Supplement: Matlab code for calculating potential spicity.

sw\_psi.m (based on UNESCO EOS-80):

function spi = sw\_pspi(s0,t0,p0,pr)

% s0: salinity, in the range of [10:40] (psu)

% t0: in-situ temperature, in the range of [-2:40] (^oC)

% p : in-situe pressure (db)

% pr: reference pressure (db), must be one of the following intergers:

% 0, 500, 1000, 2000, 3000, 4000, 5000 (db)

% Example: sw\_pspi(36.0,15.000,0,0)=0.4883 (kg/m^3);

% Author: Rui Xin Huang

% Date: Sep. 12, 2018

b0=[-0.0153300841099570, 0.0231895932005821, -0.0381875052767683,...

 0.1592557110880523, 0.0117243711053217, -0.0718653451824515,...

 0.5318847880659945, 0.0779892741936997, 0.0035239803459740,...

 0.1201750871344241, 1.3042441933369422, 0.3565702465910514,...

 0.0369715779948543, 0.0000800204884482, -1.0632874635722567,...

 1.5631387572647097, 0.0089892799984272, -0.2183716842447750,...

 -0.0281177888020686, -0.0013045569983979, 4.2176434025093101,...

 4.6913470773126011, 2.5592069121111529, 2.3758221464778653,...

 0.4911933538650005, 0.0298538964966979, 0.0016225085963151,...

 -9.3974242130945633, -4.3905044464512457, 1.5070608294125327,...

 -5.5501502356153471, -3.2062353090836222, -0.3928957921270134,...

 -0.0316989049793372, -0.0017416060933394, 13.2462318893758850,...

 19.6295852797249890, -3.3083205188612457, 5.8386677663053890,...

 7.1937016736312600, 2.1546104550028686, 0.0996470664237621,...

 0.0297021530229794, 0.0015361697390362, -9.7346615514331560,...

 -18.8955171635407950, 5.9733854291477746, 0.3783949644377257,...

 -5.8999876151527202, -3.8573920011834675, -0.6665314984311493,...

 0.0358514745101728, -0.0172904156245161, -0.0006456633104225,...

 3.5001447334308131, 13.0257424609277040, 1.0828755101246170,...

 -0.4450532843399354, 0.1809352509285085, 2.2432052797602897,...

 0.6072423205728305, 0.1123186585718297, -0.0197441171553408,...

 0.0047837338370827, 0.0001058068718505];

 b500=[-0.0170897680043427, 0.0393980201464236, -0.0322181007256357,...

 0.2465779702237007, 0.0196951777573940, -0.0340256035131898,...

 0.7548983242984324, 0.1209959405758238, 0.0060760492664506,...

 0.1186565896130432, 1.6463999712553303, 0.4709774375654697,...

 0.0526748524725206, -0.0000370598201769, -0.4596327796294014,...

 2.0379216819038586, 0.1518525728129951, -0.1916555843387189,...

 -0.0369618601778135, -0.0017944795273568, 2.3546809284893735,...

 3.8759296980147950, 2.9104105624114198, 2.4389794658940893,...

 0.5032009345452483, 0.0469302584258510, 0.0018343354907595,...

 -4.7626772767589456, -0.4809814106641089, 0.8409503724739962,...

 -5.3772643134946145, -3.2051475990896465, -0.4169693314118330,...

 -0.0603545798915546, -0.0016126506399402, 7.0904800397810774,...

 10.4358091142353400, -1.7098551480956530, 5.5920785736934606,...

 7.0190653686553324, 2.1137399496512042, 0.1209557483696642,...

 0.0567464281690320, 0.0014241231794942, -5.1119719051196704,...

 -8.9361269179306273, 4.4208404799781595, 0.3638415547771647,...

 -5.5795643245841617, -3.8205371549694354, -0.6235916487154449,...

 0.0210332177260958, -0.0298501212939195, -0.0005407915757731,...

 1.9713169360784892, 7.2023488988739333, 0.8751781695325449,...

 -0.5576302851748650, 0.3120792130214046, 2.0030004797305798,...

 0.6781634724458714, 0.0886131123332279, -0.0125258948868738,...

 0.0071733806912177, 0.0000764047696809];

b1000=[-0.0152796296361631, 0.0634840156952664, -0.0134499436502916,...

 0.3629264124823363, 0.0313022734302577, 0.0242237811432335,...

 1.0187474687702429, 0.1773719831098710, 0.0099091613026001,...

 0.1691235290636256, 1.9985805250978699, 0.5994233243005691,...

 0.0730579249356983, -0.0002047748310705, -0.0636584894370516,...

 2.3904585542604715, 0.3293130608600984, -0.1463442323972841,...

 -0.0465947637412494, -0.0027639826215597, 1.3292646659965168,...

 3.4267820352004521, 3.1062630355985164, 2.4107785782524207,...

 0.4993011197582294, 0.0643809383043240, 0.0028493345644662,...

 -2.1625538261755337, 1.4239302709720265, 0.3955622178527191,...

 -5.0171900524765860, -3.0742800375630850, -0.4399256184470501,...

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 5.3206703060792782, -0.6919221499024630, 5.2429080677277975,...

 6.5662197491194361, 2.0008960637703823, 0.1506262108518998,...

 0.0841439315207993, 0.0023309531864595, -2.5435478726615646,...

 -3.6853080297903333, 3.3399207041986787, 0.2340886383835905,...

 -5.0938462922172238, -3.6222070014123475, -0.5783801858129577,...

 0.0026567274608136, -0.0420964556511797, -0.0009336622148579,...

 1.0790284792918607, 3.8647869734498403, 0.5916969122340452,...

 -0.5168326465476724, 0.3366904017124426, 1.7730130282701744,...

 0.6905225982068610, 0.0769487350865983, -0.0057920650733116,...

 0.0094835221955953, 0.0001497191916782];

b2000=[0.0091417081396188, 0.1452955939511846, 0.0770118742407799,...

 0.6969572944033762, 0.0689590943556884, 0.2052671884421505,...

 1.6493343937052261, 0.3325382924550207, 0.0232279929569938,...

 0.3549428710544382, 2.6588535884495310, 0.8793293294099017,...

 0.1312861610175250, -0.0013913144468472, 0.3773746884403297,...

 2.8097805261579611, 0.7468352594494717, 0.0054925826410827,...

 -0.0734726572370883, -0.0054221218460469, 0.4925650505594068,...

 2.8949682015867260, 3.0445208914586348, 2.0745903040460929,...

 0.4117184896548931, 0.1122163176449262, 0.0057235041280763,...

 0.0013733957773534, 2.3823825552243458, -0.0525449092789445,...

 -3.8209684066062266, -2.4373733447193815, -0.4279490589511414,...

 -0.1729231959436325, -0.0054925819960008, 0.7046929492037855,...

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 5.0169760698229204, 1.5324604234032757, 0.1856791756573022,...

 0.1624044356549286, 0.0054301380642790, -0.3968294706581253,...

 0.3054017331910741, 1.9252531003555615, -0.0877226648348107,...

 -3.8257373677218180, -2.8440753233870275, -0.4352813145427408,...

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 -0.3034474267877694, 0.2563735218432175, 1.3041416229218938,...

 0.5919917285182480, 0.0650718724250279, 0.0034357714409026,...

 0.0166075264216577, 0.0004196791282721];

b3000=[0.0829921187927801, 0.2940570154114436, 0.2578885740581015,...

 1.1894395862680167, 0.1314295760613576, 0.4611757366676674,...

 2.3800776316930210, 0.5404506032664056, 0.0479418747927825,...

 0.5717539343370265, 3.1802290008980481, 1.1532217395761863,...

 0.2188291802224379, -0.0050117634983723, 0.5622738524648018,...

 2.9410140059929866, 1.1894880958689704, 0.2288565966419371,...

 -0.1212819030176276, -0.0100180336081773, 0.2901642712632136,...

 2.4088812196170579, 2.4138569910554297, 1.3292134446557626,...

 0.1974376712015098, 0.1877955201148325, 0.0120583403113963,...

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 -0.2973971834277590, -0.0127984759544481, -0.0898243185029628,...

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 2.7661066543570692, 0.6444098115446179, 0.1834064684876638,...

 0.2771091355143084, 0.0128028706653020, 0.1443158973235865,...

 0.9521965669200102, 0.9250791797991642, -0.3374875218359553,...

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 0.3694396473607853, 0.0318541718233533, 0.0132853113210982,...

 0.0266429967409608, 0.0010890850132457];

b4000=[0.2370002318651782, 0.5381589430593935, 0.5387332509583285,...

 1.8367328878855200, 0.2190076533245268, 0.7527436638782535,...

 3.1045464711421662, 0.7710129605215795, 0.0894202672607398,...

 0.7482044198379578, 3.4607088826442109, 1.3769400814627872,...

 0.3395747291647098, -0.0144359439344768, 0.5845814889160134,...

 2.7749098715576741, 1.4552709439955931, 0.4077830363517979,...

 -0.2056660897277933, -0.0174856389508560, 0.2872973066717510,...

 1.8522445541076458, 1.5986862566228270, 0.6203915955318132,...

 0.0190869991558108, 0.2957002215280178, 0.0264031095282703,...

 0.3015680656488169, 1.0062127553156917, -0.0100938790000904,...

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 -0.0847613325636572, 0.4843116193937502, 1.4496276135138042,...

 0.9628824750866357, -0.1306978534604700, 0.2138998039833219,...

 0.4085072429345181, 0.0302894687290413, 0.1128438575883403,...

 0.4713019340266491, 0.2885042964220720, -0.3231744990167486,...

 -1.2269978401137021, -0.6365606225666358, 0.1550364472972289,...

 -0.0836582108559878, -0.1851024503722259, -0.0140010791448744,...

 -0.0197718505975002, -0.1262118069000105, -0.1611870955479239,...

 -0.0559238641448582, 0.0930198972851187, 0.4090199622334122,...

 0.1744755449159634, -0.0099361780755030, 0.0262336469312906,...

 0.0369115755434412, 0.0027324983705219];

b5000=[0.5137108656598407, 0.9272118361918661, 0.9237574106913609,...

 2.6488771120490111, 0.3203064640437509, 1.0396844175235527,...

 3.7457447497414229, 0.9682339828436751, 0.1598527167686548,...

 0.8449949476579887, 3.4769854850202657, 1.4949967184869493,...

 0.5045073446974311, -0.0450435727340453, 0.5229812333095537,...

 2.3513000303991149, 1.3920139847466240, 0.4511115607461256,...

 -0.3670587255997733, -0.0134242433773768, 0.2558677222788089,...

 1.2471581703858128, 0.9523495152661099, 0.3074440965302491,...

 0.0114939329849617, 0.4812484081251261, 0.0324515116106133,...

 0.1114887314469300, 0.4173385012799878, 0.0228174936852482,...

 -0.0826327488562640, 0.0403434422478097, -0.3518776929784379,...

 -0.6675432305132891, -0.0432864238607635, 0.0016930899000822,...

 0.0437619774486480, 0.2221900544906569, 0.6442939140253805,...

 0.1692791407743907, -0.3308066513013085, 0.3363847718265349,...

 0.5811985675973489, 0.0456362418587216, 0.0207294612505628,...

 0.0781348649106775, 0.0398163605209567, -0.1604848102578897,...

 -0.5895951930360275, -0.1754460644090687, 0.2209529745724252,...

 -0.1407328439846876, -0.2569291682263102, -0.0218758921025089,...

 -0.0047991381246822, -0.0292812892190461, -0.0342521306783400,...

 -0.0216511237754927, 0.0494919851708555, 0.1980313253516407,...

 0.0745912573742710, -0.0211661411562899, 0.0380984000054902,...

 0.0500761805296033, 0.0043823530255001];

IC=0;

if (pr==0), b=b0; spi0=3.446776934; IC=1; end

if (pr==500), b=b500; spi0=1.705024348; IC=1; end

if (pr==1000), b=b1000; spi0=1.367927975; IC=1; end

if (pr==2000), b=b2000; spi0=1.513725542; IC=1; end

if (pr==3000), b=b3000; spi0=1.916367274; IC=1; end

if (pr==4000), b=b4000; spi0=2.428307519; IC=1; end

if (pr==5000), b=b5000; spi0=3.091480510; IC=1; end

if (IC==0), error('Reference pressure incorrect '), end

if (s0<10 | s0>40), error('Salinity out of bound'), end

if (t0<-2 | t0>40), error('Temperature out of bound'), end

t00=sw\_ptmp(s0,t0,p0,pr);

s=(s0-10)/30;

t=(t00+2)/42;

 s2=s.\*s;s3=s2.\*s;s4=s3.\*s;s5=s4.\*s;s6=s5.\*s;s7=s6.\*s;s8=s7.\*s;s9=s8.\*s;s10=s9.\*s;

 t2=t.\*t;t3=t2.\*t;t4=t3.\*t;t5=t4.\*t;t6=t5.\*t;t7=t6.\*t;t8=t7.\*t;t9=t8.\*t;t10=t9.\*t;

sp=b(1).\*s+b(2).\*t+b(3).\*s2+b(4).\*s.\*t+b(5).\*t2;

sp=sp+b(6).\*s3+b(7).\*s2.\*t+b(8).\*s.\*t2+b(9).\*t3;

sp=sp+b(10).\*s4+b(11).\*s3.\*t+b(12).\*s2.\*t2+b(13).\*s.\*t3+b(14).\*t4;

sp=sp+b(15).\*s5+b(16).\*s4.\*t+b(17).\*s3.\*t2+b(18).\*s2.\*t3+b(19).\*s.\*t4+b(20).\*t5;

sp=sp+b(21).\*s6+b(22).\*s5.\*t+b(23).\*s4.\*t2+...

 b(24).\*s3.\*t3+b(25).\*s2.\*t4+b(26).\*s.\*t5+b(27).\*t6;

sp=sp+b(28).\*s7+b(29).\*s6.\*t+b(30).\*s5.\*t2+...

 b(31).\*s4.\*t3+b(32).\*s3.\*t4+b(33).\*s2.\*t5+b(34).\*s.\*t6+b(35).\*t7;

sp=sp+b(36).\*s8+b(37).\*s7.\*t+b(38).\*s6.\*t2+...

 b(39).\*s5.\*t3+b(40).\*s4.\*t4+b(41).\*s3.\*t5+b(42).\*s2.\*t6+b(43).\*s.\*t7+b(44).\*t8;

sp=sp+b(45).\*s9+b(46).\*s8.\*t+b(47).\*s7.\*t2+b(48).\*s6.\*t3+b(49).\*s5.\*t4+...

 b(50).\*s4.\*t5+b(51).\*s3.\*t6+b(52).\*s2.\*t7+b(53).\*s.\*t8+b(54).\*t9;

sp=sp+b(55).\*s10+b(56).\*s9.\*t+b(57).\*s8.\*t2+b(58).\*s7.\*t3+b(59).\*s6.\*t4+...

 b(60).\*s5.\*t5+b(61).\*s4.\*t6+b(62).\*s3.\*t7+b(63).\*s2.\*t8+b(64).\*s.\*t9+b(65).\*t10;

spi = sp-spi0;

return

gsw\_pspi.m (based on TEOS\_10):

function spi = gsw\_pspi(SA,CT,pr)

% Potential spicity based on TEOS\_10

% SA: Absolute salinity, in the range of [10:40] (g/kg).

% CT: Conservative temperature, in the range of [-2:40] (^oC)

% pr: Reference pressure (db), must be one of the following intergers:

% 0, 500, 1000, 2000, 3000, 4000, 5000 (db)

% Example: gsw\_pspi(37.0,15.000,0)=1.4651 (kg/m^3);

% Author: Rui Xin Huang

% Date: Sep. 12, 2018

b0=[ -0.0171500663640825, 0.0278126882615466, -0.0377076764387318,...

 0.1766949182578261, 0.0123660614159258, -0.0786187616470358,...

 0.5654881379784148, 0.0819229370724436, 0.0016117501650810,...

 0.3399789798792979, 1.1510501460340983, 0.2269712954132772,...

 0.0034027893357210, -0.0006433028065820, -2.4325213233770255,...

 1.7986328638555464, 1.0630530543043479, 0.1315650249668150,...

 0.0123872288821259, -0.0001162370520279, 9.4412720110135577,...

 5.2288742719111454, -2.0527960573002453, -0.5351256154930265,...

 -0.2538791804144606, -0.0209657872828231, 0.0013762624523221,...

 -20.8951737319684660,-12.0500968552060320, 11.3282734921878920,...

 2.6701702134225695, 0.5047618576788786, 0.4114298464948320,...

 0.0054621969229276, -0.0011544718126917, 27.9102532787346750,...

 38.3524589057019940,-15.7880978505589340, -5.2014100596868458,...

 -1.6444622029678000, -0.1940601182950926, -0.4451390714439674,...

 0.0318285987830426, 0.0002610786604573,-19.9067865528804480,...

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 0.6852984398082621, 1.0864034614467579, -0.1443123955763263,...

 0.3116506259221469, -0.0374707683235198, 0.0003602355280168,...

 6.4526166843817130, 23.5603943927535690, -0.1544936317675803,...

 -2.0654213392823562, -2.3484390479461044, 1.2077832413374705,...

 -0.7375977238163819, 0.2037145511491106, -0.1037032514606002,...

 0.0135916525382002, -0.0002031986199229];

b500=[-0.0182391987673546, 0.0460367847358395, -0.0286182192704045,...

 0.2660847104116245, 0.0206673399387414, -0.0298007013259687,...

 0.7770094369066807, 0.1251051429700339, 0.0028476405867851,...

 0.2732186418523409, 1.4034080039262458, 0.3119256718363070,...

 0.0090495634322624, -0.0019995910040957, -1.4285067908881954,...

 2.4382974814612299, 1.3470633754508330, 0.2346478272358809,...

 -0.0024859020619016, 0.0035261905625462, 6.0718169574685028,...

 3.2771054529421333, -2.1234813624271149, -0.8676978602413056,...

 -0.4525801376304305, 0.0302373171446931, -0.0066258727117268,...

 -13.0149881442439100, -4.8980524182905798, 11.2404267704152550,...

 3.6705166907148050, 0.9927811680516538, 0.6597340841418953,...

 -0.0890970730587889, 0.0113440640814710, 17.6138287954952340,...

 23.1042897942189110,-14.0150247189858150, -6.7035271369546621,...

 -2.3493946449434784, -0.6652221178039853, -0.6098849102442132,...

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 4.1599595530865345, 15.0628535938609790, 0.2359014673160792,...

 -2.5129596228128590, -2.3628293562073948, 0.7771260421750895,...

 -0.6377943796237359, 0.0934531200410584, -0.1017862844693545,...

 0.0249840213426481, -0.0014670482649370];

b1000=[-0.0150169592493302, 0.0713618996357972, -0.0063107595207969,...

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 1.0068345758287314, 0.1795605422124667, 0.0046453697978788,...

 0.2660759416082976, 1.6500909237389616, 0.4159308583779059,...

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b2000=[0.0118725171307861, 0.1477131706258137, 0.0834813257093114,...

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b3000=[0.0785827635885904, 0.2695551278473896, 0.2382238071652584,...

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 2.0015284460583023, 0.5108760266785902, 0.0229668651712469,...

 0.4710255345980255, 2.4507597986923821, 0.9595824732835634,...

 0.0912687197370605, -0.0240034498070701, 0.4836291827068407,...

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 -0.9999286994881966, 0.1998449905375284, -0.0808028164411438,...

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 0.4487343447885416, 1.4512313465086606, -0.3360118727756923,...

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b4000=[0.2025292728310694, 0.4535805178193371, 0.4619529228253870,...

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 2.5243360744326573, 0.7412658851522664, 0.0423704843675533,...

 0.6140978851799495, 2.7862073290509763, 1.2998138955622245,...

 0.1641947081515549, -0.0449927428457055, 0.6279650013273181,...

 3.1207312076604552, 2.2407723123627745, 0.5974101842363415,...

 -0.1825641579944942, 0.0855909178828273, 0.1844413155784955,...

 0.5223664533265552, -0.3519721696481735, -0.9008619702435032,...

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 0.3384673101491614, 3.6348681214896899, 5.3562413927987294,...

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b5000=[0.3820086307374105, 0.6807613639619611, 0.7180920672500770,...

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 0.7221376372236928, 2.9668170274813592, 1.6548086286881780,...

 0.2275290990451938, -0.0590145072807306, 0.6090090598891532,...

 2.7374627218706937, 2.0801130054946806, 0.4628016849985791,...

 -0.2343271318404560, 0.0994940210577284, 0.1681432252906211,...

 0.8912020824082482, 0.5479975819471963, -0.1748191031230424,...

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 1.8627674152533542, 0.6905272676347027, 0.4954414141356421,...

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 0.7971207608475803, 2.0059253087100357, 2.7952067050958371,...

 1.4339645049242822, 0.7106855454689587, 0.5809337260602813,...

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 -0.2288471328224155, -0.1616192788490930, -0.0193525655071953,...

 0.0253750796226042, -0.0103837266541834];

IC=0;

if (pr==0), b=b0; spi0=3.494486289; IC=1; end

if (pr== 500), b=b500; spi0=1.720013647; IC=1; end

if (pr==1000), b=b1000; spi0=1.362343815; IC=1; end

if (pr==2000), b=b2000; spi0=1.451450857; IC=1; end

if (pr==3000), b=b3000; spi0=1.765290149; IC=1; end

if (pr==4000), b=b4000; spi0=2.180009299; IC=1; end

if (pr==5000), b=b5000; spi0=2.628557566; IC=1; end

if (IC==0), error('Reference pressure incorrect '), end

if (SA<10 | SA>40), error('Salinity out of bound'), end

if (CT<-2 | CT>40), error('Temperature out of bound'), end

s=(SA-10)/30;

t=(CT+2)/42;

 s2=s.\*s;s3=s2.\*s;s4=s3.\*s;s5=s4.\*s;s6=s5.\*s;s7=s6.\*s;s8=s7.\*s;s9=s8.\*s;s10=s9.\*s;

 t2=t.\*t;t3=t2.\*t;t4=t3.\*t;t5=t4.\*t;t6=t5.\*t;t7=t6.\*t;t8=t7.\*t;t9=t8.\*t;t10=t9.\*t;

sp=b(1).\*s+b(2).\*t+b(3).\*s2+b(4).\*s.\*t+b(5).\*t2;

sp=sp+b(6).\*s3+b(7).\*s2.\*t+b(8).\*s.\*t2+b(9).\*t3;

sp=sp+b(10).\*s4+b(11).\*s3.\*t+b(12).\*s2.\*t2+b(13).\*s.\*t3+b(14).\*t4;

sp=sp+b(15).\*s5+b(16).\*s4.\*t+b(17).\*s3.\*t2+b(18).\*s2.\*t3+b(19).\*s.\*t4+b(20).\*t5;

sp=sp+b(21).\*s6+b(22).\*s5.\*t+b(23).\*s4.\*t2+...

 b(24).\*s3.\*t3+b(25).\*s2.\*t4+b(26).\*s.\*t5+b(27).\*t6;

sp=sp+b(28).\*s7+b(29).\*s6.\*t+b(30).\*s5.\*t2+...

 b(31).\*s4.\*t3+b(32).\*s3.\*t4+b(33).\*s2.\*t5+b(34).\*s.\*t6+b(35).\*t7;

sp=sp+b(36).\*s8+b(37).\*s7.\*t+b(38).\*s6.\*t2+...

 b(39).\*s5.\*t3+b(40).\*s4.\*t4+b(41).\*s3.\*t5+b(42).\*s2.\*t6+b(43).\*s.\*t7+b(44).\*t8;

sp=sp+b(45).\*s9+b(46).\*s8.\*t+b(47).\*s7.\*t2+b(48).\*s6.\*t3+b(49).\*s5.\*t4+...

 b(50).\*s4.\*t5+b(51).\*s3.\*t6+b(52).\*s2.\*t7+b(53).\*s.\*t8+b(54).\*t9;

sp=sp+b(55).\*s10+b(56).\*s9.\*t+b(57).\*s8.\*t2+b(58).\*s7.\*t3+b(59).\*s6.\*t4+...

 b(60).\*s5.\*t5+b(61).\*s4.\*t6+b(62).\*s3.\*t7+b(63).\*s2.\*t8+b(64).\*s.\*t9+b(65).\*t10;

spi = sp-spi0;

return