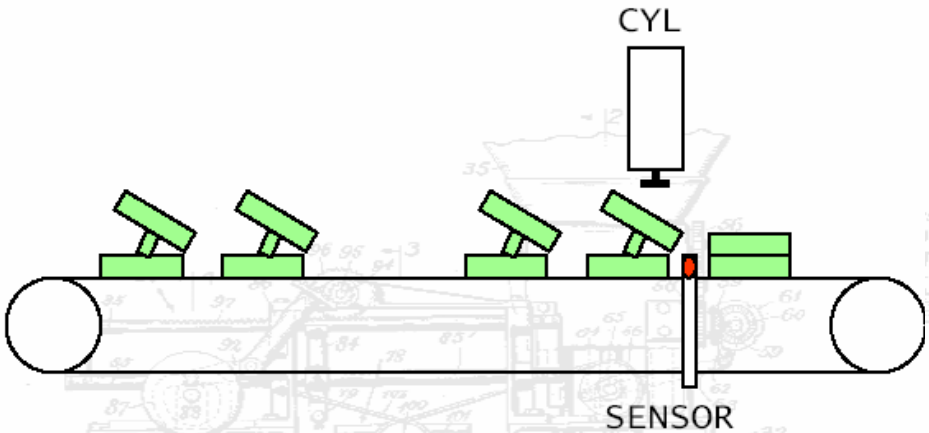
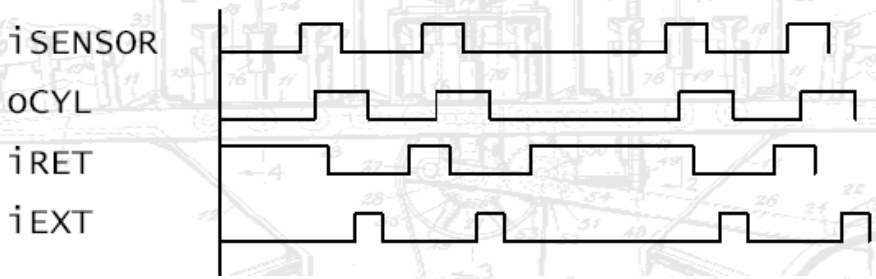
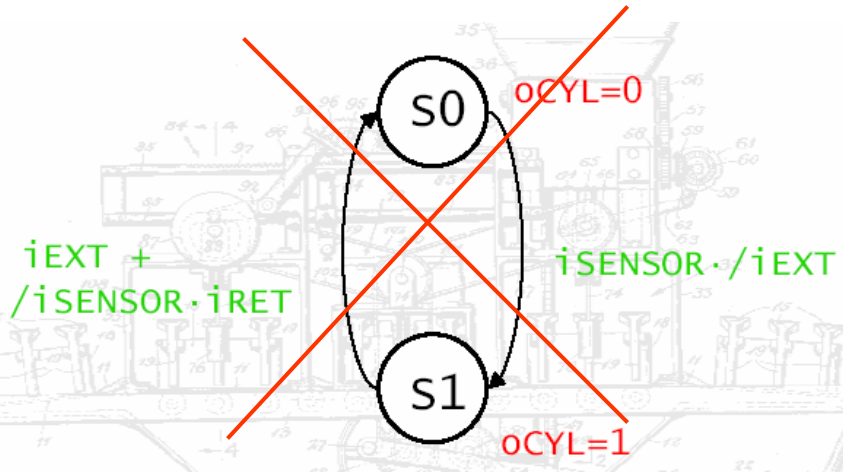
State Machines in Ladder Logic

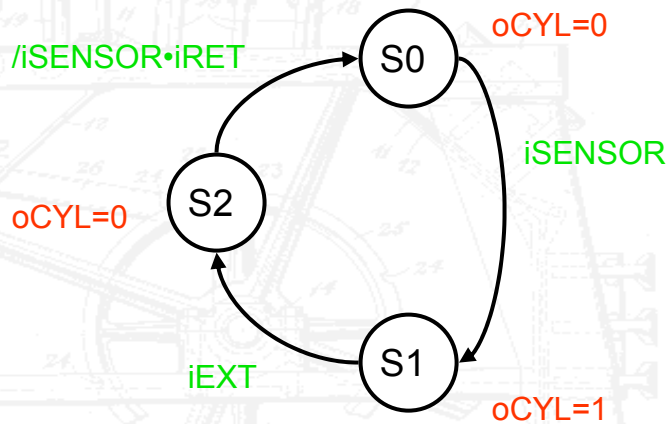
- Pure relay logic - traditional design:
  - 2 states = 1 coil
  - 3-4 states = 2 coils
  - 5-8 states = 3 coils, etc.
  - difficult to debug, modify and document
- Pure relay logic - "one-hot" design
  - 1 coil per state
  - easier to debug, modify, and document
- RLL-Plus
  - "Stages"
  - JMP "coils"
  - easiest to write and maintain
  - not available in all brands of PLC's

Second Example Revisited

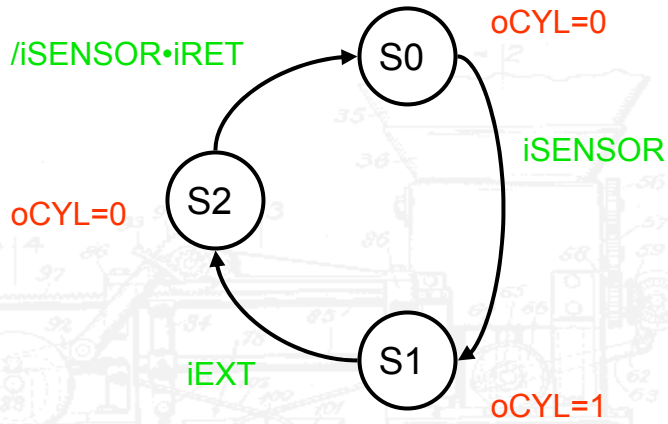








Example #2 State Diagram



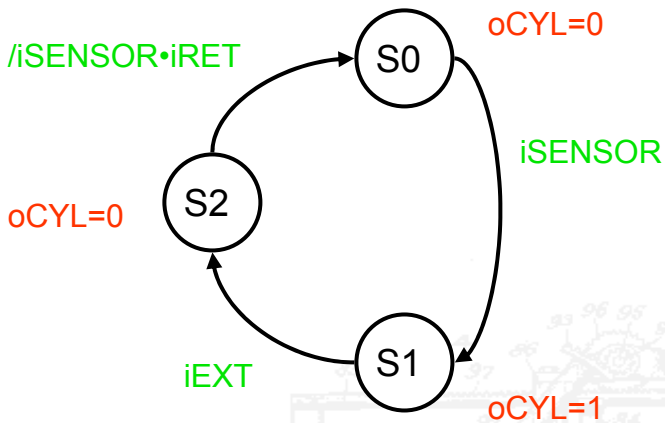
cS0 = cS2•/iSENSOR•iRET + cS0•/iSENSOR + /cS0•/cS1•/cS2

cS1 = cS0•iSENSOR + cS1•/iEXT

cS2 = cS1•iEXT + cS2•/(/iSENSOR•iRET)

= cS1•iEXT + cS2•(iSENSOR + /iRET)

Example #2 State Diagram



cS0 = cS2•/iSENSOR•iRET

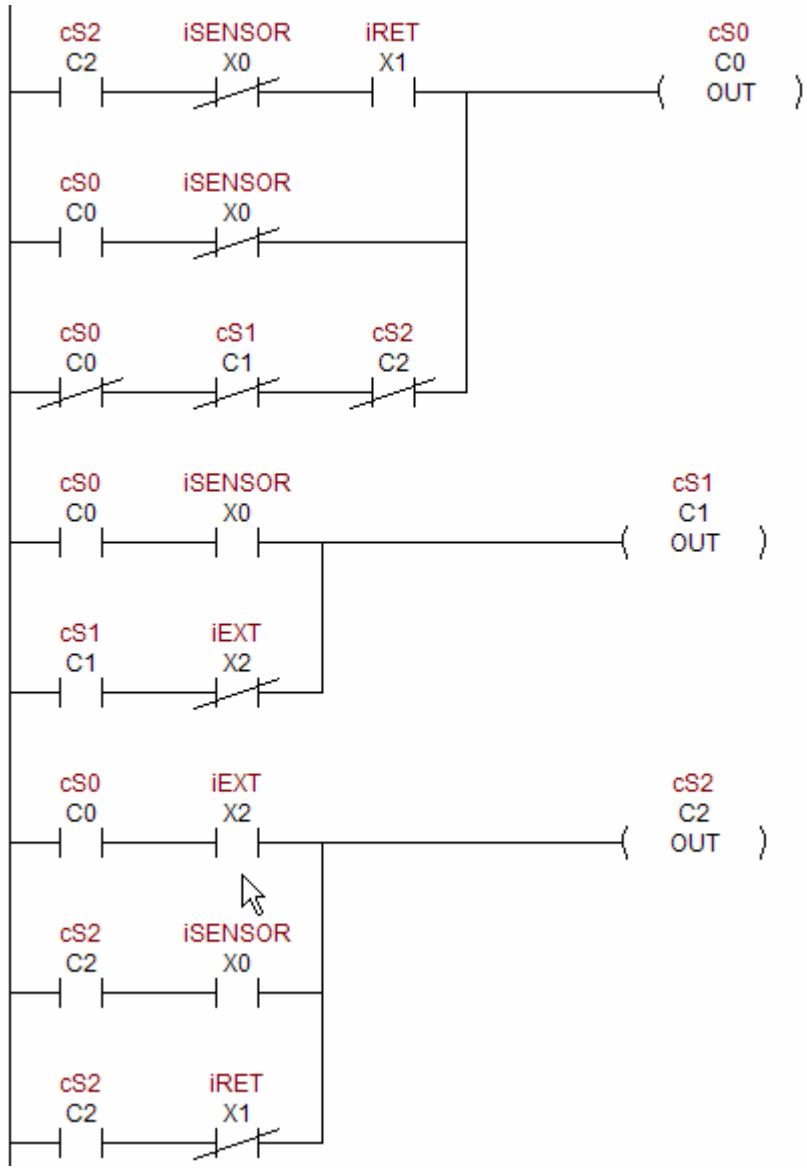
+ cS0•/iSENSOR

+ /cS0•/cS1•/cS2

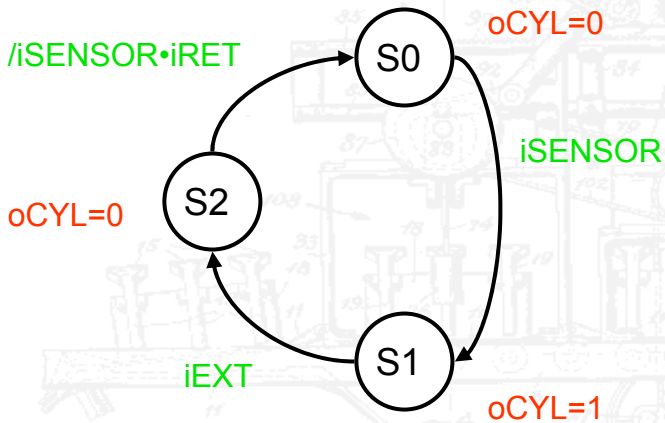
cS1 = cS0•iSENSOR + cS1•/iEXT

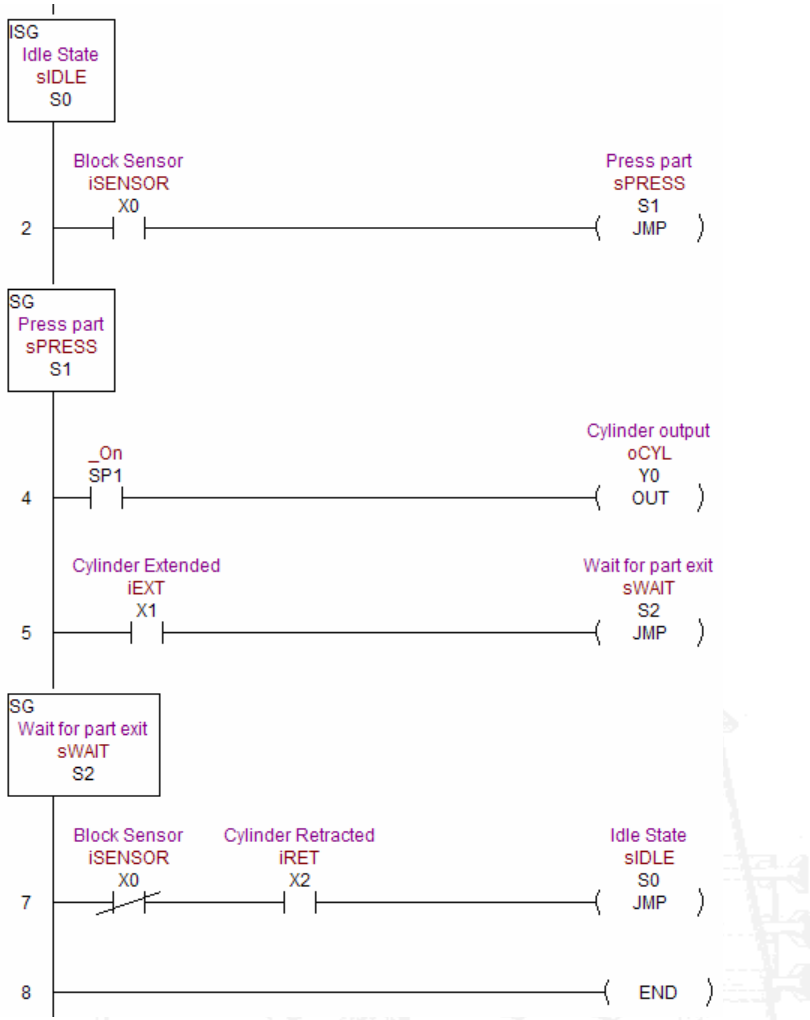
cS2 = cS1•iEXT + cS2•iSENSOR

+ cS2•/iRET)

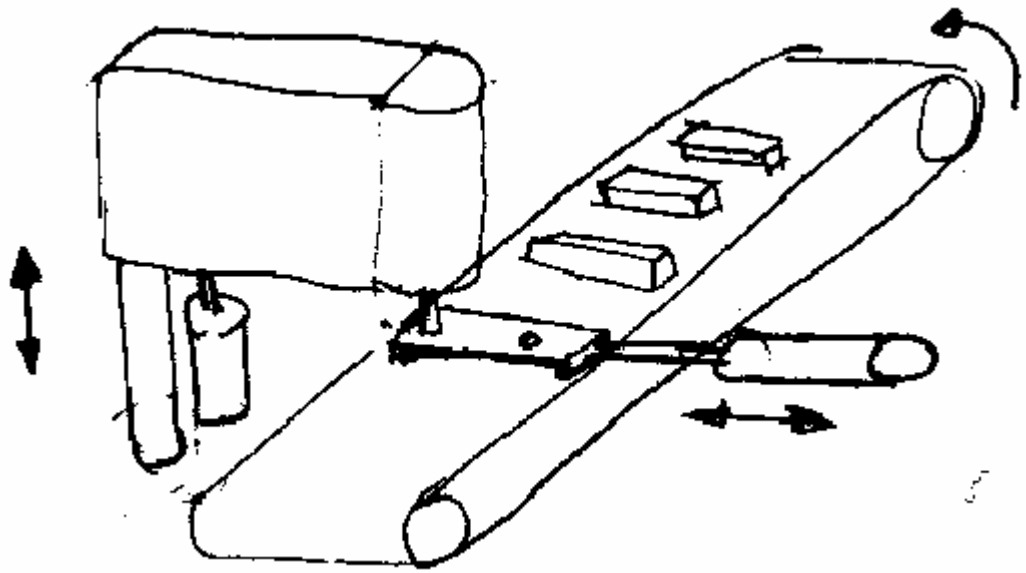


Ex #2 - RLL-Plus Stages





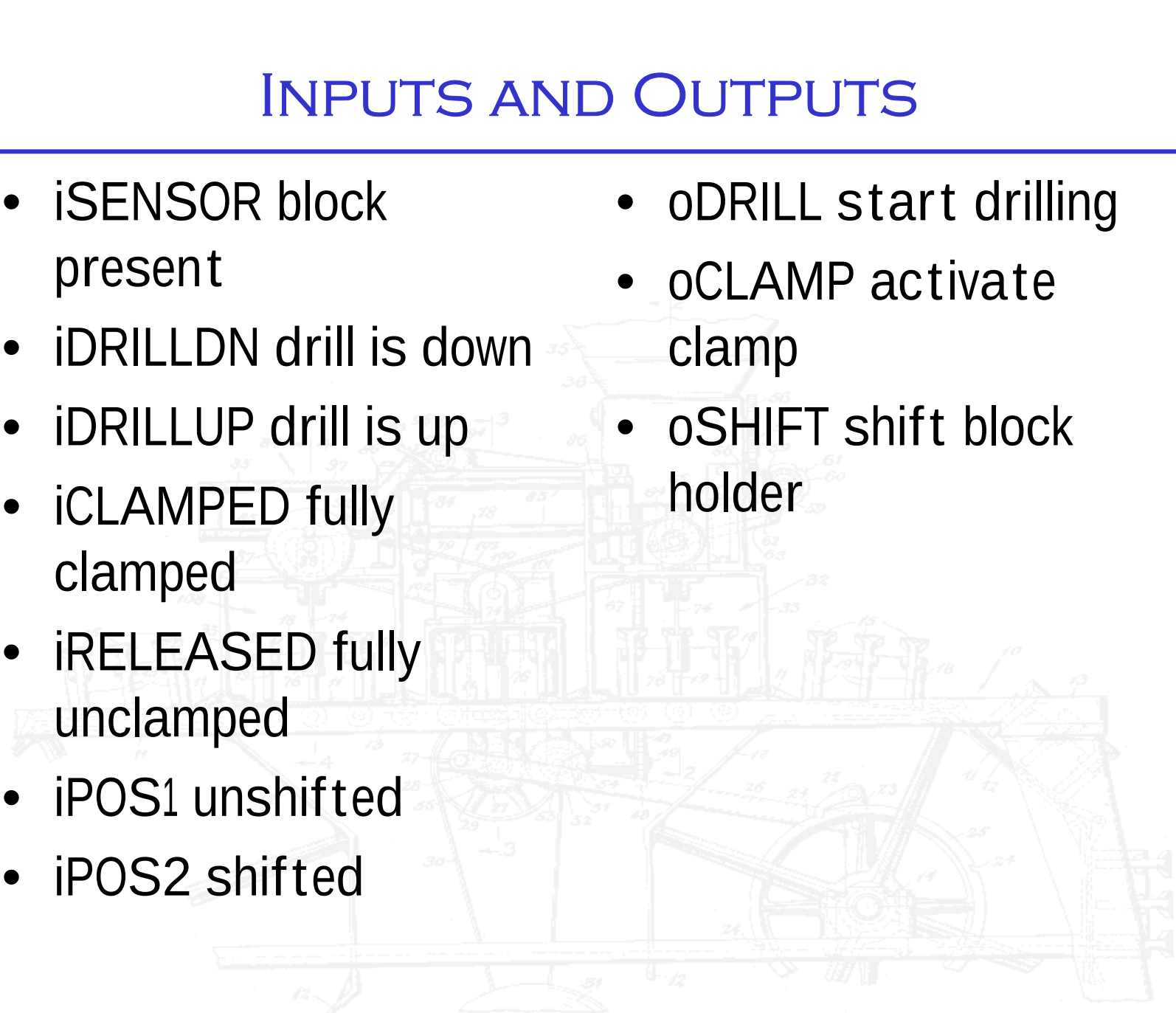
Multi-state Example



- When sensor detects block; clamp block, drill hole, shift, drill 2nd hole, shift back, release clamp

Inputs and Outputs

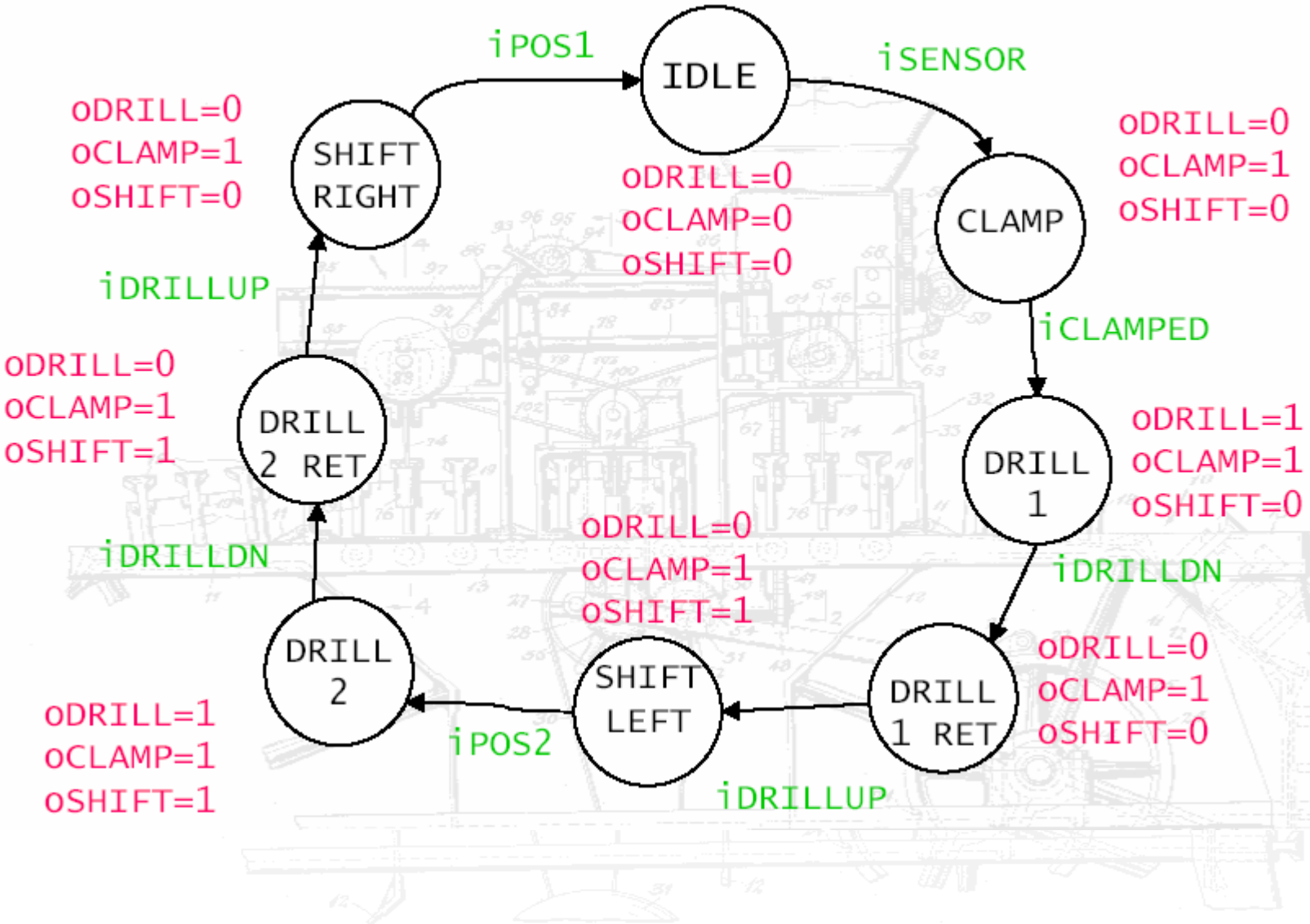
- iSENSOR block present
- iDRILLDN drill is down
- iDRILLUP drill is up
- iCLAMPED fully clamped
- iRELEASED fully unclamped
- iPOS1 unshifted
- iPOS2 shifted
- oDRILL start drilling
- oCLAMP activate clamp
- oSHIFT shift block holder



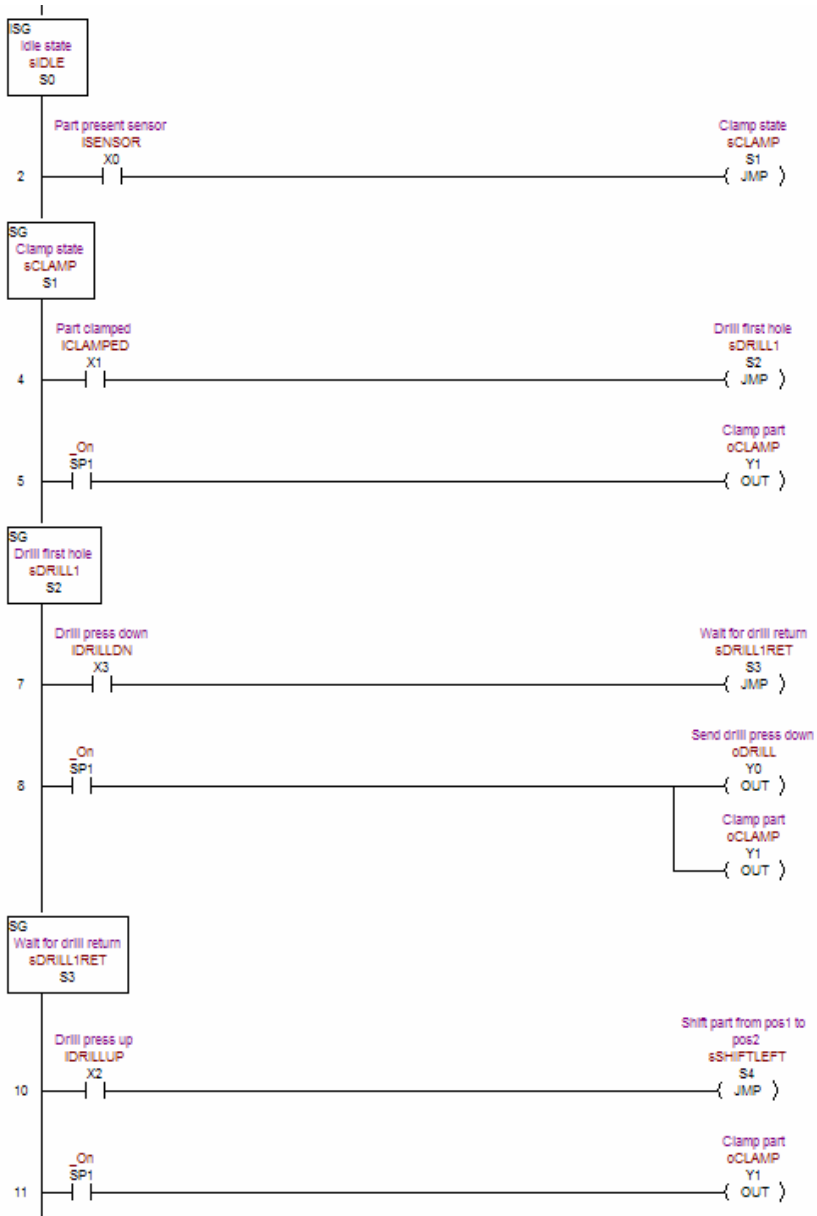
State Diagrams

- One `state` per "action"
- Look for "wait" `states` needed

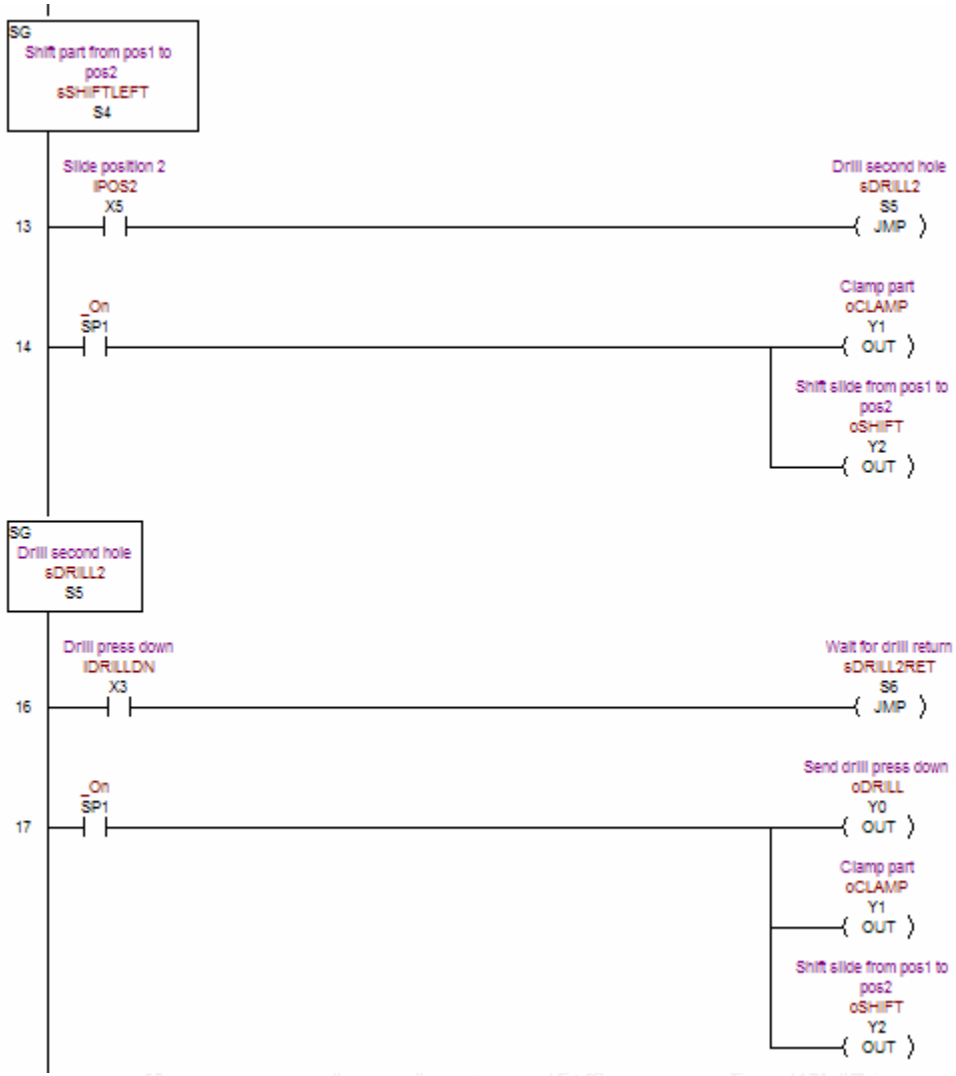
State Diagram



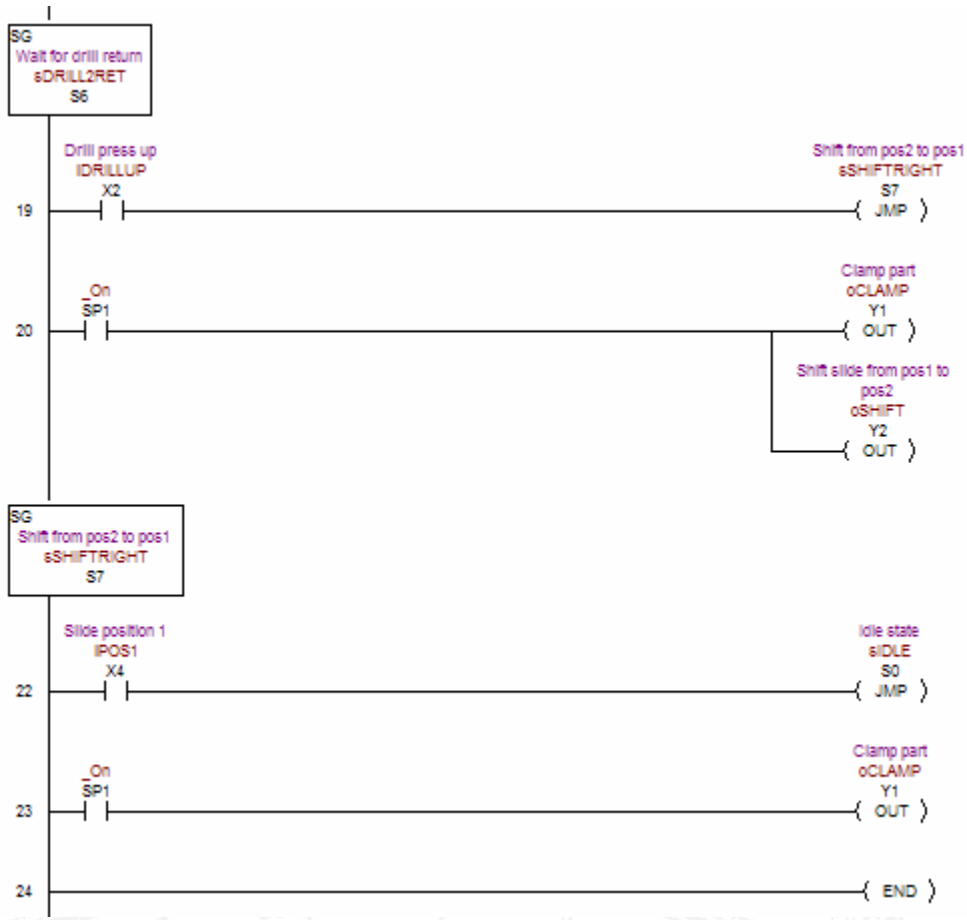
RLL-Plus


SG
Idle state
sIDLE
S0
Part present sensor
ISENSOR
X0
2
Clamp state
sCLAMP
S1
JMP
SG
Clamp state
sCLAMP
S1
Part clamped
ICLAMPED
X1
4
Drill first hole
sDRILL1
S2
JMP
_On
SP1
5
Clamp part
oCLAMP
Y1
OUT
SG
Drill first hole
sDRILL1
S2
Drill press down
IDRILLDN
X3
7
Wait for drill return
sDRILL1RET
S3
JMP
_On
SP1
8
Send drill press down
oDRILL
Y0
OUT
Clamp part
oCLAMP
Y1
OUT
SG
Wait for drill return
sDRILL1RET
S3
Drill press up
IDRILLUP
X2
10
Shift part from pos1 to pos2
sSHIFTLEFT
S4
JMP
_On
SP1
11
Clamp part
oCLAMP
Y1
OUT

RLL-Plus


SG
Shift part from pos1 to pos2
sSHIFTLEFT
S4
Slide position 2
IPOS2
X5
13
Drill second hole
sDRILL2
S5
JMP
_On
SP1
14
Clamp part
oCLAMP
Y1
OUT
Shift slide from pos1 to pos2
oSHIFT
Y2
OUT
SG
Drill second hole
sDRILL2
S5
Drill press down
IDRILLDN
X3
16
Wait for drill return
sDRILL2RET
S6
JMP
_On
SP1
17
Send drill press down
oDRILL
Y0
OUT
Clamp part
oCLAMP
Y1
OUT
Shift slide from pos1 to pos2
oSHIFT
Y2
OUT

RLL-Plus


SG
Wait for drill return
sDRILL2RET
S6
Drill press up
IDRILLUP
X2
19
Shift from pos2 to pos1
sSHIFTRIGHT
S7
JMP
_On
SP1
20
Clamp part
oCLAMP
Y1
OUT
Shift slide from pos1 to pos2
oSHIFT
Y2
OUT
SG
Shift from pos2 to pos1
sSHIFTRIGHT
S7
Slide position 1
IPOS1
X4
22
Idle state
sIDLE
S0
JMP
_On
SP1
23
Clamp part
oCLAMP
Y1
OUT
24
END