Multitasking Autotuning PID Controller in Heat Transfer Application

or how to build a 30 BGN universal vectorized regulator

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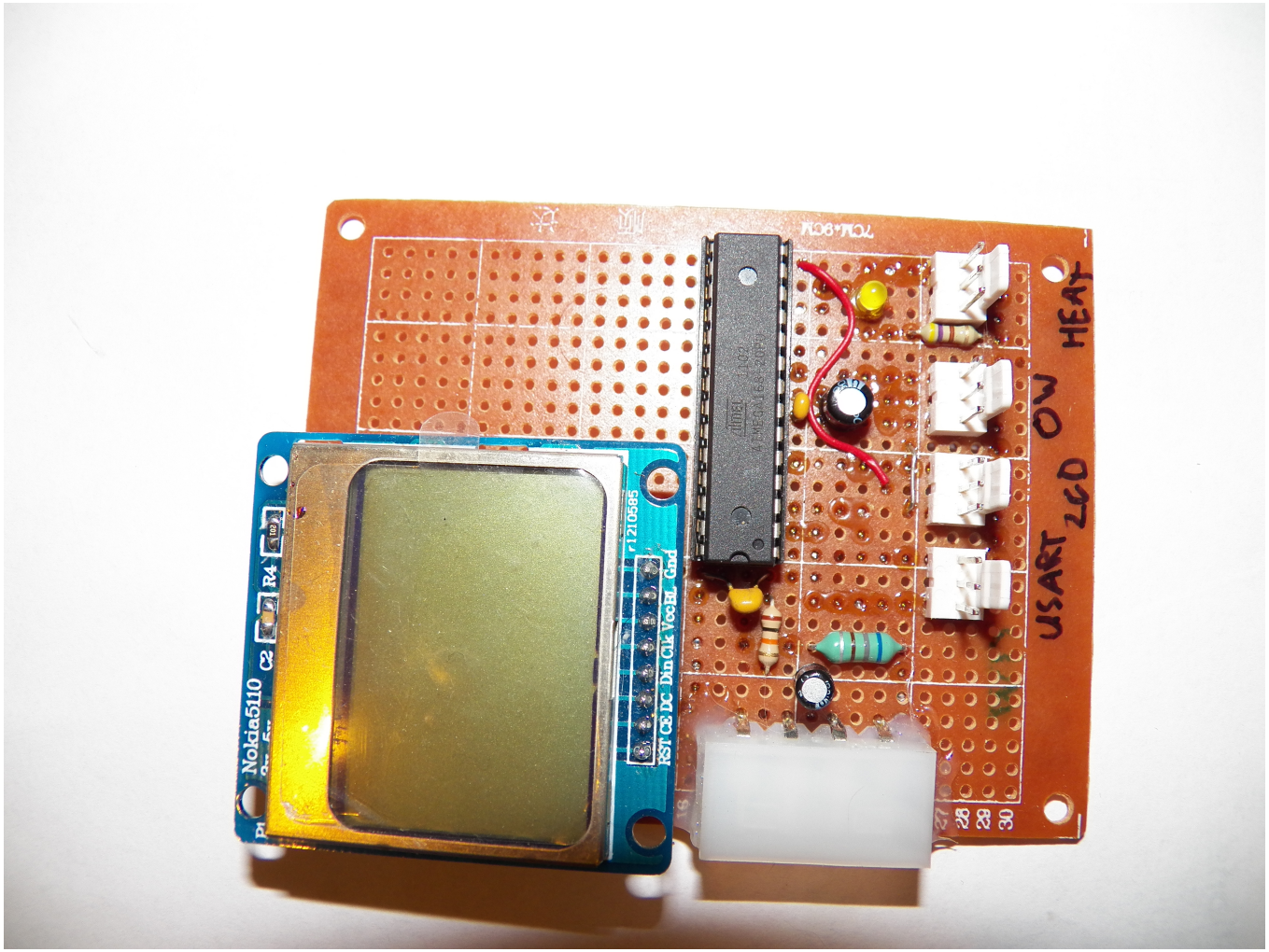
The device

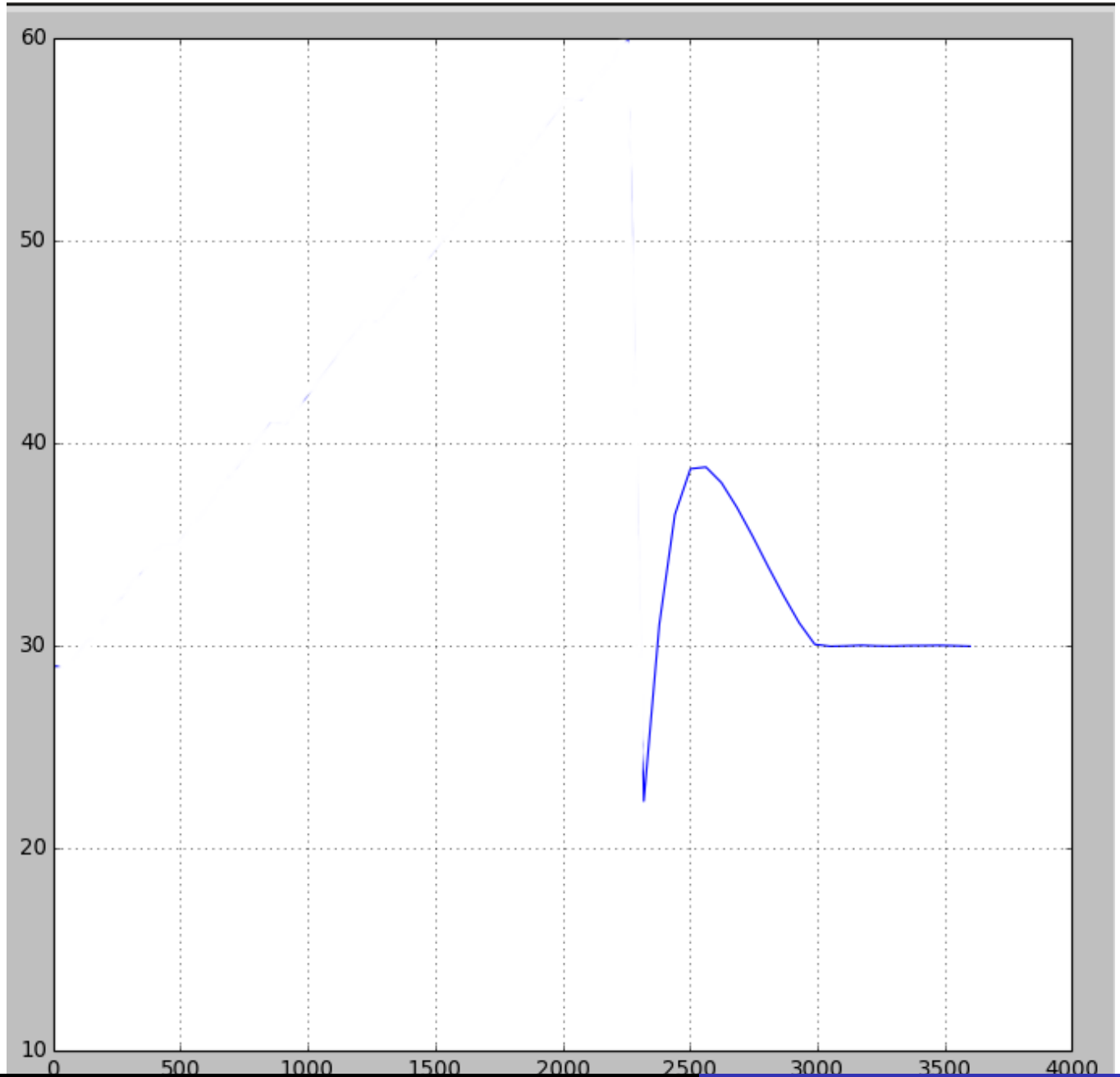


```
// Decide if this particular half-wave should be turned on. Further discussion:
// http://programmers.stackexchange.com/questions/304546/algorithm-to-express-an-integer-as-a-sum-of-some-binary-numbers
// The function simulates an uint16_t overflow.
bool should_turn_on()
{
    static uint32_t acu = 0;
    acu += g_setpoint;
    if(acu > PROC_VAL_MAX)
    {
        acu &= PROC_VAL_MAX;
        return true;
    }
    else
    {
        return false;
    }
}
```

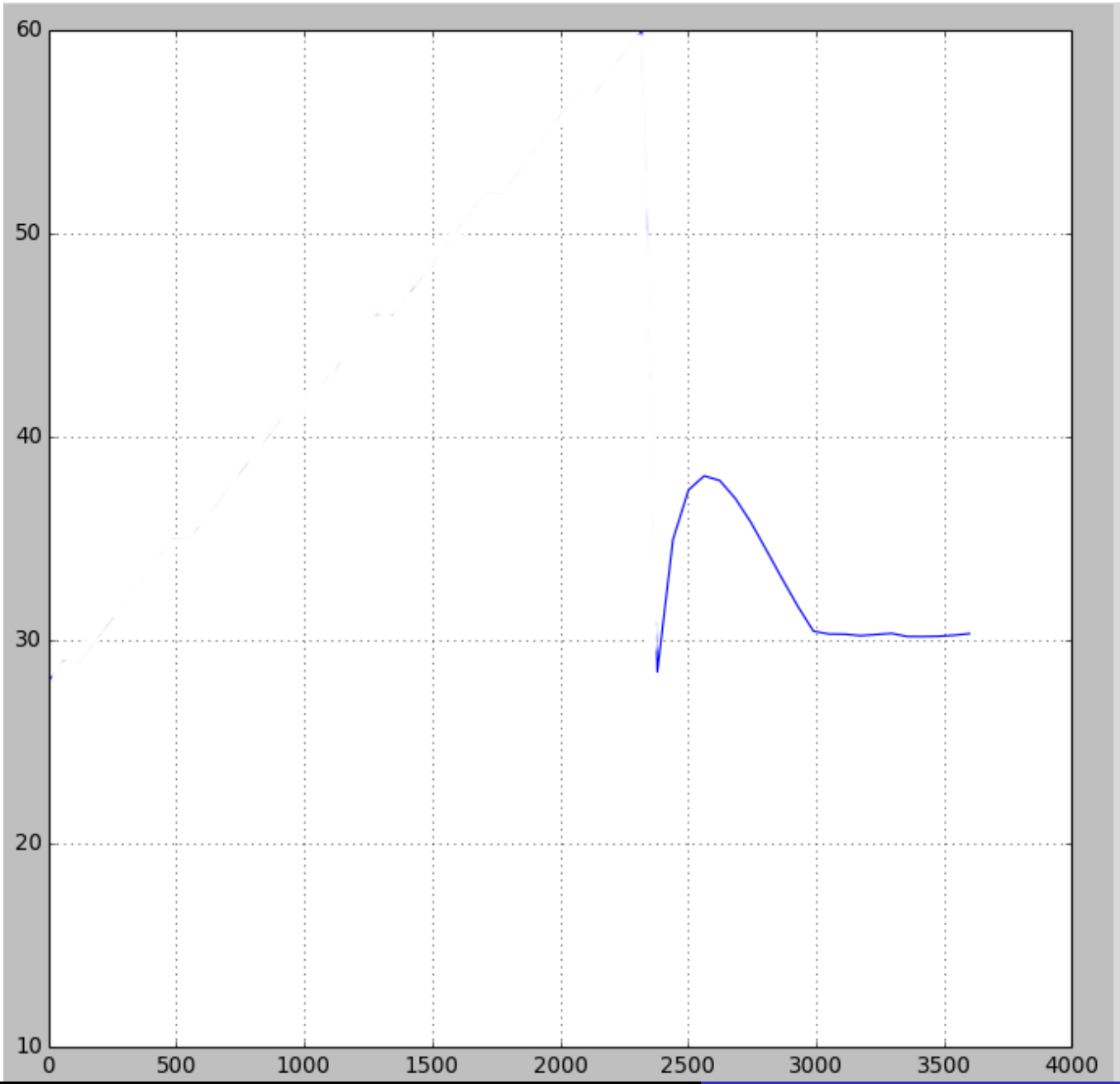
Peak deterctor algorithm

```
pid_state_t pid_wait_to_settle(pid_inout_t proc_val, pid_inout_t critical, pid_inout_t treshold, clock_seconds_t now)
{
    extremum_t *min = &g_pid_tune.min;
    extremum_t *max = &g_pid_tune.max;
    extremum_t **curr = &g_pid_tune.curr;
    extremum_t **prev_ = &g_pid_tune.prev;

    static pid_inout_t prev, prevprev;

    if(*curr == min)
    {
        // Look for a local maximum.
        if(prevprev <= prev && prev > proc_val)
        {
            (*max).val = proc_val;
            (*max).when = now;
            *curr = max;
            *prev_ = min;
        }
    }
    else
    {
        if(prevprev >= prev && prev < proc_val)
        {
            (*min).val = proc_val;
            (*min).when = now;
            *curr = min;
            *prev_ = max;
        }
    }

    prevprev = prev;
    prev = proc_val;

    if(proc_val >= critical)  return UNSTABLE;
    else if((*min).val + treshold < (*max).val)
return SETTLED;
    else return OSCILLATING;
}
```

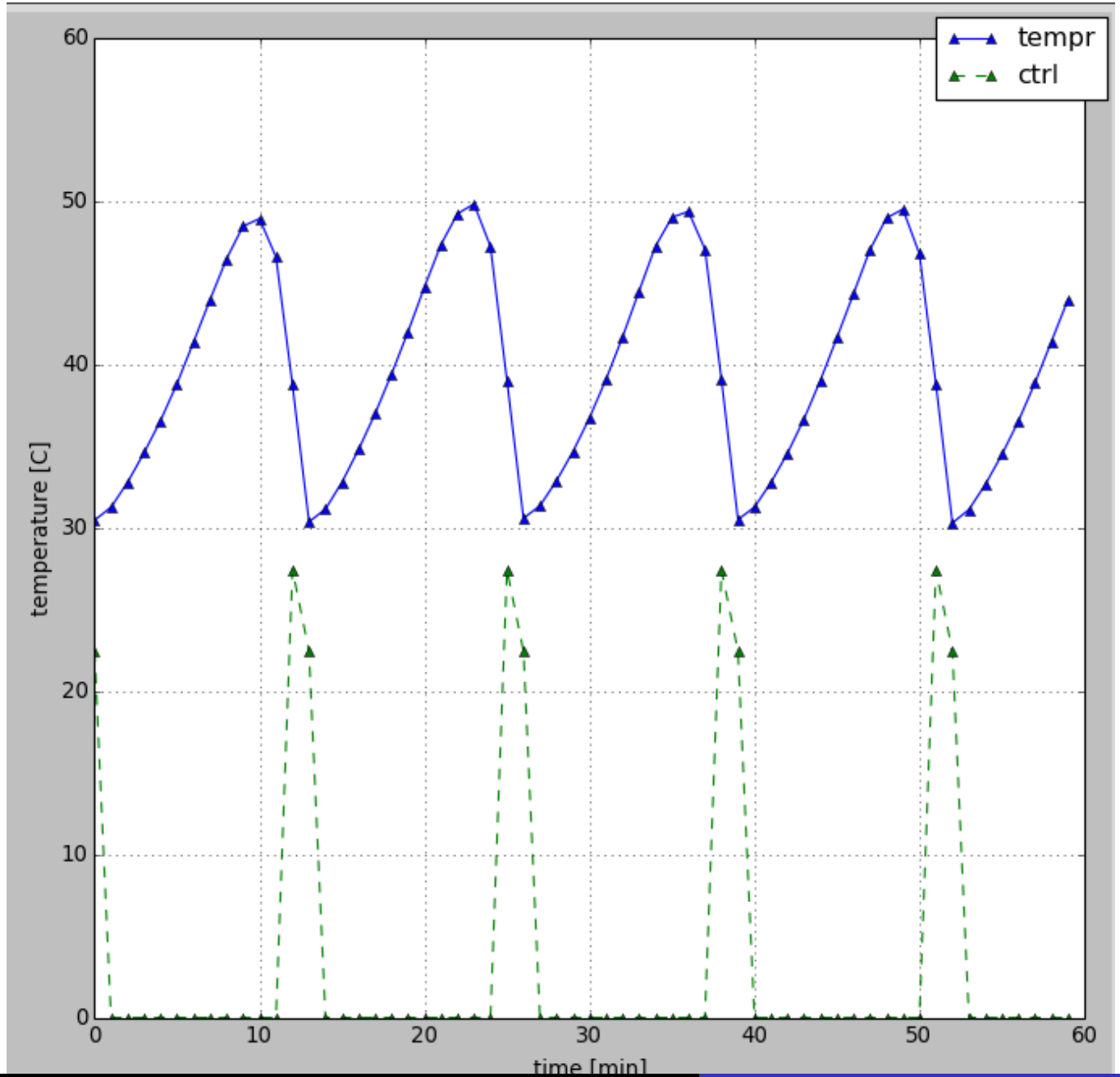
Ziegler-Nichols sustained oscillation mode



Astrom-Hagglund sustained oscillation mode



Sampling frequency reduced



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