an early experiment to allow bank changing outside ISR
        ;; to read SFR’s is now deprectated, only known use is in olirelay.asm
zOS_R   macro   file,bankf,prsrv;inline int8_t zOS_R(const int8_t* file, int8_t ban
k, int8_t prsrv) {
        if (prsrv)
         movf   INTCON,w
         bcf    INTCON,GIE
         movwf  zOS_AR1
        else
         bcf    INTCON,GIE
        endif
        if file & 0x60
         error "tried to access disallowed RAM range (global or another job’s)"
        endif
        banksel file            ; INTCON &= ~(1<<GIE); // access zOS_AR* globals
        movf    file,w          ; bsr = file >> 7;
        movwf   zOS_AR0         ; zOS_AR0 = *file; // any 0-0x1f SFR in any bank
        movf    bankf,w         ; bsr = bankf;
        movwf   BSR             ; w = zOS_AR0;
        movf    zOS_AR0,w       ; if (prsrv && (zOS_AR1 & (1<<GIE)))
        if prsrv
         btfss  zOS_AR1,GIE     ;  INTCON |= 1<<GIE; // restore interrupt state
        endif
        bsf     INTCON,GIE      ; return w;
        endm                    ;} // zOS_R()

;;; like zOS_CON, but also accepts console input for command-line interaction
zOS_INP macro   p,ra,rt,h,pi,isr;inline void zOS_INP(int8_t p, int8_t ra, int8_t
        local   rxtask,no_opt,rxisr,rxdecl
        bra     rxdecl          ;      rt, int8_t* h, int8_t pi, void(*isr)()) {

        ;; reserve constants and variables
        local   p0,p1,wrap,t0scale,isradrl,isradrh,tskadrl,tskadrh,optadrl
        local   optadrh,accumul,accumuh,numbase,destreg,destreh,char_io,buf,max

        ;; 0x20~24 reserved for zOS_CON
p0      set     0x20
p1      set     0x21
wrap    set     0x22
t0scale set     0x23
```

```
        ;; 0x24˜28 reserved for zOS_INP
isradrl set     0x24
isradrh set     0x25
tskadrl set     0x26
tskadrh set     0x27

        ;; 0x28˜2F reserved for zOS_MON and derivations e.g. zOS_MAN
optadrl set     0x28
optadrh set     0x29
accumul set     0x2a
accumuh set     0x2b
numbase set     0x2c
destreg set     0x2d
destreh set     0x2e
char_io set     0x2f
buf     set     0x30
max     set     0x70

;copy the preceding lines rather than including this file, as definitions for
;zOS_MON()-derived macros referring to these local variables wouldn’t open it
;until expansion and would throw an undefined-var error during the processing

        local   uarbase,uarecv,rxflag
        if (p == 0)
uarbase  set    RCREG & 0xff80
uarecv   set    RCREG & 0x7f
rxflag   set    RCIF
        else
uarbase  set    RC#v(p)REG & 0xff80
uarecv   set    RC#v(p)REG & 0x7f
rxflag   set    RC#v(p)IF
        endif

        zOS_NAM "console I/O"
;;; FIXME: haven’t actually written the var init code for zOS_MON et al yet
rxtask
        movf    optadrh,w       ; goto rxdecl;
        movwf   PCLATH          ;rxtask:
        iorwf   optadrl,w       ;
        btfsc   STATUS,Z        ;
        bra     no_opt          ;
        movf    optadrl,w       ;  if ((optadrh<<8) | optadrl)
        callw                   ;   (*(optadrh<<8) | optadrl)) (); //returns to:
;;; FIXME: do anything interesting with return value? 0 sent if nothing happened
no_opt
        movf    tskadrh,w       ;
        movwf   PCLATH          ;  goto (tskadrh<<8) | tskadrl;// zOS_CON() code
        movf    tskadrl,w       ;
        movwf   PCL     ;callw  ; // will retreive its own address as a loop

rxisr
        movf    zOS_JOB,w       ;rxisr:
        movwf   BSR             ; bsr = zOS_JOB; // isr starts with unknown bank

        movf    isradrh,w       ;
        movwf   PCLATH          ;
        movf    isradrl,w       ; if (rt && (1<<RCIF) == 0) // SWI, not inp char
        banksel rt
        btfss   rt,rxflag       ;  goto (isradrh<<8)|isradrl;//zOS_CON takes SWI
        movwf   PCL             ; else {
        bcf     rt,rxflag       ;  rt &= ˜(1<<RCIF);
#ifdef CAUTIOUS
        btfss   RCSTA,OERR      ;
        bra     noovrrn         ;  if ((uarbase | RCSTA) & (1<<OERR)) {
        movlw   ’!’             ;   zOS_AR0 = ’!’;
        movwf   zOS_AR0         ;   zOS_BUF(zOS_JOB, p0);
        zOS_BUF FSR0,max,p0     ;  }
noovrrn
#endif
```

```
        banksel uarbase
        movf    uarecv,w        ;  // this read removes it from the FIFO
#ifdef CAUTIOUS
        btfss   RCSTA,OERR      ;  if (RCSTA & (1<<OERR)) // rx overrun
        bcf     RCSTA,CREN      ;   RCSTA &= ˜(1<<CREN); // cleared by disable
        bsf     RCSTA,CREN      ;  RCSTA |= 1<<CREN; // (re-)enable reception
#endif
        if (isr)
         movwf  zOS_AR0         ;  zOS_AR0 = RCREG;
        pagesel isr             ;  if (zOS_AR0)
         btfss  STATUS,Z        ;   goto isr; // continue with parser
         goto   isr             ;  zOS_RFI(); //return from interrupt
        endif
        zOS_RFI                 ; }

        local   vars,arg0,arg1,adrl,adrh,optl,opth,accl,acch,base,dstl,dsth,chio
vars    set     0x20
arg0    set     isradrl-vars
arg1    set     isradrh-vars
adrl    set     tskadrl-vars
adrh    set     tskadrh-vars
optl    set     optadrl-vars
opth    set     optadrh-vars
accl    set     accumul-vars
acch    set     accumuh-vars
base    set     numbase-vars
dstl    set     destreg-vars
dsth    set     destreh-vars
chio    set     char_io-vars

rxdecl
        zOS_CON p,ra,rt,h,pi
        zOS_LAU FSR1H
        zOS_LOC FSR1L,FSR1H,vars
        movf    zOS_AR0,w       ;rxdecl:
        movwi   arg0[FSR1]      ; zOS_CON(p,rat,rts,hb,pin);// extend zOS_CON()
        movf    zOS_AR1,w       ; zOS_LAU(&fsr1);// by rewriting after launch
        movwi   arg1[FSR1]      ; fsr1 <<= 7;
        movf    FSR0L,w         ; isradr[fsr1] = (zOS_AR1<<8) | zOS_AR0;
        movwi   adrl[FSR1]      ;
        movf    FSR0H,w         ;
        movwi   adrh[FSR1]      ; tskadr[fsr1] = fsr0; // still zOS_CON’s handle
        movlw   0               ;
        movwi   optl[FSR1]      ; // caller sets optional task
        movwi   opth[FSR1]      ; optadr[fsr1] = ((*void)()) 0; // no func
        movwi   accl[FSR1]      ;
        movwi   acch[FSR1]      ;
        movwi   dstl[FSR1]      ;
        movwi   dsth[FSR1]      ;
        movwi   chio[FSR1]      ; char_io[fsr1] = 0; // zero = no action to take
        movlw   0x0a            ;
        movwi   base[FSR1]      ;
        rlf     FSR1L,w         ; w = fsr1 >> 7; // restore zOS_LAU() job number
        rlf     FSR1H,w         ;
        zOS_MEM FSR0,WREG,0
        movlw   low rxtask      ; fsr0 = 0x10 + w << 4;
        movwi   zOS_HDL[FSR0]   ;
        movwi   zOS_PCL[FSR0]   ;
        movlw   high rxtask     ;
        movwi   zOS_PCH[FSR0]   ; zOS_PC[fsr0] = rxtask;
        iorlw   0x80            ;
        movwi   zOS_HDH[FSR0]   ; zOS_HD[fsr0] = rxtask | 0x8000;
        addfsr  FSR0,zOS_ISR    ; fsr0 += zOS_ISR; // last 4 bytes of job record
        movlw   low rxisr       ; *fsr0++ = rxisr & 0x00ff;
        movwi   FSR0++          ;
        movlw   high rxisr      ; *fsr0++ = rxisr >> 8;
        movwi   FSR0++
        movf    zOS_AR2,w       ; *fsr0++ |= (1<<RCIF);// |(0<<TXIF)|(1<<T0IF));
        iorlw   1<<rxflag       ; // still in job "0"; caller sets any SWI value
        movwi   FSR0++          ;} // zOS_INP()
        endm


zOS_ACC macro   valregs,basereg
        clrf    valregs         ;inline uint8_t zOS_ACC(uint8_t* valregs,uint8_t
        clrf    1+valregs       ;                    *basereg) { // w unclobbered
        clrf    basereg         ; *valregs = 0;
        bsf     basereg,3       ; return *basereg = 10; // decimal by default
        bsf     basereg,1       ;} // zOS_ACC()
        endm


zOS_PCT macro   reg
        movlw   0x7e            ; // 0 <= reg <= 100
        andwf   reg,w           ; w = reg & 0x7e; // 0 <= w <= reg (even, trunc)
        lslf    reg,f           ;
        lslf    reg,f           ; uint16_t c = reg *= 4; // 0 <= reg <= 400
        btfsc   STATUS,C        ; if (c > 0xff)
        iorlw   0x01            ;  w |= 1;
        addwf   reg,f           ; c = reg += w;
        btfsc   STATUS,C        ; if (c > 0xff)
        iorlw   0x01            ;  w |= 1;
        rrf     WREG            ; // 0 <= (w&1)*256 + reg <= 500
        rrf     reg,f           ; reg = ((w&1)*256 + reg)/2; // 0 <= reg <= 250
        endm

zOS_MON macro   p,ra,rt,h,pi,isr;inline void zOS_MON(int8_t p, int8_t ra, int8_t
        local   monisr,monchr1,monchr2,monchr3,mondump,mondest,monram,monchr4
        local   monchr5,monchr6,monchr7,monchr8,monchr9,monprmp,monlast,monpctg
        local   endmon

        pagesel endmon          ;      rt, int8_t* h, int8_t pi, void(*isr)()) {
        goto    endmon          ; zOS_INP(p,ra,rt,h,pi,monisr); }// isr may be 0

        local   p0,p1,wrap,t0scale,isradrl,isradrh,tskadrl,tskadrh,optadrl
        local   optadrh,accumul,accumuh,numbase,destreg,destreh,char_io,buf,max

        ;; 0x20˜24 reserved for zOS_CON
p0      set     0x20
p1      set     0x21
wrap    set     0x22
t0scale set     0x23

        ;; 0x24˜28 reserved for zOS_INP
isradrl set     0x24
isradrh set     0x25
tskadrl set     0x26
tskadrh set     0x27

        ;; 0x28˜2F reserved for zOS_MON and derivations e.g. zOS_MAN
optadrl set     0x28
optadrh set     0x29
accumul set     0x2a
accumuh set     0x2b
numbase set     0x2c
destreg set     0x2d
destreh set     0x2e
char_io set     0x2f
buf     set     0x30
max     set     0x70

;copy the preceding lines rather than including this file, as definitions for
;zOS_MON()-derived macros referring to these local variables wouldn't open it
;until expansion and would throw an undefined-var error during the processing

monback
        andlw   0x3f            ;void monback(uint3_t job, uint8_t ptr, char w){
        btfsc   STATUS,Z        ; if (w &= 0x3f) {
```

```
        return                  ;  // 63 \b's should be enough in a buffer of 64
        movwf   zOS_AR1         ;
#if 0
monbac2
        movf    p0,w            ; // don't actually want to wind back buffer;
        xorwf   p1,w            ; // the point is show what will be overwritten
        btfsc   STATUS,Z        ;
        bra     monbarn         ;
        movf    p1,w            ;
        xorwf   wrap,w          ;
        movlw   max-1           ;
        btfss   STATUS,Z        ;
        movwf   p1              ;
        btfsc   wrap,7          ;
        bsf     p1,7            ;
        decf    p1,f            ;
        decfsz  zOS_AR1,f       ;
        bra     monbac2         ;
        return                  ;
monbarn
#endif
        movlw   0x08            ;
        movwf   zOS_AR0         ;  zOS_AR0 = '\b'; // FIXME: or '\0177'?

monloop
        zOS_BUF FSR0,max,p0
        andlw   0x1             ;  for (zOS_AR1 = w; zOS_AR1; zOS_AR1--) {
        btfsc   STATUS,Z        ;   if (zOS_BUF(job, ptr) == 0) // buff full
        return                  ;    return;
        decfsz  zOS_AR1,f       ;  }
        bra     monloop         ; }
        return                  ;} // monback() monloop()

monout
        btfss   STATUS,C        ;void monout(char w, uint1_t c) {
        bra     monbufs         ; if (c == 0) monbufs(w); else monlsb(w);
        bra     monlsb          ;}
monhex
        movf    accumuh,w       ;void monhex(void) { monlsb(,,w = accumuh); }
monlsb
        clrf    zOS_AR0         ;void monlsb(uint3_t job, uint8_t ptr, char w) {
        movwf   zOS_AR1         ;
        zOS_BUF FSR1,max,p0     ; return zOS_BUF(&fsr,ptr,w); } // 0/1/2 printed
        return                  ;} // monlsb

mon0
        movlw   '0'             ;void mon0(void) { zOS_AR0 = '0'; monbufs(ptr);
        bra     monbufs         ;}

monx
        movlw   'x'             ;void monx(void) { zOS_AR0 = '0'; monbufs(ptr);
        bra     monbufs         ;}

monspc
        movlw   ' '             ;void monspc(void) { zOS_AR0 = ' '; monbufs(ptr);
        bra     monbufs         ;}
monlf
        movlw   '\n'            ; return zOS_BUF(zos_job, ptr, w);
monbufs
        movwf   zOS_AR0         ;} // moncrlf() monlf()
monbufd
        movlw   1               ;void monbufs(uint8_t ptr, char w) {
        movwf   zOS_AR1         ; goto monloop();
        bra     monloop         ;} //FIXME: these comments above are useless

monisr
        movf    zOS_JOB,w       ;void monisr(void) {
        movwf   BSR             ;  bsr = zos_job;// to access char_io var et al
        pagesel monbufd
        movlw   0xe0            ; // from zOS_INP isr with char zOS_AR0>0
        addwf   zOS_AR0,w       ;
        btfss   WREG,7          ; // refuse to echo unprintable characters
        call    monbufd         ; if (zOS_AR0 > 31 && monbuf(zos_job,p0) > 0) {
        andlw   0x1             ;  // successful echo into circular buffer
        pagesel monlast
        btfsc   STATUS,Z        ;
        goto    monlast         ;

        movf    zOS_AR0,w       ;  // handle ’˜’ before the tolower() conversion
        xorlw   ’˜’             ;
        btfss   STATUS,Z        ;
        bra     monchr1         ;  if (zOS_AR0 == ’˜’) {
        pagesel mon0
        call    mon0            ;
        pagesel monx
        call    monx            ;
        comf    accumul,f       ;   accumul = ˜accumul;
        comf    accumuh,w       ;
        movwf   accumuh         ;
        movwf   char_io         ;   char_io = accumuh = ˜accumuh; // preserve
        pagesel monhex
        call    monhex          ;   monhex(zos_job, p0);
        movf    accumul,w       ;   accumuh = accumul; // accumuh overwritten
        movwf   accumuh         ;   monlsb(zos_job, p0);
        pagesel monlsb
        call    monlsb          ;   accumuh = char_io; // accumuh now restored
        movf    char_io,w       ;   char_io = 0; // completely handled in ISR
        movwf   accumuh         ;   zOS_RFI();
        clrf    char_io         ;  }
        zOS_RFI

monchr1
        btfsc   zOS_AR0,6       ;  if (zOS_AR0 & 0x40)
        bcf     zOS_AR0,5       ;   zOS_AR0 &= 0xdf; // zOS_AR0=tolower(zOS_AR0)
        movf    zOS_AR0,w       ;//FIXME: ‘ { | } ˜ DEL mapped onto @ [ \ ] ^ _
        movwf   char_io         ;
        xorlw   0x08            ;  switch (char_io = zOS_AR0) {
        movlw   0x7f            ;
        btfss   STATUS,Z        ;  case ’\b’:
        movf    char_io,w       ;
        xorlw   0x7f            ;
        btfss   STATUS,Z        ;  case ’\0177’:
        bra     monchr2         ;
        movlw   ’\r’            ;
        pagesel monbufs
        call    monbufs         ;   monbuf(zos_job, p0, ’\r’);
        bra     monprmp         ;   goto monprmp;

monchr2
        movf    char_io,w       ;
#if 0
        xorlw   0x0a            ;
        movlw   0x0d            ;
        btfss   STATUS,Z        ;  case ’\n’:
        movf    char_io,w       ;
#endif
        xorlw   0x0d            ;
        btfss   STATUS,Z        ;  case ’\r’:
        bra     monchr3         ;   monbuf(zos_job, p0, ’\n’);// follows the \r
        movlw   ’\r’            ;
        pagesel monbufs         ;
        call    monbufs         ;
        movlw   ’\n’            ;
        pagesel monbufs         ;
        call    monbufs         ;

        movf    destreg,w       ;   // repeat \r’s can set a whole range of
        movwf   FSR0L           ;   // addresses to zero???
```

```
        movf    1+destreg,w     ;
        movwf   FSR0H           ;   fsr0 = destreg;
        iorwf   FSR0L,w         ;
        btfsc   STATUS,Z        ;
        bra     monprmp         ;   if (fsr0) { // destreg was set by ’ ’ or =
        movf    accumul,w       ;    if (fsr0 & 0x8000 == 0)
        btfss   FSR0H,7         ;
        movwi   FSR0++          ;     *fsr0 = accumul & 0x00ff; // not in flash
        movf    FSR0L,w         ;
        movwf   destreg         ;
        movf    FSR0H,w         ;    destreg++; // advances for next access
        movwf   1+destreg       ;   }
        bra     monprmp         ;   goto monprmp;

monchr3
        movf    char_io,w       ;
        xorlw   ’,’             ;
        movlw   ’ ’             ;
        btfsc   STATUS,Z        ;
        movwf   char_io         ;  case ’,’: // synonym for ’ ’
        movf    char_io,w       ;
        xorlw   ’ ’             ;
        btfsc   STATUS,Z        ;  case ’ ’:
        bra     mondump         ;
        movf    char_io,w       ;
        xorlw   ’.’             ;
        btfsc   STATUS,Z        ;  case ’.’:
        bra     mondump         ;
        movf    char_io,w       ;
        xorlw   ’=’             ;
        btfss   STATUS,Z        ;  case ’=’:
        bra     monchr4         ;

mondump
        movf    accumul,w       ;   // pressing ’ ’ or ’.’ or ’=’ should apply
        iorwf   accumuh,w       ;   // to the recently incremented address from
        btfsc   STATUS,Z        ;   // a previous operation (if any) or to an
        bra     mondest         ;   // an address typed immediately before it
        movf    accumul,w       ;
        movwf   destreg         ;
        movf    accumuh,w       ;   if (accumul) // typed a value before ’ ’/=
        movwf   1+destreg       ;    destreg = accumul; // otherwise no clobber
        movf    char_io,w       ;   if (char_io == ’ ’) {
        xorlw   ’ ’             ;    char_io = 0; // all we do is a destreg xfer
        btfsc   STATUS,Z        ;    break;
        bra     monzero         ;   }
mondest
        btfss   1+destreg,7     ;   if (destreg & 0x8000) { // flash, not RAM
        bra     monram          ;
        pagesel mon0
        call    mon0            ;    putchar(’0’);
        pagesel monx
        call    monx            ;    putchar(’x’);
        movf    destreg,w       ;
        movwf   FSR0L           ;
        movf    1+destreg,w     ;
        movwf   FSR0H           ;    fsr0 = destreg;
        zOS_PSH BSR
        banksel zOS_ADL
        movf    FSR0L,w         ;    zOS_PSH(&bsr);
        movwf   zOS_ADL         ;
        movf    FSR0H,w         ;
        movwf   zOS_ADH         ;    zOS_AD = fsr0;
        zOS_RDF
        movf    zOS_RDH,w       ;    zOS_RDF();
        movwf   zOS_AR0         ;    zOS_ARG(0,zOS_RDH); // only way to access
        zOS_POP BSR
        movf    zOS_AR0,w       ;    zOS_POP(&bsr);
        movwf   accumuh         ;
        pagesel monhex
        call    monhex          ;    monhex(zos_job, p0, accumuh=0);// high byte
        movf    destreg,w       ;
        movwf   FSR0L           ;
        movf    1+destreg,w     ;
        movwf   FSR0H           ;    fsr0 = destreg; // monhex() clobbered fsr0
        moviw   FSR0++          ;
        movwf   accumul         ;
        movf    FSR0L,w         ;
        movwf   destreg         ;    accumuh = *fsr0++;
        movf    FSR0H,w         ;    destreg = fsr0;
        movwf   1+destreg       ;    monlsb(zos_job, p0, accumuh);  //      LSB
        movf    accumul,w       ;
        pagesel monlsb
        call    monlsb          ;    moncrlf(zos_job, p0);          //     \r\n
#ifdef zos_opc
        pagesel zos_opc
        goto    zos_opc         ;    zos_opc(); // disassemble accumu, jump back
zos_opr
#endif
        movlw   ’\r’
        pagesel monbufs
        call    monbufs
        pagesel monlf
        call    monlf           ;    goto monprmp;
        bra     monprmp         ;   }

monram
        pagesel mon0
        call    mon0            ;
        pagesel monx
        call    monx            ;
        movf    destreg,w       ;
        movwf   FSR0L           ;
        movf    1+destreg,w     ;
        movwf   FSR0H           ;   fsr0 = destreg;
        moviw   FSR0++          ;
        movwf   accumuh         ;   accumuh = *fsr0++;
        pagesel monhex
        call    monhex          ;   monhex(p0, accumuh);

        movf    char_io,w       ;
        xorlw   ’.’             ;   // then exits in the ’.’ case to just print
        btfss   STATUS,Z        ;   if (char_io == ’.’) {
        bra     monramd         ;
        movf    FSR0L,w         ;
        movwf   destreg         ;
        movf    FSR0H,w         ;
        movwf   1+destreg       ;    destreg = fsr0;
        movlw   ’\r’            ;    monbufs(’\r’);
        pagesel monbufs
        call    monbufs         ;    monbufs(’\n’);
        pagesel monlf
        call    monlf           ;    goto monprmp;
        bra     monprmp         ;   }
monramd
        movf    char_io,w       ;   // or follow by 3 backspaces in the ’=’ case
        xorlw   ’.’             ;   // to show that \r will result in a 0 write
        btfss   STATUS,Z        ;
        movlw   3               ;
        pagesel monback
        call    monback         ;   monback(zos_job, p0, (char_io == ’.’)?0:3);
        clrf    char_io         ;   char_io = 0;
        zOS_RFI                 ;  break;

monchr4
        movf    char_io,w       ;
        xorlw   ’X’             ;
        btfss   STATUS,Z        ;  case ’X’:
```

```
        bra     monchr5         ;
        movlw   0x10            ;   numbase = 16;
        movwf   numbase         ;   char_io = 0;
        clrf    char_io         ;  break;
        zOS_RFI
monchr5
        movf    char_io,w       ;
        xorlw   ’%’             ;
        btfss   STATUS,Z        ;  case ’%’:
        bra     monchr6         ;
        movlw   0x9b            ;
        addwf   accumul,w       ;
        btfsc   WREG,7          ;
        bra     monpctg         ;   if (accumul > 102)
        movlw   0x66            ;
        movwf   accumul         ;    accumul = 102;
monpctg
        movf    accumul,w       ;   accumul = zOS_PCT(accumul);
        zOS_PCT accumul
        movf    accumul,w       ;  monecho:
        movwf   accumuh         ;   accumuh = accumul;
        pagesel monhex          ;   monhex(zos_job, p0); print as e.g. 50%0x7d
        call    monhex          ;   accumuh = 0;
        clrf    accumuh         ;   char_io = 0;
        clrf    char_io         ;  break;
        zOS_RFI

monchr6
        movlw   0-0x30          ;  default:
        addwf   char_io,f       ;
        btfsc   char_io,7       ;
        bra     monchr9         ;   if ((char_io -= (’0’&0xdf /*0x10*/)) >= 0) {
        movlw   0-0x10          ;
        addwf   char_io,w       ;
        btfsc   WREG,7          ;    if (char_io > 0x10)
        bra     $+3             ;
        movlw   0xf9            ;
        addwf   char_io,f       ;     char_io -= 0x07;// 0x41->0x11->0x0a... so
#if 0;seems unnec 18 Jan
        movf    char_io,f       ;                     // now in range 0x00-0x09,
#endif
        btfss   STATUS,Z        ;                     // or :=0x0a,...,?=0x0f,
        bra     monchr7         ;                     // or A=0x2a,B=0x2b,...
        movf    accumul,w       ;                     // G=0x30,...,Z=0x43
        iorwf   accumuh,w       ;    if ((char_io == 0) &&
        btfss   STATUS,Z        ;        (accumul == 0) && (accumuh == 0)) {
        bra     monchr7         ;     numbase &= ~2; // digit(s) leading 0(s),
        bcf     numbase,1       ;     char_io = 0;
        clrf    char_io         ;     break;         // just go into octal mode
        zOS_RFI

monchr7
        movlw   0xf0            ;
        andwf   char_io,w       ;
        btfss   STATUS,Z        ;    } else if ((char_io & 0xf0 == 0) // 0-9,a-f
        bra     monsave         ;              && (numbase & 0x10)) { // base 16
        btfss   numbase,4       ;
        bra     monchr8         ;
        swapf   accumuh,f       ;
        movlw   0xf0            ;
        andwf   accumuh,f       ;     accumuh <<= 4;
        swapf   accumul,w       ;
        andlw   0x0f            ;
        iorwf   accumuh,f       ;     accumuh |= accumul >> 4;
        movlw   0x0f            ;
        andwf   char_io,f       ;     char_io &= 0x0f;
        andwf   accumul,f       ;     accumul &= 0x0f;
        swapf   accumul,w       ;
        iorwf   char_io,w       ;     accumul = (accumul << 4) | char_io;
        movwf   accumul         ;     char_io = 0;
        clrf    char_io         ;     break;
        zOS_RFI

monchr8
        movf    char_io,w       ;    } else /*if (char_io <= 9)*/ {
        andlw   0xf0            ;     uint16_t sum;
        btfss   STATUS,Z        ;     accumuh <<= 1;
        bra     monsave         ;     accumuh |= (accumul & 0x80) ? 1 : 0;
                                ;     accumul <<= 1;
        lslf    accumul,f       ;     w = accumul;//w keeps original accumul<<1
        rlf     accumuh,f       ;     accumuh <<= 1;
        movf    accumul,w       ;     accumuh |= (accumul & 0x80) ? 1 : 0;
                                ;     accumul <<= 1;
        lslf    accumul,f       ;     accumuh |= (accumul & 0x80) ? 1 : 0;
        rlf     accumuh,f       ;     accumul <<= 1; // accumuh:accumul <<= 3;
                                ;     if (numbase & 2) { // base 10 presumed
        lslf    accumul,f       ;      sum = (accumuh<<8)+accumul + w;
        rlf     accumuh,f       ;      accumul = sum & 0x00ff;
        btfss   numbase,1       ;      accumuh = sum >> 8;
        bra     $+4             ;     }
        addwf   accumul,f       ;     sum = (accumuh<<8)+accumul + char_io&0x0f;
        movlw   0               ;     accumul = sum & 0x00ff;
        addwfc  accumuh,f       ;     accumuh = sum >> 8;
        movf    char_io,w       ;     break;
        andlw   0x0f            ;    }
        addwf   accumul,f       ;   } // if we get here, restore input character
        movlw   0               ;   char_io += 0x37; // 0x10->’G’,0x11->’H’ etc.
        addwfc  accumuh,f       ;   zOS_AR1 = accumul;
        zOS_RFI
monchr9
        movlw   0-0x37          ;   if (isr) goto isr; // with zOS_AR1=accumul
monsave
        movlw   0x37            ;  } // switch ()
        addwf   char_io,f       ;  char_io = 0;
        movf    accumul,w       ; } // if () // was less than 32 so aborts
        movwf   zOS_AR1         ;
        if (isr)
        pagesel isr
         goto   isr             ; zOS_RFI(); // reached only if isr == 0
        else
         zOS_RFI
        endif

;;;
monprmp
        movf    1+destreg,w     ;monprmp:
        movwf   accumuh         ; accumuh = destreg>>8;
        iorwf   destreg,w       ; if (destreg) { // prompt with destreg if nonzero
        pagesel monhex
        btfsc   STATUS,Z        ;  monhex(zos_job, p0);
        bra     $+6             ;  accumuh = destreg & 0xff;
        call    monhex          ;  monlsb(zos_job, p0);
        movf    destreg,w       ; }
        movwf   accumuh         ;monlast: zOS_ACC(&accumul,&numbase); zOS_RFI();
        pagesel monlsb
        call    monlsb          ;         char_io = 0;
        pagesel monspc
        call    monspc          ;    putchar(’ ’);
monzero
        zOS_ACC accumul,numbase
monlast
        clrf    char_io         ;} // zOS_MON()
        zOS_RFI
endmon
        zOS_INP p,ra,rt,h,pi,monisr
        endm
```

```
zOS_DEC macro   putch,enc,retadr;e.g. zOS_DEC monout,accumul,zos_opr

        local   puts,loop,done  ; NOT zos_opc because my purpose is to define it
        local
        local   top1bcf,top1bsf,top1btc,top1bts,calllit,gotolit,endopc
        local   literal,litbyte,calllit,gotolit,lit11,opc_lit,opccall,opcgoto
        local   destreg,namereg,putname,flagreg,opc_reg
        local   regnam0,regnam1,regnam2,regnam3,regnam4,regnam5
        local   regnam6,regnam7,regnam8,regnam9,regnamA,regnamB
        local   overld0,omnibus,overld1,clr_reg,overld2,paging,overld3,moviwwi
puts
        banksel zOS_ADL
        movf    FSR0L,w         ;void puts(char w) {
        movwf   zOS_ADL         ;
        movf    FSR0H,w         ;//FIXME: needs comments
        movwf   zOS_ADH         ;
loop
        zOS_RDF                 ;
        rlf     zOS_RDL,w       ;  zOS_RDF(); // read packed 14-bit contents
        rlf     zOS_RDH,w       ;
        btfsc   STATUS,Z        ;
        bra     done            ;  if ((w = (zOS_RDH<<1)|(zOS_RDL>>7)) != ’\0’){
        pagesel putch
        bcf     STATUS,C        ;
        call    putch           ;

        banksel zOS_RDL
        movf    zOS_RDL,w       ;
        andlw   0x7f            ;
        btfsc   STATUS,Z        ;
        bra     done            ;
        pagesel putch
        bcf     STATUS,C        ;
        call    putch           ;

        banksel zOS_ADL         ;
        incfsz  zOS_ADL,f       ;
        bra     loop            ;
        incf    zOS_ADH,f       ;
        bra     loop            ;
done
        return                  ;} // puts()
zos_opc
        movlw   0x3f            ;void zos_opc(uint14_t enc) {
        andwf   1+enc,w         ; uint8_t w = (enc &= 0x3fff) >> 8;
                                ; enc &= 0x00ff; // builds string index in 1+enc
        clrf    1+enc           ; switch (w) { case 0: /*
        brw                     ;movwf/callw/movlb/brw/retfie/return/clrwdt/nop/
        bra     overld0         ;option/reset/sleep/tris/mov[wi]*/ goto overld0;
        bra     overld1         ;/* 0x01nn=>clrf/clrw*/ case 1: goto overld1;
        bra     destreg-0x12    ;/* 0x02nn => subwf  */ case 2: goto destreg-18;
        bra     destreg-0x11    ;/* 0x03nn => decf   */ case 3: goto destreg-17;
        bra     destreg-0x10    ;/* 0x04nn => iorwf  */ case 4: goto destreg-16;
        bra     destreg-0xf     ;/* 0x05nn => andwf  */ case 5: goto destreg-15;
        bra     destreg-0xe     ;/* 0x06nn => xorwf  */ case 6: goto destreg-14;
        bra     destreg-0xd     ;/* 0x07nn => addwf  */ case 7: goto destreg-13;
        bra     destreg-0xc     ;/* 0x08nn => movf   */ case 8: goto destreg-12;
        bra     destreg-0xb     ;/* 0x09nn => comf   */ case 9: goto destreg-11;
        bra     destreg-0xa     ;/* 0x0ann => incf   */case 10: goto destreg-10;
        bra     destreg-9       ;/* 0x0bnn => decfsz */case 11: goto destreg-9;
        bra     destreg-8       ;/* 0x0cnn => rrf    */case 12: goto destreg-8;
        bra     destreg-7       ;/* 0x0dnn => rlf    */case 13: goto destreg-7;
        bra     destreg-6       ;/* 0x0enn => swapf  */case 14: goto destreg-6;
        bra     destreg-5       ;/* 0x0fnn => incfsz */case 15: goto destreg-5;

        bra     top1bcf         ;/*0x10nn to 0x13nn => bcf*/ case 16:
        bra     top1bcf         ;                           case 17:
        bra     top1bcf         ;                          case 18:
```

```
        bra     top1bcf         ;                         case 19: goto top1bcf;
        bra     top1bsf         ;/*0x14nn to 0x17nn => bsf*/ case 20:
        bra     top1bsf         ;                           case 21:
        bra     top1bsf         ;                          case 22:
        bra     top1bsf         ;                         case 23: goto top1bsf;
        bra     top1btc         ;/*0x18nn to 0x1bnn => btfsc*/case 24:
        bra     top1btc         ;                           case 25:
        bra     top1btc         ;                          case 26:
        bra     top1btc         ;                         case 27: goto top1btc;
        bra     top1bts         ;/*0x1cnn to 0x1fnn => btfss*/case 28:
        bra     top1bts         ;                           case 29:
        bra     top1bts         ;                          case 30:
        bra     top1bts         ;                         case 31: goto top1bts;

        bra     calllit         ;/* 0x20nn to 0x27nn => call */ case 32:
        bra     calllit         ;                              case 33:
        bra     calllit         ;                             case 34:
        bra     calllit         ;                            case 35:
        bra     calllit         ;                           case 36:
        bra     calllit         ;                          case 37:
        bra     calllit         ;                         case 38:
        bra     calllit         ;                        case 39: goto calllit;
        bra     gotolit         ;/* 0x28nn to 0x2fnn => goto */ case 40:
        bra     gotolit         ;                              case 41:
        bra     gotolit         ;                             case 42:
        bra     gotolit         ;                            case 43:
        bra     gotolit         ;                           case 44:
        bra     gotolit         ;                          case 45:
        bra     gotolit         ;                         case 46:
        bra     gotolit         ;                        c:ase 47: goto gotolit;

        bra     literal-6       ;/* 0x30nn => movlw */ case 48: goto literal-6;
        bra     overld2         ;/*0x31nn => movlp/addfsr*/case 49:goto overld2;
        bra     brafwd          ;/*0x32nn => bra(negative)*/case 50:goto brafwd;
        bra     brarev          ;/*0x33nn => bra(positive)*/case 51:goto brarev;
        bra     literal-5       ;/* 0x34nn => retlw */ case 52: goto literal-5;
        bra     destreg-4       ;/* 0x35nn => lslf  */ case 53: goto destreg-4;
        bra     destreg-3       ;/* 0x36nn => lsrf  */ case 54: goto destreg-3;
        bra     destreg-2       ;/* 0x37nn => asrf  */ case 55: goto destreg-2;
        bra     literal-4       ;/* 0x38nn => iorlw */ case 56: goto literal-4;
        bra     literal-3       ;/* 0x39nn => andlw */ case 57: goto literal-3;
        bra     literal-2       ;/* 0x3ann => xorlw */ case 58: goto literal-2;
        bra     destreg-1       ;/* 0x3bnn => subwfb*/ case 59: goto destreg-1;
        bra     literal-1       ;/* 0x3cnn => sublw */ case 60: goto literal-1;
        bra     destreg-0       ;/* 0x3dnn => addwfc*/ case 61: goto destreg-0;
        bra     literal-0       ;/* 0x3enn => addlw */ case 62: goto literal-0;
        bra     ovrld3          ;/* 0x3fnn => movwi(offset)/moviw(offset) */

bitops
        andlw   0x0f            ;//fortuitous that opcodes separated by 4 in enc
        movwf   1+enc           ;//as well as the opcode strings of 4 words!
        addlw   low opc_bcf     ;
        movwf   FSR0L           ;
        movlw   high opc_bcf    ;
        movwf   FSR0H           ;
        clrw                    ;
        addwfc  FSR0H,f         ;
        pagesel print
        call    print           ; print(fsr0 = bit_lit[w]);
        movlw   0x03            ;
        andwf   1+enc           ; enc[1] &= 0x07; // bit number < 8
        rlf     enc,w           ; enc[1] <<= 1; // pull in bit 7 from low byte
        rlf     1+enc,f         ; enc[1] |= (w & 0x80) ? 1 : 0;  // bit number<8
        lslf    1+enc,f         ; enc[1] <<= 1; // bit number now in bits 3:1
        bsf     1+enc,1         ; enc[1] |= 1; // so that C is set for print
        bra     nametst         ;

;;; FIXME
```

```
        incf    1+enc,f         ; // opc_lit[6] = "movlw 0"
        incf    1+enc,f         ; // opc_lit[5] = "retlw 0"
        incf    1+enc,f         ; // opc_lit[4] = "iorlw 0"
        incf    1+enc,f         ; // opc_lit[3] = "andlw 0"
        incf    1+enc,f         ; // opc_lit[2] = "xorlw 0"
        incf    1+enc,f         ; // opc_lit[1] = "sublw 0"
literal
        lslf    1+enc,w         ; // opc_lit[0] = "addlw 0"
        lslf    WREG            ;
        addlw   low opc_lit     ;
        movwf   FSR0L           ;
        movlw   high opc_lit    ;
        movwf   FSR0H           ;
        clrw                    ;
        addwfc  FSR0H,f         ;
        pagesel print
        call    print           ; print(fsr0 = opc_lit[w]);
        movf    enc,f           ;
        btfsc   STATUS,Z        ;
        bra     endopc          ; if (enc) {
        movlw   ’x’             ;
        pagesel putch
        bcf     STATUS,C        ;
        call    putch           ;  putch(’x’);
litbyte
        movf    enc,w           ;
        pagesel putch
        bsf     STATUS,C        ;
        call    putch           ;
        bra     endopc          ;
calllit
        movwf   1+enc           ;
        zOS_ADR opccall,zOS_FLA
        pagesel print
        call    print           ;
        bra     lit11           ;
gotolit
        movwf   1+enc           ;
        zOS_ADR opcgoto,zOS_FLA
        pagesel print
        call    print           ;
lit11
        movf    1+enc,w         ;
        andlw   0x07            ;
        pagesel putch
        bsf     STATUS,C        ;
        call    putch           ;
        bra     litbyte         ;


        incf    1+enc,f         ; // opc_reg[18] = "subwf  "
        incf    1+enc,f         ; // opc_reg[17] = "decf   "
        incf    1+enc,f         ; // opc_reg[16] = "iorwf  "
        incf    1+enc,f         ; // opc_reg[15] = "andwf  "
        incf    1+enc,f         ; // opc_reg[14] = "xorwf  "
        incf    1+enc,f         ; // opc_reg[13] = "addwf  "
        incf    1+enc,f         ; // opc_reg[12] = "movf   "
        incf    1+enc,f         ; // opc_reg[11] = "comf   "
        incf    1+enc,f         ; // opc_reg[10] = "incf   "
        incf    1+enc,f         ; // opc_reg[9] = "decfsz "
        incf    1+enc,f         ; // opc_reg[8] = "rrf    "
        incf    1+enc,f         ; // opc_reg[7] = "rlf    "
        incf    1+enc,f         ; // opc_reg[6] = "swapf  "
        incf    1+enc,f         ; // opc_reg[5] = "incfsz "
        incf    1+enc,f         ; // opc_reg[4] = "lslf   "
        incf    1+enc,f         ; // opc_reg[3] = "lsrf   "
        incf    1+enc,f         ; // opc_reg[2] = "asrf   "
        incf    1+enc,f         ; // opc_reg[1] = "subwfb "
destreg
```

```
        lslf    1+enc,w         ; // opc_reg[0] = "addwfc "
        clrf    1+enc           ; //so test between w and f will happen for wf’s
        lslf    WREG            ;
        addlw   low opc_reg     ;
        movwf   FSR0L           ;
        movlw   high opc_reg    ;
        movwf   FSR0H           ;
        clrw                    ;
        addwfc  FSR0H,f         ;
        pagesel print
        call    print           ;
nametst
        movlw   0x7f            ;
        andwf   enc,f           ;
        addlw   0-0x0c          ;
        btfsc   WREG,7          ;
        bra     namereg         ;
        zOS_ADR hexpref,zOS_FLA ;
        pagesel print
        call    print           ;
        movf    enc,w           ;
        pagesel putch
        bsf     STATUS,C        ;
        call    putch           ;
        bra     flagreg         ;
namereg
        movf    enc,w           ;
        callw                   ;
        bra     putname         ;
        retlw   regnam1-regnam0 ;
        retlw   regnam2-regnam0 ;
        retlw   regnam3-regnam0 ;
        retlw   regnam4-regnam0 ;
        retlw   regnam5-regnam0 ;
        retlw   regnam6-regnam0 ;
        retlw   regnam7-regnam0 ;
        retlw   regnam8-regnam0 ;
        retlw   regnam9-regnam0 ;
        retlw   regnamA-regnam0 ;
        retlw   regnamB-regnam0 ;
putname
        addlw   low regnam0     ;
        movwf   FSR0L           ;
        movlw   high regnam0    ;
        movwf   FSR0H           ;
        clrw                    ;
        addwfc  FSR0H,f         ;
        pagesel print
        call    print           ;
flagreg
        movlw   ’,’             ;
        pagesel putch
        bcf     STATUS,C        ;
        call    putch           ;
        lsrf    1+enc,w         ;
        btfsc   STATUS,C        ;
        bra     regarg2         ;
        movlw   ’f’             ;
        btfss   enc,7           ;
        movlw   ’w’             ;
regarg2
        pagesel putch
        call    putch           ;
endopc
        pagesel retadr
        goto    retadr          ;
overld0
        pagesel omnibus
        goto    omnibus         ;
```

```
overld1
        pagesel clr_reg
        goto    clr_reg         ;
overld2
        pagesel paging
        goto    paging          ;
overld3
        pagesel moviwwi
        goto    moviwwi         ;

bitops
        andlw   0x07            ;void bitops(uint8_t w, uint8_t* enc) {
        movwf   1+enc           ; enc[1] &= 0x07; // bit number < 8
        rlf     enc,w           ; enc[1] <<= 1; // pull in bit 7 from low byte
        rlf     1+enc,f         ; enc[1] |= (w & 0x80) ? 1 : 0;  // bit number<8
        lslf    1+enc,f         ; enc[1] <<= 1; // bit number now in bits 3:1
        bsf     1+enc,1         ; enc[1] |= 1; // so that C is set for print
        movlw   0x7f            ; enc[0] &= 0x7f; // register file number
        andwf   enc,f           ;}

omnibus

clr_reg

paging

moviwwi
;;; if we arrive from omnibus, must have enc already swapf’ed
;;; FIXME: use some branching, don’t need to always use carry flag to select < 3
        clrw                    ;
        btfsc   enc,7           ;
        movlw   opc_mwi-opc_miw ;
        addlw   low opc_miw     ;
        movwf   FSR0L           ;
        movlw   high opc_miw    ;
        movwf   FSR0H           ;
        clrw                    ;
        addwfc  FSR0H,f         ;
        pagesel print
        call    print           ;

        btfsc   1+enc,0         ;
        bra     movoffs         ;
        btfsc   enc,5           ;
        bra     postinc



        pagesel retadr
        goto    retadr          ;

movoffs
        movlw   ’0’             ;
        pagesel putch
        call    putch           ;
        movlw   ’x’             ;
        pagesel putch
        call    putch           ;
        movlw   0x3f            ;
        andwf   enc,w           ;
        btfsc   enc,5           ;
        bsf     enc,6           ;
        btfsc   enc,5           ;
        bsf     enc,7           ;
        movwf   zOS_AR0         ;
        clrw                    ;
        pagesel putch
        call    putch           ;
        zOS_ADR offset0,zOS_FLA ;
        movlw   0               ;
        btfsc   enc,6           ;
        movlw   offset1-offset0 ;
        addwf   FSR0L           ;
        movlw   0               ;
        addwfc  FSR0H           ;
        pagesel print
        call    print           ;
        pagesel retadr
        goto    retadr          ;

offset0
        da      "[FSR0]"
offset1
        da      "[FSR1]"
minfsr
        da      "--FSR"
minmin
        da      "--"
plufsr
        da      "++FSR"
pluplu
        da      "++"
opc_miw
        da      "moviw  "
opc_mwi
        da      "movwi  "
opc_lit
        da      "addlw 0"
        da      "sublw 0"
        da      "xorlw 0"
        da      "andlw 0"
        da      "iorlw 0"
        da      "retlw 0"
        da      "movlw 0"
opc_reg
        da      "addwfc "
        da      "subwfb "
        da      "asrf   "
        da      "lsrf   "
        da      "lslf   "
        da      "incfsz "
        da      "swapf  "
        da      "rlf    "
        da      "rrf    "
        da      "decfsz "
        da      "incf   "
        da      "comf   "
        da      "movf   "
        da      "addwf  "
        da      "xorwf  "
        da      "andwf  "
        da      "iorwf  "
        da      "decf   "
        da      "subwf  "
opcbcf
        da      "bcf    "
opcbsf
        da      "bsf    "
opcbtc
        da      "btfsc  "
opcbts
        da      "btfss  "
opccall
        da      "call 0x"
opcgoto
        da      "goto 0x"
regnam0
        da      "INDF0"
```

```
regnam1
        da      "INDF1"
regnam2
        da      "PCL"
regnam3
        da      "STATUS"
regnam4
        da      "FSR0L"
regnam5
        da      "FSR0H"
regnam6
        da      "FSR1L"
regnam7
        da      "FSR1H"
regnam8
        da      "BSR"
regnam9
        da      "WREG"
regnamA
        da      "PCLATH"
regnamB
        da      "INTCON"
        endm


zOS_NAM macro   str
        local   start
start
        dt      str
        dt      0
        dt      start-$
        endm

zOS_MAN macro   p,rat,rts,hb,pin,isr ;inline void zOS_MAN(int8_t p, int8_t rat,
        pagesel endman
        goto    endman          ;                      int8_t* hb, int8_t pin) {

        local   mantask,manisr,manchr,manchr0,reenable,manchr1,manchr2,manchr3
        local   manchr4,manchr5,manchr6,manchr7,manchr8,manchr9,mannone,jobinfo
        local   manname,manloop,crlf,stkinfo,stkloop,endman

        local   p0,p1,wrap,t0scale,isradrl,isradrh,tskadrl,tskadrh,optadrl
        local   optadrh,accumul,accumuh,numbase,destreg,destreh,char_io,buf,max

        ;; 0x20˜24 reserved for zOS_CON
p0      set     0x20
p1      set     0x21
wrap    set     0x22
t0scale set     0x23

        ;; 0x24˜28 reserved for zOS_INP
isradrl set     0x24
isradrh set     0x25
tskadrl set     0x26
tskadrh set     0x27

        ;; 0x28˜2F reserved for zOS_MON and derivations e.g. zOS_MAN
optadrl set     0x28
optadrh set     0x29
accumul set     0x2a
accumuh set     0x2b
numbase set     0x2c
destreg set     0x2d
destreh set     0x2e
char_io set     0x2f
buf     set     0x30
max     set     0x70

;copy the preceding lines rather than including this file, as definitions for
```

```
;zOS_MON()-derived macros referring to these local variables wouldn’t open it
;until expansion and would throw an undefined-var error during the processing


mantask
#if 0;seems unnec 18 Jan
        movf    zOS_JOB,w       ;int8_t mantask(void) {//destreg,accumul,char_io
        movwf   BSR             ; bsr = zos_job; // to access char_io
#endif
        movf    char_io,w       ; if (char_io == 0)
        btfsc   STATUS,Z        ;  return 0; // back to zOS_CON task
        return                  ; switch (char_io) {

        xorlw   ’G’             ;
        btfss   STATUS,Z        ; caseG:
        bra     manchr          ; case ’G’: // Generate a fork/duplicate of job
        clrf    char_io         ;  char_io = 0; // presume failure, so no retry

        movf    accumul,w       ;  if (accumul == 0)
        btfsc   STATUS,Z        ;   return 0;
        return                  ;  zOS_ARG(0, accumul);
        zOS_ARG 0
        zOS_ACC accumul,numbase
        movlw   ’J’             ;  zOS_ACC(&accumul, &numbase); // reset
        movwf   char_io         ;  if (zOS_SWI(zOS_FRK))
        zOS_SWI zOS_FRK
        andlw   0x07            ;   goto caseJ; // success, prints in job list
        btfsc   STATUS,Z        ;  else
        clrf    char_io         ;   break; // failure, drop to end of switch()

manchr
        movf    char_io,w       ;
        xorlw   ’H’             ;
        btfss   STATUS,Z        ; caseH:
        bra     manchr0         ; case ’H’: // find jobs by Handle (start addr)
        clrf    char_io         ;  char_io = 0;

        movf    accumul,w       ;  if (accumul == 0)
        iorwf   accumuh,w       ;
        btfsc   STATUS,Z        ;   return 0;
        return                  ;  zOS_ARG(0, accumul);
        movf    accumul,w       ;
        zOS_ARG 0
        movf    accumuh,w       ;
        zOS_ARG 1
        zOS_ACC accumul,numbase
        movlw   ’J’             ;  zOS_ACC(&accumul, &numbase);
        movwf   char_io         ;  if (zOS_SWI(zOS_FND))
        zOS_SWI zOS_FND
        andlw   0x07            ;   goto caseJ; // FIXME: table, from match down
        movwf   accumul         ;
        btfsc   STATUS,Z        ;  else
        clrf    char_io         ;   break;

manchr0
        movf    char_io,w       ;
        xorlw   ’I’             ;
        btfss   STATUS,Z        ; caseI:
        bra     manchr1         ; case ’I’: // send a software Interrupt > 7
        clrf    char_io         ;  char_io = 0; // with destreg zOS_AR1:zOS_AR0

        movf    destreg,w       ;  zOS_ARG(0, destreg);
        clrf    destreg         ;
        zOS_ARG 0
        movf    1+destreg,w     ;  zOS_ARG(1, destreh);
        clrf    1+destreg       ;
        zOS_ARG 1
        movf    accumul,w       ;  w = accumul;
        zOS_ACC accumul,numbase
```

```
        andlw   0xf8            ;  zOS_ACC(&accumul, &numbase); // reset
        btfsc   STATUS,Z        ;  if (w & 0xf8) {
        bra     reenabl         ;   int w = zOS_SWI(accumul); // disable again
        movlp   0               ;   INTCON &= ˜(1<<GIE);// for zOS_AR and _BUF()
        call    0x02            ;   zOS_ARG(1, w);
        zOS_ARG 0               ;   zOS_ARG(0, 0);
#if 0
        clrf    zOS_AR1         ;   zOS_BUF(zos_job, p0); // print hex SWI result
        xorwf   zOS_AR1,f       ;   zOS_ENA();
        xorwf   zOS_AR0,f       ;   goto caseJ;
        zOS_BUF FSR0,max,p0
#else
        zOS_ARG 1               ;
        xorwf   zOS_AR0,f       ;
        zOS_SWI 0xff
        movlw   ’\r’            ;
        zOS_ARG 0               ;
        zOS_SWI 0xff            ;
        movlw   ’\n’            ;
        zOS_ARG 0               ;
        zOS_SWI 0xff            ;
#endif

reenabl
        zOS_ENA

manchr1
        movf    char_io,w       ; }
        xorlw   ’J’             ;
        btfss   STATUS,Z        ; caseJ:
        bra     manchr2         ; case ’J’: // List struct for all running jobs

        decf    accumul,w       ; // keep char_io=’J’ until last job line prints
        andlw   0x07            ;
        btfsc   WREG,2          ;  if ((accumul < 1) || (accumul > 5))
        movlw   zOS_NUM-1       ;
        addlw   0x01            ;
        movwf   accumul         ;   accumul = zOS_NUM;
        bcf     INTCON,GIE      ;  INTCON &= ˜(1<<GIE); // to keep p0==p1 atomic
        pagesel jobinfo
        movf    p0,w            ;
        xorwf   p1,w            ;  if (p0 == p1)
        btfsc   STATUS,Z        ;   return jobinfo(); // will decrement accumul
        goto    jobinfo         ;  zOS_ENA(); // re-enable interrupts if p0!=p1
        zOS_ENA
        retlw   0               ;  return 0;//try again after caller advances p0

manchr2
        movf    char_io,w       ;
        xorlw   ’K’             ;
        btfss   STATUS,Z        ; caseK:
        bra     manchr3         ; case ’K’: // Kill a single job (# mandatory)
        clrf    char_io         ;  char_io = 0;

        movf    accumul,w       ;  if (accumul == 0)
        btfsc   STATUS,Z        ;   return 0;
        return                  ;  zOS_ARG(0, accumul);
        zOS_ARG 0
        zOS_ACC accumul,numbase
        movlw   ’J’             ;  zOS_ACC(&accumul, &numbase);
        movwf   char_io         ;  zOS_SWI(zOS_END); // listed indicates failure
        zOS_SWI zOS_END
;;; FIXME: put J at bottom so K onward don’t pay a performance penalty awaiting

manchr3
        movf    char_io,w       ;
        xorlw   ’L’             ;
        btfss   STATUS,Z        ; caseL:
        bra     manchr4         ; case ’L’: // Launch a fresh instance of a job
        clrf    char_io         ;  char_io = 0;

        movf    accumul,w       ;  if (accumul == 0)
        btfsc   STATUS,Z        ;   return 0;
        return                  ;  zOS_ARG(0, accumul);
        zOS_ARG 0
        zOS_ACC accumul,numbase
        movlw   ’J’             ;  zOS_ACC(&accumul, &numbase); // reset
        movwf   char_io         ;  if ((w = zOS_SWI(zOS_FRK)) != 0) {
        zOS_SWI zOS_FRK
        andlw   0x07            ;   zOS_ARG(0,w); zOS_SWI(zOS_RST);
        btfsc   STATUS,Z        ;   goto caseJ; // success, prints in job list
        clrf    char_io         ;  } else
        zOS_ARG 0
        zOS_SWI zOS_RST         ;   break; // failure, drop to end of switch()

manchr4
        movf    char_io,w       ;
        xorlw   ’N’             ;
        btfss   STATUS,Z        ; caseN:
        bra     manchr5         ; case ’N’: // New (parameterless) job at addr

        movf    accumul,w       ;
        movwf   FSR0L           ;
        movf    accumuh,w       ;
        movwf   FSR0H           ;
        clrw                    ;
        zOS_ARG 0
        zOS_ARG 1
        zOS_ARG 2
        zOS_ARG 3
        zOS_SWI zOS_NEW
        zOS_ARG 0
;       zOS_BUF FSR0,max,p0
;       movlw   ’J’             ;
;       movwf   char_io         ;

;       movf    accumul,w       ;  if (accumul == 0)
;       btfsc   STATUS,Z        ;   return 0;
;       return                  ;  zOS_ARG(0, accumul);
        clrw                    ;
        zOS_ARG 0
        zOS_ACC accumul,numbase
        movlw   ’J’             ;  zOS_ACC(&accumul, &numbase);
        movwf   char_io         ;  if ((w = zOS_SWI(zOS_SLP)) != 0) {
;       zOS_SWI zOS_SLP
;       andlw   0xff            ;   accumul = w;
;       movwf   accumul         ;   goto caseJ;
;       btfsc   STATUS,Z        ;  } else
;       clrf    char_io         ;   break;

manchr5
        movf    char_io,w       ;
        xorlw   ’P’             ;
        btfss   STATUS,Z        ; caseP:
        bra     manchr6         ; case ’P’: // Pause job by putting it to Sleep
        clrf    char_io         ;  char_io = 0;

        movf    accumul,w       ;  if (accumul == 0)
        btfsc   STATUS,Z        ;   return 0;
        return                  ;  fsr1 = 0x10 * (1 + accumul) + zOS_PCH;
        movlw   ’J’             ;
        movwf   char_io         ;
        zOS_MEM FSR1,accumul,zOS_PCH
        movf    INDF1,w         ;  if (*fsr1) { // is a valid (PCH not 0x00) job
        btfsc   STATUS,Z        ;   *fsr |= 0x80;
        clrf    char_io         ;   goto caseJ;
        iorlw   0x80            ;  } else {
        movf    INDF1,f         ;
```

```
        btfss   STATUS,Z        ;
        movwf   INDF1           ;   zOS_ACC(&accumul, &numbase);
        btfsc   STATUS,Z        ;   break; // only clear accumul if not caseJ
        bra     manchr6         ;  }
        zOS_ACC accumul,numbase

manchr6
        movf    char_io,w       ;
        xorlw   ’Q’             ;
        btfss   STATUS,Z        ; caseQ:
        bra     manchr7         ; case ’Q’: // Quit without wake (off)
        clrf    char_io         ;  char_io = 0;

        bcf     WDTCON,SWDTEN   ;  WDTCON &= ˜(1<<SWDTEN);
        movf    accumul,f       ;
        btfss   STATUS,Z        ;  if (accumul)
        sleep                   ;   sleep(); // never wakes up

manchr7
        movf    char_io,w       ;
        xorlw   ’R’             ;
        btfss   STATUS,Z        ; caseR:
        bra     manchr8         ; case ’R’: // Resume a pause/asleep job
        clrf    char_io         ;  char_io = 0;

        swapf   accumul,w       ;  if (accumul == 0x5a /*e.g.*/)
        xorwf   accumul,w       ;
        addlw   1               ;
        btfsc   STATUS,Z        ;
        reset                   ;   reset();

        movf    accumul,w       ;  if (accumul == 0)
        btfsc   STATUS,Z        ;   return 0;
        return                  ;  fsr1 = 0x10 * (1 + accumul) + zOS_PCH;
        movlw   ’J’             ;
        movwf   char_io         ;  if (*fsr1 &= ˜(1<<zOS_WAI)) {
        zOS_MEM FSR1,accumul,zOS_PCH
        movlw   0x7f            ;   goto caseJ; // valid job won’t be 0 or 0x80
        andwf   INDF1,f         ;  } else {
        btfss   STATUS,Z        ;   zOS_ACC(&accumul, &numbase);
        bra     manchr8         ;
        zOS_ACC accumul,numbase
        clrf    char_io         ;   break;

manchr8
        movf    char_io,w       ;  }
        xorlw   ’S’             ;
        btfss   STATUS,Z        ;
        bra     manchr9         ; case ’S’: // Stack dump is actually scratch
        clrf    char_io         ;  char_io = 0; // always succeeds, no arg

        decf    accumul,w       ; // keep char_io=’S’ until last job line prints
        andlw   0x07            ;
        btfsc   WREG,2          ;  if ((accumul < 1) || (accumul > 5))
        movlw   zOS_NUM-1       ;
        addlw   0x01            ;
        movwf   accumul         ;   accumul = zOS_NUM;
        bcf     INTCON,GIE      ;  INTCON &= ˜(1<<GIE); // to keep p0==p1 atomic
        pagesel stkinfo
        movf    p0,w            ;
        xorwf   p1,w            ;  if (p0 == p1)
        btfsc   STATUS,Z        ;   return jobinfo(); // will decrement accumul
        goto    stkinfo         ;  zOS_ENA(); // re-enable interrupts if p0!=p1
        zOS_ENA
        retlw   0               ;  return 0;//try again after caller advances p0

manchr9
        movf    char_io,w       ;
        xorlw   ’Z’             ;
        btfss   STATUS,Z        ;
        bra     mannone         ; case ’Z’: // go to low-power Zz mode for time
        clrf    char_io         ;  char_io = 0;

        bsf     WDTCON,SWDTEN   ;  if (w = accumul<<1) { // WDT prescalre
        lslf    accumul,w       ;   w |= 1<<SWDTEN; // enable the wakeup
        btfsc   STATUS,Z        ;
        bra     mannone         ;
        iorlw   1<<SWDTEN       ;
        movwf   WDTCON          ;
        sleep                   ;  break;  // wakes up according to prescaler

mannone
        retlw   0               ; } return 0; //naught to do }

        ;guaranteed to arrive with p0=p1, interrupts off and in the correct bank
stkinfo
        movf    wrap,f          ;int8_t stkinfo(void) {
        movwf   p0              ; p0 = p1 = wrap;
        movwf   p1              ;
        movlw   low zOS_STK     ;
        movwf   FSR0L           ;
        movlw   high zOS_STK    ;
        movwf   FSR0H           ;
        decf    accumul,w       ;
        brw                     ;
        addfsr  FSR0,6          ;
        addfsr  FSR0,6          ;
        addfsr  FSR0,6          ;
        addfsr  FSR0,6          ; fsr0 = zOS_STK + 6 * (5 - accumul);
        zOS_LOC FSR1,zOS_JOB,buf
        movlw   ’\r’            ; fsr1 = (zOS_JOB << 7) + buf;
        movwi   FSR1++          ;
        movlw   ’\n’            ;
        movwi   FSR1++          ;
        movlw   ’-’             ;
        movwi   FSR1++          ;
        movf    accumul,w       ;
        addlw   -12             ; // print this stack offset as -0/-1/-2/-3/-4
        zOS_HEX
        movwi   FSR1++          ; p1 += sprintf(p1, "\r\n-%1X", accumul & 7);
        movlw   3               ;
        movwf   accumuh         ; for (accumuh = 3; accumuh; accumuh--) {
stkloop
        movlw   ’ ’             ;
        movwi   FSR1++          ;  p1 += sprintf(p1, " %04X", *((int*) fsr0));
        moviw   --FSR0          ;
        movwi   FSR1++          ;
        moviw   --FSR0          ;
        movwi   FSR1++          ;
        decfsz  accumuh,f       ;
        bra     stkloop         ; }

        movf    FSR1L,w         ;
        movwf   p1              ; w = accumul--; // return with w as nonzero job
        movf    accumul,w       ; if (accumul == 0)
        decf    accumul,f       ;  char_io = 0;// final row in table was printed
        btfsc   STATUS,Z        ; zOS_ENA(); // interrupts back ON!
        clrf    char_io         ; return w;
        zOS_ENA
        return                  ;} // stkinfo()

        ;guaranteed to arrive with p0=p1, interrupts off and in the correct bank
jobinfo
        movf    wrap,w          ;int8_t jobinfo(void) {
        movwf   p0              ; p0 = p1 = wrap;
        movwf   p1              ; fsr0 = 0x10 * (1 + accumul); //FIXME: 2+
        zOS_MEM FSR0,accumul,0
        zOS_LOC FSR1,zOS_JOB,buf
```

```
        movlw   ’\r’            ; fsr1 = (zOS_JOB << 7) + buf;
        movwi   FSR1++          ;
        movlw   ’\n’            ;
        movwi   FSR1++          ;
        movf    accumul,w       ; // print this job number 5/4/3/2/1
        zOS_HEX
        movwi   FSR1++          ; p1 += sprintf(p1, "\r\n%1X", accumul);

        moviw   zOS_HDH[FSR0]   ;
        andlw   1<<zOS_PRB      ;
        movlw   ’:’             ; // print ’*’ if the job is privileged else ’:’
        btfss   STATUS,Z        ;
        movlw   ’*’             ; p1 += sprintf(p1, "%c", (zOS_HDH[fsr0] &
        movwi   FSR1++          ;                    (1<<zOS_PRB)) ? ’*’ : ’:’);

        zOS_IHF zOS_HDH,FSR0,FSR1
        zOS_IHF zOS_HDL,FSR0,FSR1
        movlw   ’ ’             ;
        movwi   FSR1++          ;
        movlw   ’P’             ; // print the 4-hex-digit header then PC
        movwi   FSR1++          ;
        movlw   ’C’             ; p1 += sprintf(p1, "%04X PC",
        movwi   FSR1++          ;         (zOS_HDH[fsr0] << 8) + zOS_HDL[fsr0]);

        moviw   zOS_PCH[FSR0]   ;
        andlw   1<<zOS_WAI      ;
        movlw   ’=’             ; // print ’=’ if the job is sleeping else ’z’
        btfss   STATUS,Z        ;
        movlw   ’z’             ; p1 += sprintf(p1, "%c", (zOS_PCH[fsr0] &
        movwi   FSR1++          ;                    (1<<zOS_WAI)) ? ’z’ : ’:’);

        zOS_IHF zOS_PCH,FSR0,FSR1
        moviw   zOS_PCH[FSR0]   ; // drop out after PCH if 0 (job is deleted)
        btfsc   STATUS,Z        ; p1 += sprintf(p1, "%02X", zOS_PCH[fsr0]);
        bra     manname         ; if (zOS_PCH[fsr0] & 0xff00) {
        zOS_IHF zOS_PCL,FSR0,FSR1
        movlw   ’ ’             ;  // print the low byte of program counter
        movwi   FSR1++          ;  p1 += sprintf(p1, "%02X", zOS_PCL[fsr0]);
        moviw   zOS_ISH[FSR0]   ;
        btfsc   STATUS,Z        ;  // drop out after PCL if no interrupt routine
        bra     manname         ;  if (zOS_ISH[fsr0] & 0xff00) {
        movlw   ’I’             ;
        movwi   FSR1++          ;
        movlw   ’S’             ;
        movwi   FSR1++          ;
        movlw   ’R’             ;
        movwi   FSR1++          ;
        movlw   ’@’             ;
        movwi   FSR1++          ;   // print ISR@ then 4-hex-digit routine addr
        zOS_IHF zOS_ISH,FSR0,FSR1
        zOS_IHF zOS_ISR,FSR0,FSR1
        movlw   ’(’             ;   p1 += sprintf(p1, " ISR@%04X",
        movwi   FSR1++          ;         (zOS_ISH[fsr0] << 8) + zOS_ISR[fsr0]);
        movlw   ’h’             ;
        movwi   FSR1++          ;
        zOS_IHF zOS_HIM,FSR0,FSR1
        movlw   ’s’             ;
        movwi   FSR1++          ;  // print (hw HwIMask sw SwIMask) scrunched up
        zOS_IHF zOS_SIM,FSR0,FSR1
        movlw   ’)’             ;   p1 += sprintf(p1, "(h%02Xs%02X) ",
        movwi   FSR1++          ;                 zOS_HIM[fsr0], zOS_SIM[fsr0]);
manname
        movlw   ’ ’             ;
        movwi   FSR1++          ;
        movlw   0x22 ;’"’       ;
        movwi   FSR1++          ;
        moviw   zOS_PCH[FSR0]   ;
        btfss   STATUS,Z        ;
        bra     manlive         ;   if (zOS_PCH[fsr0] == 0) {
```

```
        movlw   low mandead     ;    static char mandead = "<not running>";
        movwf   FSR0L           ;
        movlw   high mandead    ;
        movwf   FSR0H           ;    fsr0 = mandead;
        movlw   mandead-manlive ;
        movwf   char_io         ;    char_io = strlen(mandead);
        bra     manloop         ;
mandead
        zOS_NAM "<not running>"
manlive
        moviw   zOS_HDL[FSR0]   ;   } else {
        movwf   char_io         ;
        moviw   zOS_HDH[FSR0]   ;
        iorlw   0x80            ;
        movwf   FSR0H           ;    fsr0 = 0x8000 | (zOS_HDH[fsr0] << 8) ;
        movf    char_io,w       ;
        movwf   FSR0L           ;    fsr0 |= zOS_HDL[fsr0];
        moviw   --FSR0          ;
        iorlw   0xe0            ;
        movwf   char_io         ;    char_io = 0xe0 | *--fsr0; // max 32? chars
#if 1
        addwf   FSR0L,f         ;
        btfss   STATUS,C        ;
        decf    FSR0H,f         ;   for (fsr0 -= char_io; ++char_io; fsr1++) {
#else
        local   manbit0,manbit1
        movf    FSR0L,w         ;
        addwf   char_io,w       ;
        btfss   WREG,7          ;
        bra     manbit0         ;
        btfss   FSR0L,7         ;
        decf    FSR0H,f         ;
        bra     manbit1         ;
manbit0
        btfsc   FSR0L,7         ;
        decf    FSR0H,f         ;
manbit1
        movwf   FSR0L           ;   for (fsr0 -= char_io; ++char_io; fsr1++) {
#endif
manloop
        moviw   FSR0++          ;    char w = *fsr0++ ;
        btfsc   WREG,7          ;
        bra     crlf            ;    if ((w > ’\0177’) ||
        addlw   0-0x20          ;
        btfsc   WREG,7          ;
        bra     crlf            ;        (w < ’ ’))
        addlw   0x20            ;     break;
        movwi   FSR1++          ;    *fsr1 = w; // added to buffer
        incfsz  char_io,f       ;
        bra     manloop         ;   }
crlf
        movlw   0x22 ;’"’       ;
        movwi   FSR1++          ;
        movlw   ’\r’            ;  }
        movwi   FSR1++          ; }
        movlw   ’\n’            ; // print a second \r\n, double-spacing table
        movwi   FSR1++          ; p1 += sprintf(p1, "\r\n");

        movlw   ’J’             ;
        movwf   char_io         ;
        movf    FSR1L,w         ;
        movwf   p1              ; w = accumul--; // return with w as nonzero job
        movf    accumul,w       ; if (accumul == 0)
        decf    accumul,f       ;  char_io = 0;// final row in table was printed
        btfsc   STATUS,Z        ; zOS_ENA(); // interrupts back ON!
        clrf    char_io         ; return w;
        zOS_ENA
        return                  ;
endman
```

```
        local   vars,manl,manh
vars    set     0x20
manl    set     optadrl-vars
manh    set     optadrh-vars

        zOS_MON p,rat,rts,hb,pin,isr
        movlw   low mantask     ; zOS_MON(p,ra,rt,h,pi,manisr); //fsr0=swi,1=adr
        movwi   manl[FSR1]      ; optadrl = mantask & 0x00ff;
        movlw   high mantask    ; optadrh = mantask >> 8;
        movwi   manh[FSR1]      ;} // zOS_MAN()
        endm

;;; zOS_CLC is an extension of the zOS_MAN() job manager shell into an rpn calc-
;;; ulator, as an example of how to use and customize the above console macros
;;;
;;; Note: because the max call depth of zOS_MON’s ISR is nonzero (1), the max
;;; call depth for jobs in a system invoking these macros is reduced from 3 to 2
;;;
;;; (job 0)
;;; zOS_CLC is invoked with an optional isr routine (for any custom extensions):
;;;  First a jump over the clcisr code ends the macro expansion
;;;  zOS_MAN is invoked with all the zOS_CON arguments and its clcisr address:
;;;   zOS_MON is invoked with all the zOS_CON arguments (and the clcisr address)
;;;    First a jump over zOS_MON’s monisr and all its support functions (no task)
;;;    zOS_INP is invoked with all the zOS_CON arguments (and monisr’s address)
;;;     Immediately a near branch to rxdecl over the rxtask and rxisr code:
;;;     When run, rxtask first calls any code at nonzero optadrh:optadrl address
;;;     then jumps to the mandatorily nonzero tskadrh:tskadrl task of zOS_CON
;;;     When handling an interrupt, rxisr either handles a received character or
;;;     jumps to the mandatorily nonzero isradrh:isradrl isr address of zOS_CON
;;;     and if a received character the ISR in this case jumps to nonzero monisr
;;;     Unlike most declarations, rxdecl not only declares but launches, tweaks:
;;;     zOS_CON is invoked with the port,rate,rtsflag,heartbeat,pin arguments:
;;;      Immediately a near branch to decl over the task and isr code:
;;;      When run, task initializes the global pair, circular buffer and greets
;;;      (if the pair was still zero) then cedes the core awaiting a character
;;;      which it then sends and loops back (to the zOS_INP task, not its own!)
;;;      When handling an interrupt, isr handles the heartbeat and Timer0 stuff
;;;      (if hardware) else assumes that a software interrupt is a char to send
;;;      since any other applicable situation was handled by rxisr pre-jump
;;;     end of zOS_CON expansion
;;;     zOS_LAU then immediately assigns a job bank to the zOS_CON instance and
;;;     uses FSR1 to set locals isradrh:isradrl,tskadrh:tskadrl,optadrh:optadrl
;;;     to values zOS_CON just put in zOS_ARG1:zOS_ARG0, FSR0 (left at latter)
;;;     at which point it overwrites the Program Counter and HanDle fields with
;;;     rxtask, ISR field with rxisr and RX HWI mask using FSR0 (left at SWI)
;;;    end of zOS_INP expansion
;;;   FSR1 (pointing to optadrh:optadrl) then gets the address of the ensuing
;;;   mantask code (no ISR) which is then jumped over
;;;   end of zOS_MON expansion
;;;  end of zOS_MAN expansion
;;; end of zOS_CLC expansion
;;; (job 0)
;;; Since the end of zOS_INP, FSR0 has been pointing to the job information byte
;;; for the SWI mask that the job is to listen on for characters to output, so
;;; movwi 0[FSR0] with w set to the appropriate value: 8, 16, 32, 64 or 128

zOS_CLC macro   p,ra,rt,h,pi,isr;inline void zOS_CLC(int8_t p, int8_t ra, int8_t
        local   endclc,clcisr,clcprmp,endclc

        pagesel endclc
        goto    endclc          ;      rt, int8_t* h, int8_t pi, void(*isr)()) {

        local   p0,p1,wrap,t0scale,isradrl,isradrh,tskadrl,tskadrh,optadrl
        local   optadrh,accumul,accumuh,numbase,destreg,destreh,char_io,buf,max

        ;; 0x20~24 reserved for zOS_CON
p0      set     0x20
p1      set     0x21
```

```
wrap    set     0x22
t0scale set     0x23

        ;; 0x24˜28 reserved for zOS_INP
isradrl set     0x24
isradrh set     0x25
tskadrl set     0x26
tskadrh set     0x27

        ;; 0x28˜2F reserved for zOS_MON and derivations e.g. zOS_MAN
optadrl set     0x28
optadrh set     0x29
accumul set     0x2a
accumuh set     0x2b
numbase set     0x2c
destreg set     0x2d
destreh set     0x2e
char_io set     0x2f
buf     set     0x30
max     set     0x70

;copy the preceding lines rather than including this file, as definitions for
;zOS_MON()-derived macros referring to these local variables wouldn’t open it
;until expansion and would throw an undefined-var error during the processing

        local   clctbl;,clcsize ; throws "Duplicate label or redefining symbol"
clcisr
        movf    zOS_AR0,w       ; switch (char_io = zOS_AR0) {
        zOS_T63                 ;
clctbl
        retlw   ’ ’
        retlw   ’!’
        retlw   0x22
        retlw   ’#’
        retlw   ’$’
        retlw   ’%’
        retlw   ’&’
        retlw   "’"
        retlw   ’(’
        retlw   ’)’
        retlw   ’*’;0 ;zos_mac() not defined for ’*’
        retlw   ’+’
        retlw   ’,’
        retlw   ’-’
        retlw   ’.’
        retlw   ’/’;0 ;zos_div() not defined for ’/’
        retlw   ’0’
        retlw   ’1’
        retlw   ’2’
        retlw   ’3’
        retlw   ’4’
        retlw   ’5’
        retlw   ’6’
        retlw   ’7’
        retlw   ’8’
        retlw   ’9’
        retlw   ’:’
        retlw   0x3b
        retlw   ’<’
        retlw   ’=’
        retlw   ’>’
        retlw   ’?’
        retlw   ’@’
        retlw   ’A’
        retlw   ’B’
        retlw   ’C’
        retlw   ’D’
        retlw   ’E’
        retlw   ’F’
```

```
        retlw   ’G’
        retlw   ’H’
        retlw   ’I’
        retlw   ’J’
        retlw   ’K’
        retlw   ’L’
        retlw   ’M’
        retlw   ’N’
        retlw   ’O’
        retlw   ’P’
        retlw   ’Q’
        retlw   ’R’
        retlw   ’S’
        retlw   ’T’
        retlw   ’U’
        retlw   ’V’
        retlw   ’W’
        retlw   ’X’
        retlw   ’Y’
        retlw   ’Z’
        retlw   ’[’ ; ’{’       ;
        retlw   ’\\’ ; ’|’      ;
        retlw   ’]’ ; ’}’       ;
        retlw   ’^’ ; ’˜’       ;
clcsize equ     $-clctbl
        if clcsize-0x3f
         error "bad size: ASCII translation table expected to span 0x20 to 0x5e"
        endif
        movwf   char_io         ;
        xorlw   ’+’             ;
        btfss   STATUS,Z        ;
        bra     clcchr2         ; case ’+’: // 16-bit signed/unsigned add

        movf    accumul,w       ;
        addwf   destreg,f       ;
        movf    accumuh,w       ;
        addwfc  1+destreg,f     ;  destreg += (accumuh << 8) | accumul;
        bra     clcprmp         ; break;

clcchr2
        movf    char_io,w       ;
        xorlw   ’-’             ;
        btfss   STATUS,Z        ;
        bra     clcchr3         ; case ’-’: // 16-bit signed/unsigned subtract

        movf    accumul,w       ;
        subwf   destreg,f       ;
        movf    accumuh,w       ;
        subwfb  1+destreg,f     ;  destreg -= (accumuh << 8) | accumul;
        bra     clcprmp         ; break;

clcchr3
        movf    char_io,w       ;
        xorlw   ’*’             ;
        btfss   STATUS,Z        ;
        bra     clcchr4         ; case ’*’: // 8-bit by 8-bit unsigned multiply
#ifdef zos_mac
        clrf    zOS_AR0         ;  // invoker of macro must implement zos_mac():
        clrf    zOS_AR1         ;  //  input arg zOS_AR1:zOS_AR0 (accumulator)
        movf    accumul,w       ;  //                    zOS_AR2 (factor 1)
        movwf   zOS_AR2         ;  //                    zOS_AR3 (factor 2)
        movf    destreg,w       ;  //  output arg zOS_AR1:zOS_AR0 (product)
        movwf   zOS_AR3         ;  zOS_AR0 = (uint16_t) 0;
                                ;  zOS_AR2 = accumul & 0x00ff;
        zOS_LOC FSR0,zOS_JOB,char_io
        pagesel zos_mac
        call    zos_mac         ;  zOS_AR3 = destreg & 0x00ff;
        movf    zOS_AR0,w       ;  fsr0 = &char_io; // temp register (as INDF0)
        movwf   destreg         ;  zos_mac(&zOS_AR0 /* += */,
        movf    zOS_AR1,w       ;          &zOS_AR2 /* * */, &zOS_AR3, fsr0);
        movwf   1+destreg       ;  destreg = (uint16_t) zOS_AR0;
#endif
        bra     clcprmp         ; break;

clcchr4
        movf    char_io,w       ;
        xorlw   ’/’             ;
        btfss   STATUS,Z        ;
        bra     clcchr5         ; case ’/’: // 15-bit by 8-bit unsigned divide
#ifdef zos_div
        movf    destreg,w       ;  // invoker of macro must implement zos_div():
        movwf   zOS_AR0         ;  //  input arg zOS_AR1:zOS_AR0 (dividend)
        movf    1+destreg,w     ;  //                    zOS_AR2 (divisor)
        andlw   0x7f            ;  //  output arg zOS_AR1:zOS_AR0 (quotient/exc)
        movwf   zOS_AR1         ;  zOS_AR0 = (uint16_t) destreg & 0x7fff;
        movf    accumul,w       ;  zOS_AR2 = accumul & 0xff;
        movwf   zOS_AR2         ;  fsr0 = &char_io; // temp register (as INDF0)
        zOS_LOC FSR0,zOS_JOB,char_io
        pagesel zos_div
        call    zos_div         ;  zos_div(&zOS_AR0 /* /= */
        movf    zOS_AR0,w       ;          &zOS_AR2, &zOS_AR3/*scratch*/, fsr0);
        movwf   destreg         ;
        movf    zOS_AR1,w       ;
        movwf   1+destreg       ;  destreg = (uint16_t) zOS_AR0;
#endif
        bra     clcprmp         ; break;

clcchr5
        movf    char_io,w       ;
        xorlw   ’^’             ;
        btfss   STATUS,Z        ;
        bra     clcchr6         ; case ’^’: // 8-bit by 8-bit exponentiation
#ifdef zos_mac
        movlw   0x01            ;  // invoker of macro must implement zos_mac():
        clrf    zOS_AR1         ;  //  input arg zOS_AR1:zOS_AR0 (accumulator)
        movf    accumul,f       ;  //                    zOS_AR2 (factor 1)
        btfsc   STATUS,Z        ;  //                    zOS_AR3 (factor 2)
        bra     clcexp1         ;  //  output arg zOS_AR1:zOS_AR0 (product)
clcexp0
        clrf    zOS_AR0         ;  zOS_AR1 = 0;
        clrf    zOS_AR1         ;  for (uint8_t w = 1; accumul > 0; accumul--) {
        movwf   zOS_AR2         ;   zOS_AR0 = (uint16_t) 0;
        movf    destreg,w       ;   zOS_AR2 = w;
        movwf   zOS_AR3         ;   zOS_AR3 = destreg & 0x00ff;
        zOS_LOC FSR0,zOS_JOB,char_io
        pagesel zos_mac
        call    zos_mac         ;   fsr0 = &char_io; // temp register (as INDF0)
        movf    zOS_AR0,w       ;   zos_mac(&zOS_AR0 /* += */,
        decfsz  accumul,f       ;           &zOS_AR2 /* * */, &zOS_AR3, fsr0);
        bra     clcexp0         ;   w = zOS_AR0;
clcexp1
        movwf   destreg         ;  }
        clrf    1+destreg       ;  destreg = ((uint16_t) zOS_AR1) << 8) | w;
#endif
        bra     clcprmp         ; break;

clcchr6
        movf    char_io,w       ;
        xorlw   ’!’             ;
        btfss   STATUS,Z        ;
        bra     clcchr7         ; case ’!’: // 3-bit factorial
#ifdef zos_mac
        movlw   0x01            ;  // invoker of macro must implement zos_mac():
        clrf    zOS_AR1         ;  //  input arg zOS_AR1:zOS_AR0 (accumulator)
        movf    accumul,f       ;  //                    zOS_AR2 (factor 1)
        btfsc   STATUS,Z        ;  //                    zOS_AR3 (factor 2)
        bra     clcexp1         ;  //  output arg zOS_AR1:zOS_AR0 (product)
        decfsz  accumul,f       ;
```

```
        bra     clcexp1         ;
clcfac0
        clrf    zOS_AR0         ;  zOS_AR1 = 0;
        clrf    zOS_AR1         ;  for (uint8_t w = 1; accumul-- > 1; accumul--) {
        movwf   zOS_AR2         ;   zOS_AR0 = (uint16_t) 0;
        movf    destreg,w       ;   zOS_AR2 = w;
        decf    destreg,f       ;   zOS_AR3 = destreg-- & 0x00ff;
        movwf   zOS_AR3         ;   fsr0 = &char_io; // temp register (as INDF0)
        zOS_LOC FSR0,zOS_JOB,char_io
        pagesel zos_mac
        call    zos_mac         ;   zos_mac(&zOS_AR0 /* += */,
        movf    zOS_AR0,w       ;           &zOS_AR2 /* * */, &zOS_AR3, fsr0);
        decfsz  accumul,f       ;   w = zOS_AR0;
        bra     clcexp0         ;  }
clcfac1
        movwf   destreg         ;  destreg = ((uint16_t) zOS_AR1) << 8) | w;
        clrf    1+destreg       ;  // 1 <= destreg <= 720
#endif
        bra     clcprmp         ; break;
clcchr7
        movf    accumul,w       ; default: zOS_AR1 = accumul; if (isr) goto isr;
        movwf   zOS_AR1         ; }// caller may use zOS_AR1 or accumuh:accumul
        pagesel isr             ;
        if(isr)
         goto   isr             ; zOS_RFI();
        else
         zOS_RFI
        endif

clcprmp
        movlw   ’\r’            ;
        pagesel monbufs
        call    monbufs         ;
        movlw   ’\n’            ;
        pagesel monbufs
        call    monbufs         ;clcprmp:
        movf    1+destreg,w     ; moncrlf(zos_job, p0);
        movwf   accumuh         ; accumuh = destreg>>8; monhex(zos_job, p0);
        pagesel monhex
        call    monhex          ; accumuh = destreg & 0xff; monlsb(zos_job, p0);
        movf    destreg,w       ; moncrlf(zos_job, p0);
        movwf   accumuh         ;clclast:
        pagesel monlsb
        call    monlsb          ; zOS_ACC(&accumul,&numbase); zOS_RFI();
        movlw   ’\r’            ;
        pagesel monbufs
        call    monbufs         ;
        movlw   ’\n’            ;
        pagesel monbufs
        call    monbufs         ; char_io = 0;
        zOS_ACC accumul,numbase
clclast
        clrf    char_io         ;} // zOS_CLC()
        zOS_RFI
endclc
        zOS_MAN p,ra,rt,h,pi,clcisr
        endm


zOS_T63 macro
        local   chrtran
        addlw   0-0x1f          ;#define zOS_T63(w) \
        btfsc   WREG,7          ;\
        clrw                    ;\
        andlw   0x3f            ;\
        pagesel chrtran         ;\
        call    chrtran         ; w = table[(w >= ’ ’) ? (w & 0x3f) : 0];\
        bra     $+0x42          ; /*must be followed by 63-char retlw string:*/\
chrtran
```

```
        brw                     ; static char table[64] = "\0\
        retlw   0               ;/* zOS_T63() */
        endm
```