Adaptive Fault-Resilient Robotic Pick-and-Place Cell

DIGITAL OUTPUTS

O:2/0 = MOTOR 1 OUTPUT (EXTEND ARM)
O:2/1 = MOTOR 2 OUTPUT (GRIPPER)
O:2/2 = MOTOR 3 OUTPUT (RETRACT ARM)
O:2/3 = FAULT LIGHT OUTPUT
O: 2/4 = CYCLE COMPLETE OUTPUT
O: 2/5 = HEAD MOTOR
O:2/6 = BRAIN LED OUTPUT

DIGITAL INPUTS

I:1/0 = START BUTTON INPUT
I:1/1 = RESET BUTTON INPUT
I:1/3 = E-STOP INPUT
I:1/4 = LOOP MODE BUTTON INPUT
I:1/5 = PART SENSOR INPUT
I:1/2 = ARM EXTEND SENSOR INPUT
I:1/6 = GRIPPER SENSOR INPUT
I:1/7 = ARM RETRACT SENSOR INPUT
I:4/0 = SCANNER SENSOR INPUT
I:4/1 = AUTO SHUTDOWN BUTTON INPUT
I:4/2 = BRAIN OVERRIDE INPUT

ANALOG INPUTS

I:3/0 = PRESSURE SENSOR INPUT

BINARY

B3:0/0 = START BUTTON
B3:0/1 = ATTEMPT START
B3:0/2 = ONS
B3:0/3 = MOTOR 1 (ARM EXTEND)
B3:0/4 = MOTOR 2 (RETRACT)
B3:0/5 = GRIPPER MOTOR

B3:0/6 = CYCLE COMPLETE
B3:0/7 = E-STOP
B3:0/8 = E-STOP ACTIVE TRIGGER
B3:0/9 = E-STOP ACTIVE
B3:0/10 = E-STOP DEACTIVATE
B3:0/11 = E STOP OFF SWITCH
B3:0/12 = LOOP MODE BUTTON
B3:0/13 = LOOP MODE TRIGGER
B3:0/14 = LOOP MODE OFF
B3:0/15 = LOOP MODE OFF BUTTON
B3:1/0 = SYSTEM RESET
B3:1/1 = LOOP MODE ONS
B3:1/2 = CYCLE COMPLETE ONS
B3:1/3 = E-STOP ONS
B3:1/4 = E-STOP OFF ONS
B3:1/5 = SYSTEM RESET ONS
B3:1/6 = LOOP MODE ACTIVE
B3:1/7 = PART DETECTED
B3:1/8 = START OK
B3:1/9 = PART SENSOR
B3:1/10 = FAULT LIGHT TRIGGER
B3:1/11 = FAULT LIGHT
B3:1/12 = UNIVERSAL STATE RESET
B3:1/13 = FAULT RESET
B3:2/0 = STATE 0 (IDLE)
B3:2/1 = STATE 1 (ARM EXTEND)
B3:2/2 = STATE 2 (GRIPPER CLOSE)
B3:2/3 = STATE 3 (ARM RETRACT)
B3:2/4 = STATE 4 (CYCLE COMPLETE)
B3:3/0 = ARM EXTENDED FULLY
B3:3/1 = GRIPPER CLOSED FULLY
B3:3/2 = ARM RETRACTED FULLY
B3:3/3 = ARM EXTEND SENSOR
B3:3/4 = GRIPPER SENSOR
B3:3/5 = ARM RETRACT SENSOR
B3:4/0 = FAULT MOTOR 1 WATCHDOG
B3:4/1 = FAULT GRIPPER WATCHDOG
B3:4/2 = FAULT MOTOR 2 WATCHDOG
B3:4/3 = ARM NOT EXTENDED
B3:4/4 = GRIPPER NOT CLOSED
B3:4/5 = ARM NOT RETRACTED
B3:5/0 = LOCKOUT MOTOR 1
B3:5/1 = LOCKOUT GRIPPER
B3:5/2 = LOCKOUT MOTOR 2

B3:5/3 = LOCKOUT ARM POSITION
B3:5/4 = LOCKOUT GRIPPER POSITION
B3:5/5 = LOCKOUT ARM RETRACT POSITION
B3:6/0 = HEAD MOTOR ACTIVE
B3:6/1 = TARGET FOUND
B3:6/2 = SCAN TIMEOUT
B3:6/3 = LOCKOUT HEAD
B3:6/4 = SCANNER SENSOR
B3:6/5 = SCAN RETRIGGER ONS
B3:6/6 = SCAN ACTIVE
B3:6/7 = HEAD STATE 0 (IDLE)
B3:6/8 = HEAD STATE 1 (SCANNING)
B3:6/9 = HEAD STATE 2 (TARGET LOCK)
B3:6/10 = HEAD RESET
B3:6/11 = NO TARGET
B3:7/0 = BRAIN MODE ACTIVE
B3:7/1 = GRIPPER TIMEOUT EXTEND
B3:7/2 = RETRY ARM EXTEND
B3:7/3 = AUTO SHUTDOWN ENABLED
B3:7/4 = TOTAL FAULTS > 5
B3:7/5 = BRAIN LED
B3:7/6 = BRAIN OVERRIDE
B3:7/7 = SYSTEM LOCK
B3:7/8 = ARM EXTEND RETRY ONS
B3:7/9 = RETRY ARM EXTEND LOCK
B3:7/10 = END ARM EXTEND RETRY LOCK
B3:7/11 = MOTOR 1 TIMEOUT EXTEND
B3:7/12 = RETRY GRIPPER CLOSE
B3:7/13 = RETRY GRIPPER CLOSE ONS
B3:7/14 = RETRY GRIPPER CLOSE LOCK
B3:7/15 = END RETRY GRIPPER CLOSE LOCK
B3:8/0 = MOTOR 2 TIMEOUT EXTEND
B3:8/1 = RETRY ARM RETRACT
B3:8/2 = RETRY ARM RETRACT ONS
B3:8/3 = RETRY ARM RETRACT LOCK
B3:8/4 = END RETRY ARM RETRACT LOCK
B3:8/5 = AUTO SHUTDOWN BUTTON
B3:8/6 = SYSTEM SHUTDOWN

FLOATS

F8:0 = PRESSURE (PSI)

TIMERS/COUNTERS

T4:0 = MOTOR 1 TIMER
T4:1 = GRIPPER TIMER
T4:2 = MOTOR 2 TIMER
T4:3 = MOTOR 1 WATCHDOG
T4:4 = GRIPPER WATCHDOG
T4:5 = MOTOR 2 WATCHDOG
T4:6 = HEAD SCAN TIMER
T4:7 = HEAD SCANNING WATCHDOG
C5:0 = MOTOR 1 TIMEOUTS
C5:1 = GRIPPER TIMEOUTS
C5:2 = MOTOR 2 TIMEOUTS
C5:3 = ARM DID NOT EXTEND
C5:4 = GRIPPER DID NOT CLOSE
C5:5 = ARM DID NOT RETRACT
C5:6 = TARGET NOT FOUND FAULTS
C5:8 = CYCLES COMPLETED COUNTER
C5:9 = TOTAL FAULTS

MAIN CODE

SOR JSR 3 EOR SOR JSR 4 EOR SOR JSR 5 EOR SOR JSR 6 EOR SOR JSR 7 EOR SOR JSR 8 EOR SOR JSR 9 EOR SOR JSR 13 EOR SOR BST XIC B3:0/0 NXB XIC B3:1/6 BND ONS B3:0/2 OTE B3:0/1 EOR SOR XIC B3:0/1 LEQ F8:0 4.5 XIO B3:0/9 XIO B3:8/6 OTE B3:1/8 EOR SOR BST BST XIC B3:2/1 NXB XIC B3:7/2 BND NXB XIC B3:0/3 XIO T4:0/DN LEQ F8:0 4.5 BND XIO B3:0/9 XIO B3:5/0 XIO B3:5/3 XIO B3:8/6 BST TON T4:0 1.0 3 0 NXB OTE B3:0/3 BND EOR SOR BST BST XIC B3:2/2 NXB XIC B3:7/12 BND NXB XIC B3:0/5 XIO T4:1/DN LEQ F8:0 4.5 BND XIO B3:5/4 XIO B3:5/1 XIO B3:0/9 XIO B3:8/6 BST TON T4:1 1.0 1 0 NXB OTE B3:0/5 BND EOR SOR BST BST XIC B3:2/3 NXB XIC B3:8/1 BND NXB XIC B3:0/4 XIO T4:2/DN LEQ F8:0 4.5 BND XIO B3:5/2 XIO B3:5/5 XIO B3:0/9 XIO B3:8/6 BST TON T4:2 1.0 3 0 NXB OTE B3:0/4 BND EOR SOR XIC B3:2/4 ONS B3:1/2 OTE B3:0/6 EOR SOR END EOR

SAFETY CODE

SOR XIC B3:0/7 ONS B3:1/3 OTE B3:0/8 EOR SOR BST XIC B3:0/8 NXB XIC B3:0/9 XIO B3:0/10 BND OTE B3:0/9 EOR SOR XIC B3:0/11 ONS B3:1/4 OTE B3:0/10 EOR SOR GRT F8:0 4.5 OTE B3:1/10 EOR SOR XIC T4:3/DN OTE B3:4/0 EOR SOR XIC T4:4/DN OTE B3:4/1 EOR SOR XIC T4:5/DN OTE B3:4/2 EOR SOR XIO B3:3/0 XIC T4:0/DN OTE B3:4/3 EOR SOR XIO B3:3/1 XIC T4:1/DN OTE B3:4/4 EOR SOR XIO B3:3/2 XIC T4:2/DN OTE B3:4/5 EOR SOR XIC B3:4/0 CTU C5:0 2 0 EOR SOR XIC B3:4/1 CTU C5:1 2 0 EOR SOR XIC B3:4/2 CTU C5:2 2 0 EOR SOR XIC B3:4/3 CTU C5:3 2 0 EOR SOR XIC B3:4/4 CTU C5:4 2 0 EOR SOR XIC B3:4/5 CTU C5:5 2 0 EOR SOR XIC C5:0/DN OTE B3:5/0 EOR SOR

XIC C5:1/DN OTE B3:5/1 EOR SOR XIC C5:2/DN OTE B3:5/2 EOR SOR XIC C5:3/DN OTE B3:5/3 EOR SOR XIC C5:4/DN OTE B3:5/4 EOR SOR XIC C5:5/DN OTE B3:5/5 EOR SOR BST XIC B3:4/0 NXB XIC B3:4/1 NXB XIC B3:4/2 NXB XIC B3:4/3 NXB XIC B3:4/4 NXB XIC B3:4/5 BND CTU C5:9 5 0 EOR SOR XIC C5:9/DN OTE B3:7/4 EOR SOR XIC B3:7/3 XIC B3:7/4 OTE B3:8/6 EOR SOR BST XIC B3:1/10 NXB XIC B3:1/11 XIO B3:1/13 BND OTE B3:1/11 EOR SOR BST XIC B3:1/0 NXB XIC B3:0/6 BND ONS B3:1/5 BST RES T4:0 NXB RES T4:1 NXB RES T4:2 NXB OTE B3:1/13 NXB RES C5:0 NXB RES C5:1 NXB RES C5:2 NXB RES C5:3 NXB RES C5:4 NXB RES C5:5 NXB OTE B3:1/12 NXB OTE B3:6/10 NXB OTE B3:7/10 NXB OTE B3:7/15 NXB OTE B3:8/4 NXB RES C5:9 BND EOR SOR END EOR

MODES CODE

SOR BST XIC B3:0/12 NXB XIC B3:0/13 XIO B3:0/14 BND OTE B3:0/13 EOR SOR XIC B3:0/13 XIC B3:0/6 OTE B3:1/6 EOR SOR XIC B3:0/15 ONS B3:1/1 OTE B3:0/14 EOR SOR END EOR

DIGITAL IO CODE

SOR XIC I:1.0/0 OTE B3:0/0 EOR SOR XIC I:4.0/1 OTE B3:8/5 EOR SOR XIC I:4.0/2 OTE B3:7/6 EOR SOR XIC B3:7/5 OTE O:2.0/6 EOR SOR XIC I:1.0/2 OTE B3:3/3 EOR SOR XIC I:1.0/6 OTE B3:3/4 EOR SOR XIC I:1.0/7 OTE B3:3/5 EOR SOR XIC I:1.0/1 OTE B3:1/0 EOR SOR XIC I:1.0/3 OTE B3:0/7 EOR SOR XIC I:1.0/4 OTE B3:0/12 EOR SOR XIC I:1.0/5 OTE B3:1/9 EOR SOR XIC B3:0/3 OTE O:2.0/0 EOR SOR XIC B3:0/5 OTE O:2.0/1 EOR SOR XIC B3:0/4 OTE O:2.0/2 EOR SOR XIC B3:1/11 OTE O:2.0/3 EOR SOR XIC B3:0/6 OTE O:2.0/4 EOR SOR END EOR

ANALOG IO CODE

SOR BST SCP I:3.0 4000.0 20000.0 0.0 10.0 F8:0 NXB LES I:3.0 4000 MOV 0.0 F8:0 NXB LES I:3.0 20000 MOV 10.0 F8:0 BND EOR SOR END EOR

STATE MACHINE CODE

SOR BST XIO B3:2/1 XIO B3:2/2 XIO B3:2/3 NXB XIC B3:2/4 BND XIO B3:0/9 OTE B3:2/0 EOR SOR BST XIC B3:6/1 NXB XIC B3:2/1 XIO B3:2/2 XIO B3:1/12 BND XIO B3:0/9 LEQ F8:0 4.5 XIO B3:1/11 XIO B3:3/0 XIC B3:1/7 BST OTE B3:2/1 NXB TON T4:3 1.0 5 0 BND EOR SOR BST XIC T4:0/DN XIC B3:3/0 NXB XIC B3:2/2 XIO B3:2/3 XIO B3:1/12 BND XIO B3:0/9 LEQ F8:0 4.5 XIO B3:1/11 XIO B3:3/1 XIC B3:1/7 BST OTE B3:2/2 NXB TON T4:4 1.0 3 0 BND EOR SOR BST XIC T4:1/DN XIC B3:3/1 NXB XIC B3:2/3 XIO B3:2/4 XIO B3:1/12 BND XIO B3:0/9 LEQ F8:0 4.5 XIO B3:1/11 XIO B3:3/2 XIC B3:1/7 BST OTE B3:2/3 NXB TON T4:5 1.0 5

0 BND EOR SOR BST XIC T4:2/DN XIC B3:3/2 NXB XIC B3:2/4 XIO B3:2/0 XIO B3:1/12 BND XIO B3:0/9 LEQ F8:0 4.5 XIO B3:1/11 OTE B3:2/4 EOR SOR END EOR

SENSORS

SOR XIC B3:1/9 OTE B3:1/7 EOR SOR XIC B3:3/3 OTE B3:3/0 EOR SOR XIC B3:3/4 OTE B3:3/1 EOR SOR XIC B3:3/5 OTE B3:3/2 EOR SOR END EOR

HEAD SUBSYSTEM CODE

SOR JSR 10 EOR SOR JSR 11 EOR SOR JSR 12 EOR SOR BST XIC B3:6/8 NXB XIC B3:6/0 XIO B3:6/1 XIO B3:6/11 BND XIO B3:0/9 XIO B3:6/3 BST TON T4:6 1.0 10 0 NXB OTE B3:6/0 BND EOR SOR BST XIC B3:6/4 NXB XIC B3:6/1 XIO B3:0/6 BND XIO B3:0/9 XIO B3:6/3 OTE B3:6/1 EOR SOR END EOR

HEAD SAFETY CODE

SOR XIC B3:6/2 CTU C5:6 2 0 EOR SOR XIC C5:6/DN OTE B3:6/11 EOR SOR XIC T4:7/DN OTE B3:6/3 EOR SOR XIC B3:6/10 BST RES C5:6 NXB RES T4:7 BND EOR SOR XIC T4:6/DN XIO B3:6/1 ONS B3:6/5 BST RES T4:6 NXB OTE B3:6/2 BND EOR SOR END EOR

HEAD IO CODE

SOR XIC I:4.0/0 OTE B3:6/4 EOR SOR XIC B3:6/0 OTE O:2.0/5 EOR SOR END EOR

HEAD STATE MACHINE CODE

SOR BST XIO B3:6/8 XIO B3:6/9 NXB XIC B3:6/7 BND XIO B3:0/9 OTE B3:6/7 EOR SOR BST XIC B3:1/8 NXB XIC B3:6/8 XIO B3:6/9 XIO B3:1/12 BND XIO B3:0/9 XIO B3:1/11 XIO B3:6/1 BST OTE B3:6/8 NXB TON T4:7 1.0 23 0 BND EOR SOR BST XIC B3:6/1 NXB XIC B3:6/9 XIO B3:0/6 XIO B3:1/12 BND XIO B3:0/9 XIO B3:1/11 XIO B3:0/6 OTE B3:6/9 EOR SOR END EOR

LOGIC/BRAIN CODE

SOR GEQ C5:0.ACC 1 XIO B3:7/6 MOV 5 T4:0.PRE EOR SOR GEQ C5:0.ACC 1 XIO B3:7/6 OTE B3:7/11 EOR SOR EQU C5:0.ACC 0 GEQ C5:8.ACC 3 MOV 3 T4:0.PRE EOR SOR GRT C5:0.ACC 0 XIO B3:7/9 ONS B3:7/8 BST RES T4:0 NXB OTE B3:7/2 NXB RES T4:3 BND EOR SOR BST XIC B3:7/2 NXB XIC B3:7/9 XIO B3:7/10 BND OTE B3:7/9 EOR SOR GEQ C5:1.ACC 1 XIO B3:7/6 MOV 3 T4:1.PRE EOR SOR GEQ C5:1.ACC 1 XIO B3:7/6 OTE B3:7/1 EOR SOR EQU C5:1.ACC 0 GEQ C5:8.ACC 3 MOV 1 T4:1.PRE EOR SOR GRT C5:1.ACC 0 XIO B3:7/14 ONS B3:7/13 BST RES T4:1 NXB OTE B3:7/12 NXB RES T4:4 BND EOR SOR BST XIC B3:7/12 NXB XIC B3:7/14 XIO B3:7/15 BND OTE B3:7/14 EOR SOR GEQ C5:2.ACC 1 XIO B3:7/6 MOV 5 T4:2.PRE EOR SOR GEQ C5:2.ACC 1 XIO B3:7/6 OTE B3:8/0 EOR

SOR EQU C5:2.ACC 0 GEQ C5:8.ACC 3 MOV 1 T4:2.PRE EOR SOR GRT C5:2.ACC 0 XIO B3:8/3 ONS B3:8/2 BST RES T4:2 NXB OTE B3:8/1 NXB RES T4:5 BND EOR SOR BST XIC B3:8/1 NXB XIC B3:8/3 XIO B3:8/4 BND OTE B3:8/3 EOR SOR BST XIC B3:7/11 NXB XIC B3:7/2 NXB XIC B3:7/1 NXB XIC B3:7/12 NXB XIC B3:8/0 NXB XIC B3:8/1 BND OTE B3:7/0 EOR SOR XIC B3:7/0 OTE B3:7/5 EOR SOR XIC B3:7/6 BST MOV 3 T4:0.PRE NXB MOV 1 T4:1.PRE NXB MOV 2 T4:2.PRE BND EOR SOR END EOR